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Authors	Xenophon Zabulis, Nikolaos Partarakis, Carlo Meghini, Danae Kaplanidi, Arnaud Dubois, Dimitrios Menychtas, Alina Glushkova, Brenda Elizabeth Olivas Padilla, Sotiris Manitsaris, Cynthia Beisswenger, Dieter Blatt, Dick van Dijk, Ammar Qammaz, Meia Wippoo, Aggeliki Tsoli, Antonis Argyros, Chris Ringas, Maria Fasoula, Eleana Tasiopoulou ,Catherine Cuenca, Anne-Laure Carre, Arnaud Dubois, Ilka Neumann, Vito Nitti, Evropi Stefanidi, Stavroula Ntoa, Ilia Adami, Antonios Chatziantoniou, Valentina Bartalesi, Daniele Metilli, Nikolaos Patsiouras, Paraskevi Doulgeraki, Ulrike Denter, Hansgeorg Hauser
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Executive summary

This deliverable describes our approach towards the main objective of Mingei, which is the representation of HCs, supporting the curation of its digital assets and HC preservation. This representation will capture the wide spectrum of knowledge that a HC covers, from objects and their making, the hand gestures and tool uses that define craft motor skills, to the societal value, economic impact, and historical significance of HCs.

In this deliverable, we first introduce the topic of craft representation, by starting with a close understanding of what is craft, as entertained colloquially and in the literature, what is the type of knowledge and expertise required to achieve such a representation and what are the limits of the proposed approach.

In Section 2, we review state-of-the art on digitisation of CH. We first, in Section 2.1, review the projects in the CH domain over the two decades. In Sections 2.2, 2.3, and 2.4, we briefly review the progress in digitisation projects over this time, in the fields of tangible and intangible heritage. In depth reviews, on digitisation, digitisation modalities, and guidelines on selecting digitisation modalities can be found in Mingei-D2.2. The last two subsections of Section 2, review the state-of-the-art in craft documentation and representation and the associated the intellectual property rights associated with the contributors of the craft representation.

In Section 3 we overview the proposed approach and introduce the Mingei protocol as a **proposed method,** comprising of guidelines, tools, and instructions that is comprised of 6 steps. In that section, we first position Mingei in the domain of CH documentation and preservation efforts, explaining its scientific origins and conception. In that section, we study the CH dimensions due to HCs and propose a classification as to the assets associated with each. Moreover, we provide an overview of the protocol steps, the way that the protocol is implemented and the way that the produced knowledge can be accessed. We end this session with a description of the anticipate representation to be achieved following the Mingei protocol.

In Section 4, we present the first step of the protocol. In Step 1, we collect the topics of study that will be eventually transformed in digitally represented knowledge. We first recommend a prior orientation through desktop research to study already existing knowledge on the craft and pertinent community. In addition, this orientation discusses prerequisites regarding institutional collaboration, personal data, and pertinent issues to be resolved prior to digitisation efforts. In Section 4.2, we present topics of knowledge collection on craft instances required for a craft representation, as devised with cultural partners and heritage professionals in Mingei. In Section 4.3 we present the digital assets required for the representation.

In Section 5, we present Step 2 of the protocol. In this step, basic craft knowledge elements are formed, encapsulating digital assets and including curated information about an element of knowledge and links to digital assets. This information regards objects, actors, actions, processes, materials, concepts, tools, times, and places. Forming a knowledge element requires a comprehensive understanding of the assets and a **digital curation** process. Digital assets are represented in the knowledge base through knowledge elements, which associate digitisation data with the result of a curation process that yields metadata, annotations, and descriptions. The

section present the knowledge element types required for the representation, a proposed rationale on organising their formation. In Section 5.5, we discuss the topic of "visual semantics" or semiotic and their complementary value to verbal information. The association of visual and verbal content is a characteristic of the Mingei craft representation. As such, in this section, we proposed two editors for facilitating the semiotic annotation of static and dynamic scenes. Finally, in Section 5, we entertain the notion of Events and Actions as they comprise a central element in our representation. We, thus, explain how to represent historic events relevant to craft context and event schemas to represent the actions that follow a craft process. In this effort, we illustrate the represented knowledge and the semantic relationships between knowledge elements and events.

In Step 3 (presented in Section 6), we develop the craft representation by linking knowledge elements and events with semantic relationships. The knowledge that is represented follows the classification of Section 3.2. In this section, we first explain the specialisation of generic ontology classes to craft-specific classes. Using these classes and the knowledge elements of the previous step, we show how to model knowledge on crafts, depending on its type. We furthermore, explain how to model craft actions and processes. A central contribution of Mingei is the association of verbal with corresponding visual content, by linking semantic notions, like events and actions, to the media objects that provide an illustration of these notions. Notice that this illustration is not only to the benefit of the human user, who can extract a lot of knowledge from media objects, but also of the machine that can analyse these signals and learn from them.

In Step 4 (presented in Section 7), we create the narratives that will be used to present a comprehensive picture of the represented craft. The craft representation contains two types of stories: event schemas that represent **craft processes** and fabulae to represent **craft context**. Using this couple of methods we create storytelling and educational content that covers tangible and intangible craft dimensions and provide a comprehensive picture of craft processes and context. Whereas in the representation of knowledge our concern was to formally represent knowledge, in the step we focus on presenting knowledge in a human comprehensible manner. For processes, this is insured by the demarcation of process actions by the practitioners. For craft context, we obtain multiple narratives from multiple perspectives and work with the communities for the appropriation of their presentation. As in Step 1, the collection of stories and processes is provided in the form of topics of interest to be presented, though co-creation and anthropologic research.

In Step 5 (presented in Section 8), a range of presentation modalities of relevance to craft presentation and presentation are presented. These modalities are tailored to present different dimensions of a craft expression. Thereby, they matched to task of relevance in the context of Mingei pilots and demonstrated. The type of audience is of relevance to the way of presentation. For this reason, co-design with users and stakeholders is critical in the definition of narratives and channels that best suit each type of audience intended. Co-design and evaluation with practitioners and communities ensures that correct knowledge is preserved, knowledge is presented with appropriation to traditional context, contributors have ownership of the outcomes of the representation.

Finally, in Step 6 (presented in Section 9), we explore how to use the Mingei protocol and tools to

achieve positive impact in the HC and CH domains. We specifically, study how applications can be formed combining the narratives (Step 4) and presentation modalities (Step 5) to reach specific craft and community needs. In this context, we utilised the diversity of pilots to explore the broadest possible range of craft dimensions.

The **Glass** pilot focuses strongly on the representation of hand and body gestures through motion-driven narratives. It entails the re-creation of lost techniques, with the help of practitioners. The pilot studies the use of a variety of tools, personal creativity, tracking technological adaptation of the HC across time, and artistic expression for glassmaking as handicraft and as industrial craft. The **Silk** pilot regards an industrialized craft and use of machinery. Focus is placed in the representation of machine operation and corresponding motion-driven narratives. The pilot focuses at education applications to support craft preservation. The **Mastic** pilot includes indoor and outdoor narratives and presents in context the societal and economic facets of this HC, as well as its impact on legends, traditions, and heightened sense of shared identity among members of the community of this indigenous HC. Gender and intergenerational learning aspects are captured and presented, illustrating how this HC is passed on through generations. The pilot will further promote HC tourism, agro-tourism and mastic branding initiatives on the island of Chios. We present preliminary results on Mingei pilots and additional collaborations with craft practitioners and present co-creation results about envisaged future applications of the Mingei protocol.

Keywords

Craft representation protocol, Mingei protocol, Tangible Heritage, Intangible Heritage, Cultural Heritage, Heritage Craft, Art, Digitisation, Scanning, Scanner, Documentation, Photographic Documentation, 3D Documentation, Motion Capture, Visual Tracking, Action, Activity, Process, Curation, Curated Material, Testimonies, Contextual Knowledge, Representation, Preservation, Conservation, Collaborative Creation, Collaborative Design, Mingei Pilots, Stakeholders, Semantic Representation, Semantics, Archives, Documentaries, Computer Vision, Photogrammetry, Weaving, Jacquard Weaving, Storytelling, Narratives, Visualisation, Illustration.

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Abbreviations

ACE	Automatic Computing Engine
CCD	Charged Coupled Device
CCIs	Cultural and Creative Industries
CH	Cultural Heritage
CHI	Cultural Heritage Institution
CHI	Cultural Heritage Institution
CrO	Craft Ontology
CrO	Craft Ontology
HC	Heritage Craft
HC	Heritage Craft
HdS	Haus der Seidenkultur
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
ICH	Intangible Cultural Heritage
IMU	Inertial measurement unit
IPR	Intellectual Property Rights
IRI	Internationalized Resource Identifier
LHTs	Living Human Treasures
MoCap	Motion Capture
RTI	Reflectance Transformation Imaging
SKOS	Simple Knowledge Organization System
TCH	Tangible Cultural Heritage
UNSECO	United Nations Educational, Scientific and Cultural Organization

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1. Introduction

This deliverable describes our approach towards the **main objective of Mingei**, which is the **representation and preservation of HCs**.

The proposed **representation** captures the wide spectrum of knowledge that a HC covers, from objects and their making, to the societal value, economic impact, and historical significance of HCs.

To the best of our knowledge, a craft digitisation protocol has not been comprehensively proposed. The state-of-the-art towards approaches for the representation of HCs is reviewed in Section 2. Envisaged **innovation** lies in the definition of a method for the digital representation and preservation of craft as CH. This representation will:

- Cover of tangible and intangible HC dimensions.
- Adhere to digitisation standard for CH documentation.
- Formally represent knowledge and semantics.
- Aid the capture of characteristic craft qualities.
- Provide computational ways to create narratives for HC documentation and preservation.
- Contribute to the design and implementation of applications that: (a) Aid CH professionals in digital curation and CH research, (b) Support HC educators in the transmission of HC knowledge, and (c) Provide stimulation for revenues of cultural resources through thematic tourism

The protocol is overviewed as a linear series of steps, but which are implemented in an iterative fashion. During the study of a HC, digital asset acquisition and knowledge collection can be revisited and refined, as new knowledge is discovered.

1.1 What is craft?

The definition of craft is a matter of debate, varying between cultures and historical periods. We present a selection of characteristic definitions.

- Craft is characterised by a **certain type of making**, in which objects are **created by hand** through the **skilled use of tools** [17] very often to make objects of **functional use** and not solely of ornamental value.
- Craft is medium specific and characterised by the type of product, involving the creation of essentially functional objects. Moreover craft is *"identified with a **material** and the **technologies** to **manipulate** it"* [2] .
- *"Craft is an occupation or trade requiring manual dexterity or artistic skill"* (Meriam-Webster on Craft).
- Craftsmanship has been characterised as the *"workmanship of risk"*, to convey that *"the quality of the result is not predetermined, but depends on the judgement, dexterity and care which the maker exercised as he works"* [1] .

Craft is performed by human persons. As such, they include historic, geographical, artistic, traditional, economic, and religious dimensions, relevant to the **context** that a craft has or could flourish. We call knowledge relevant to these contexts **contextual knowledge**.

The anthropologic aspect is found in comprehensive definitions of craft, which denote a **social context** and link **craft evolution** with technological progress:

A craft is a **pastime** or a **profession** that requires **skills**. Mastery of a craft includes learning of skills. Historically, specialized crafts with **high value products** tended to concentrate in **urban centres** and formed guilds. The required skills often demanded a **higher level of education**, and craftsmen were usually in a more **privileged** position than peasantry in **societal hierarchy**. Crafts have undergone deep structural changes since the **Industrial Revolution**. The mass production of goods by large-scale industry has limited crafts to market segments in which mass-produced goods would not or cannot satisfy the preferences of potential buyers. (Adapted from Wikipedia on Craft).

and underscore the relationship[1] between craft and **artistic creation**:

"*In the mid-1800s William Morris began to question the differences between art and craft by bringing an artist aesthetic to a craft object, like wallpaper design. During the twentieth century, the boundaries between art and craft became blurred, particularly at the Bauhaus, as artists started to experiment with craft practices in their art. The artist Sonia Delaunay created geometric abstracts using textiles. Today contemporary artists use craft techniques.*" (from Tate Gallery "Art Terms" online glossary on Craft)

As such, and because of the relationship to tradition, crafts have been characterised as a form of **Intangible** Cultural Heritage [106] , but which has **tangible** dimensions, such as materials, tools, and man-made objects.

Heritage Crafts (HCs) are crafts that are of significance to Cultural Heritage (CH). A baseline towards the definition of HC is *"practices which employ manual dexterity and skill, and an understanding of traditional materials, designs and techniques to make or repair useful things"* [105] .

Folk art covers typically forms of visual art, made in the context of folk culture. In general, the produced objects have practical utility, rather than being exclusively decorative. As such, the products of a HC may comprise folk art.

1.2 What is the Mingei protocol?

The Mingei protocol is a **proposed method,** based on an approach to the Representation and Preservation of HCs [17] . It comprises of guidelines, tools, and instructions. Being a method, we expect and anticipate that it can be revised and improved.

Craft Representation or **Craft Digitisation** is a digital representation of a craft instance and includes digital representations of knowledge elements and digital assets. Knowledge elements regard objects, physical actions, process descriptions, instructions, testimonies, and contextual knowledge.

We call **craft instance** the practice of a craft by a community of practitioners, possibly specified by some geographical or temporal context. For example: "Silk textile manufacturing at Krefeld during

[1] We found [107] as relevant towards a comprehensive discourse on this relationship.

the last three centuries". Craft instances may be further differentiated by their degree of industrialisation, the materials, techniques, and tools that are used.

1.4 Who is the audience?

1.4.1 Audience

The protocol is addressed to persons, social groups, or organisations, interested in the documentation, preservation, and safeguarding of HCs. The targeted **audiences** of the protocol are:

- **CH professional, scholar, and the public** for comprehensive documentation of CH.
- **HC practitioner, community, student and master** for documentation of own craft, promotion of craft, educational material, interactive and educational experience, online courses.
- **HC friend, enthusiasts** for documentation of personal work, collection of works of interest.
- **CH industry**: revenue stimulation for the safeguarding of HCs, through: (a) sustainable thematic tourism services and (b) utilisation of traditional crafts in modern contexts.
- **Local authorities, businesses,** and **public bodies** interested in a comprehensive presentation of a HC, its relation to local tradition and thematic tourism.

Mingei is committed to the provision of service to the CH professional the **outcomes** of the Mingei technical tools strive to adhere to **international standards of CH documentation and representation**.

1.4.2 Expertise

The Mingei protocol encompasses a wide range of representation methods. These methods fall in the topics of artefact digitisation, semantic representation, and curation of content.

The Mingei approach strives to simplify technical topics, by providing tailored technical tools that specialise in the tasks require for craft documentation in a human comprehensible fashion. Nevertheless, as the representation of a craft includes representation of socio-historic context the **scientific** experience of the curator, historian, or anthropologist, is relevant to the quality and accuracy of the authored descriptions. The curation of **heritage** items and practices is **a multi-disciplinary subject**, which for in-depth study requires a pertinent scientific background.

At the same time, the craft representation includes (a) craft practice instructions, (b) collective memories and values of social groups. To be accurate and insightful, such representation can only be delivered by members of a respective community. Moreover, it is required that the Mingei representation should accommodate craft knowledge, organised in a way that is meaningful and natural to practitioners. As such, the "craft expertise" carried by a practitioner and the emic perspective a member of a community has, are required. When these practitioners are not anymore in life (such as for example in the Mingei glass pilot), the protocol borrows approaches from experimental archaeology: establish what is known, what is plausible (based on knowledge sources), and what needs to be hypothesised and suggested.

The Mingei protocol avails the possibility of exploiting advanced technologies in the domains of artefact digitisation, motion capture, and knowledge representation. Nevertheless, a **baseline craft representation** can be achieved even with **modest technological resources** and **expertise**, namely a camera, a computer, and an Internet connection and the capacity to operate them.

Capacity-building aims to ensure the widest possible participation of all relevant stakeholders, especially relevant community groups, in the design and implementation of safeguarding activities. In this context, Mingei strives to provide good practice guides and technical tools for communities to manage and promote their content and outreach.

1.5 Limitations

Some simple instructions to a human could be a challenge to artificially achieve. I.e., the task to *"rub this wooden surface with this sandpaper until it feels smooth when using your fingertips"* can be a significant challenge for a robotic system to first understand and then achieve. Understanding of the instruction is achieved by capitalising on common perceptual priors.

A special type of knowledge included in crafts is "felt knowledge" or knowledge that is based on sensory perception of practitioners. This is the **practitioner's interpretation of** her own **qualia**, to perceive the materials and her makings. Examples are the haptic sensation of a material (i.e. plaster dampness of the potter, or roughness of a textile), the sensations of heat and smell (i.e., in the glassmaking process), or the colour of an object, which are exploited by a **skilled** practitioner.

There exist ways to measure some of the physical properties that give rise to qualia, such as humidity, temperature, spectral, and chemical measurements. However, it ought to be pointed out that **a HC practitioner** uses her **own senses**. This is a limitation as technology does yet avail pertinent recordings.

A way that humans overcome this limitation and communicate the way the feel is verbal communication. **Practitioner testimonies and narrations** on their experiences are important and recorded, in the Mingei protocol. Another is though visual art or other types of abstractions. Yet, another way is to obtain **own experiences**. Skill development is facilitated by instruction, observation, and guided practice, (i.e. apprenticeship, tutoring) that leads to **skilled interpretation of qualia**. The Mingei protocol will facilitate the design of **experiential presentations** that avail sensory stimuli and facilitate the **development of craft skills**. The co-design of these experiences with **practitioners** is mandatory for their **relevance.**

In the context of using the Mingei protocol, it is underscored that understanding a craft cannot be a theoretical only task. All of the narrations, documentaries, VR demonstrators cannot recreate "felt experiences". Thus, besides conventional digital tools, Mingei representations include the knowledge for craft re-enactment, though meticulous representation of craft processes and techniques.

1.6 Why do we call our project Mingei?

Mingei is the name of an art movement developed in the 1920s in Japan by Yanagi Sōetsu (1889–1961), and as a term it refers to “peasant or folk arts” or “arts of the people”. The term was coined by Yanagi to refer to “hand-crafted art of ordinary people” and the beauty found in inexpensive, utilitarian objects created by nameless and unknown craftsmen, for the people by the people.

The term can be better understood when considering the earlier Arts and Crafts movement, created about 1880 in England, which focused on the aesthetic value of utilitarian objects. The movement stood for traditional craftsmanship using heritage styles and decoration patterns, against the impersonal, mechanized direction of society during the Industrial Revolution and the relatively low status of decorative arts.

Both movements underscore that craft products have a dual substance. They are usable items, yet at the same time they include heritage that represents a region and its people. This heritage does not reside only in the object as a unique, tangible work of art. Most importantly, it resides in the skills and knowledge that is necessary for its making and the traditions embedded in it.

In contrast to the preservation and study of unique, tangible works of art where individual creation and innovation has the first role, Mingei reminds us of the intangible heritage of collective creation by anonymous craftspeople within the tradition and social context is preserved.

2. Background

2.1 Knowledge representation in the Cultural Heritage domain

Semantic technologies and ontologies in particular are today standard tools that are largely in use in the domain of Cultural Heritage (CH). In fact, there is already a significant history of semantic approaches in CH, since the pioneering work of Europeana, which started to model CH with semantic technologies in 2007. However, all these approaches have failed because they have not identified the right conceptualisation. We can distinguish three phases of the adoption of semantic technologies in the CH sector:

- In the early days, projects have relied mostly on the tradition in library and archival science, and on the relative catalogues and collections, creating or converting descriptions of CH artefacts that were exclusively object- or collection-centric (Minerva, Europeana Rhine, etc.). This required an immense data integration effort due to the heterogeneity of the source descriptions, but produced very poor results on top of which no application significantly innovative could be built. The only supported functionality was the somewhat mythical semantic search, which allowed to ask queries based on semantic categories, but in return produced a list of metadata with which it was not possible to do much.
- In the second phase, 2010-2015, the focus shifted towards richer, event-centric representations, in response to the realization of the drawbacks and scarce utility of object-centric representations. The class **Event** is in fact one of the basic classes that the Europeana Data Model has inherited from the CIDOC CRM, where it is also one of the basic classes. However, this shift has not led to significant improvements due to the fact that building formal representations of events and connecting them to the object-centric representations of the early days was very difficult. Events could not be found in institutional repositories, and extracting them from external sources such as Wikipedia or Freebase did not lead to significant results. In this respect Europeana is a case in point: the class Event was not populated at all in the Danube release of the system in 2011. Several projects have attempted a complementary approach by adopting a purely syntactic, signal-based approach (i.e., audio-visual). In so doing they have been unable of providing a representation rich enough to support significant operations, like combined syntactic and semantic search-browsing-visualization-storytelling.
- Since 2015 we are now observing significant changes. IT has contributed to this new phase in various ways: (1) By providing major breakthroughs in knowledge extraction from texts and other media via deep learning methods, as well as improved signal-processing techniques. (2) By better supporting scalable semantic systems thanks to more solid implementations of semantic web standards. (3) By bringing existing ontologies, notably the CIDOC CRM, to a more consolidated status with higher expressivity and domain coverage. But also EU has made a significant contribution by funding the development of new representations of CH artefacts, based on new digitization techniques, able to exploit the above mentioned technological advances.

The **Mingei** project is a typical product of this phase: its representations are narrative-centric. Mingei relies on a strong conceptualisation, focussed on a notion of narratives that, unlike the previous approaches, exploits both sides of the representation, the semantical (fabula) and the signal-based (the narration) side, and, moreover, combines these two aspects by linking semantic

notions, like events and actions, to the media objects that provide an illustration of these notions. Notice that this illustration is not only to the benefit of the human user, who can extract a lot of knowledge from media objects, but also of the machine that can analyse these signals and learn from them.

Mingei proves the validity of this conceptualisation by providing a new representation of crafts of unprecedented richness. At the same time, Mingei realised important tools that are necessary to use the conceptualisation:

- an ontology that specifies the conceptualisation by providing a vocabulary for it and axioms to fix the meaning of the vocabulary terms in conformance with the conceptualisation;
- the ontology harmonizes in a coherent vision many sub-domain ontologies, re-using solid results in knowledge representation that have now become standards, such as: narrative modelling, based on an extension of the CIDOC CRM with narratological concepts; time, based on the OWL time ontology; process schemes, based on Activity Diagrams of the Unified Modelling Language; content representation, based on the Content in RDF ontology; 4D-fluents for the representation of time-varying properties;
- also the implementation of the ontology is based on standards: the web architecture for identifying (via IRIs), storing and retrieving the basic resources, whether media objects, formal concepts or individuals; RDF as basic data model for knowledge; OWL as ontology web language; SPARQL as knowledge manipulation language;
- an architecture for managing representations based on the ontology (creation, update, retrieval, storage, exchange), based on open-source software implementing the standards at the basis of the ontology
- a rich presentation layer, addressing various kinds of devices and various kinds of users; may expand this
- pilots showing the full potential of all of the above;
- everything obtained with advanced co-creation based methods, in which all the various actors of the scenarios have given their contribution to the development of the system and of its applications.

2.2 Digitisation of tangible heritage

Efforts to standardize the digitization process have been made through digitization projects, providing guidelines on how to digitize books and documents as well as objects and monuments of cultural heritage [13] [14] [15] [16] [17] . Guidelines regarding file management, digital preservation, online publication, and IPR management can be found through the MINERVA EU funded Thematic Network (IST-2001-35461), whose Website and handbook [82] comprise a valuable starting point for these matters, as well as, the foundation of online heritage repositories, such as Europeana.

The appropriate **digitisation modality** is relevant to the **purpose** of digitisation and to the **physical properties** of the asset to be digitised. For example, the creation of a catalogue typically requires a camera. On the other hand, precise metric information is required for the artefact conservation, such as the readings of a laser scanner.

The majority of 3D reconstruction modalities, particularly of-the-shelf-choices, regard **surface** reconstruction. Imaging below the surface is available by specific modalities i.e., multispectral cameras, X-ray, and other. In the usual case, a geometric model represents the surface shape. The spatial representation is parameterised using the XYZ orthogonal and isotropical coordinate system.

A review of the-state-of-the-art on the collection of 3D knowledge on tangible assets, is provided in Mingei-D2.2.

2.3 Digitisation of human motion

Human motion is a key component of many forms of ICH, such as dances, crafts, and rituals. As such, it has been the target of ICH digitisation EU funded projects, such as iTreasures (600676), MODUL DANCE (Moving with Dance Artists across Europe 2010-2014), DANCE (645553), European Theatre lab, and TERPSIHORE (691218). In the context of crafts, human motion is the point where the **intangible** dimensions of skill, design, and know-how meet with the **tangible** dimensions of tools, machines, materials, and artefacts.

Human motion digitisation and analysis has gained particular interest in the last two decades, due to the wide range of applications relevant to ergonomy, rehabilitation, security, sports, human-computer interaction, medical education, robotics, cognitive research, entertainment, and many others. The central goal is to record of the motion of subjects in three dimensions.

Digitisation of human motion has been achieved by a number of methods, which can classified based on whether they require subjects to **wear markers or not**.

A review of the-state-of-the-art on human motion recording technologies, is provided in Mingei-D2.2.

2.4 Digitisation of intangible heritage

Digital content to be presented by Mingei is **heterogeneous**, including **tangible** artefacts, processes, and **intangible** dimensions such as practices, traditions, socioeconomic, and historical events. ICH extends far beyond the digitisation of human activities and the capture of human motion. It includes the representation of **semantic concepts and contextual knowledge**, such as historic, religious, economic, and social. Pertinent efforts have been funded by EU in a series of projects.

One of the most important efforts was the KYOTO (ICT-211423) project which makes knowledge sharable between communities of people, culture, languages and computers, by assigning meaning to text and giving text to meaning. CASPAR (IST-033572) has provided ways of access to and preservation of cultural and scientific resources. CULTURA (269973) has focused on representation of collections heterogeneous data. PATHS (270082) provided methods in exploring collections by creating conceptual paths, linking the items. DECIPHER (270001) paved the way on the presentation of digital collections as part of coherent narratives, which included the knowledge structures that connect them and give them meaning. CHESS (270198) provided ways to create interactive stories for visitors of cultural sites, authored by curators.

2.6 State-of-the-art in craft documentation and representation

In the **humanities**, literature exists on the documentation of specific craft instances [121] [122] . Short documentaries and inscriptions of HCs are registered and publicly available in the Representative List of the Intangible Cultural Heritage of Humanity of UNESCO.

The forms, conservation, and development of crafts have been studied extensively in Asia [119] [117] . China [103] and India [118] have extensive documentation and statistics on multiple aspects. However, while the cultural and ethnographic aspects of crafts have already been the subject of many studies, investigations and publications, their economic and social role in developing countries was only recently acknowledged. Latin America [120] and Africa [116] have undertaken work since two decades now to create craft inventories, such as the "Inventory of material cultures" by in Mali. In [115] , social context, group membership, social relations are reviewed.

More recently, international and nation-wide projects underscore the need for documentation and preservation of CH due to HCs, i.e., the Erasmus+ EU programme Discovering Traditional Crafts across Europe, and the Chinese Craft Project [103] . International projects, underpin the multifaceted nature of HCs and the realization of the need for documentation and preservation of this type of ICH. Indicatively, curated digital collections exist in Europeana related to HCs, such as "Craft work", "Industrial Photography in the Machine Age", "Factories in Focus". The Erasmus+ EU programme "Discovering Traditional Crafts across Europe" has to discovered traditional crafts, some of which are slowly disappearing from today's societies. The Hantverkarens dokumentationsmetoder ("Craftsman's Documentation Methods") Danish National Project develops practical knowledge support for the craftsman's documentation in the field of construction care. Several national projects have been funded in China. The Chinese Craft Project targets promotion and preservation of Chinese ICH and a bridge between traditional and modern craft expressions. Folk art preservation has the focus of national projects in Italy [103] .

Stemming from the 1972 World Heritage Convention concerning the Protection of the World Cultural and Natural Heritage the UNESCO World Heritage List safeguards monuments of tangible heritage. That is, the Convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two. In 1994, the UNESCO launched its Global Strategy for a Representative, Balanced and Credible World Heritage List. This initiative stemmed from a global study carried out by ICOMOS from 1987 to 1993 revealed that Europe, historic towns and religious monuments, Christianity, historical periods and 'elitist' architecture (in relation to vernacular) were all over-represented on the World Heritage List; whereas, all living cultures, and especially 'traditional cultures', were underrepresented.

The Living Human Treasures action of UNESCO contains verbal and functional testimonies that provide insight into traditional craftsmanship. This programme encouraged official recognition to talented tradition bearers and practitioners, thus contributing to the transmission of their knowledge and skills to the younger generations. The programme lasted for a decade (1993 – 2003) and aimed at encouraging Member States to grant official recognition to talented tradition bearers and practitioners, thus contributing to the transmission of their knowledge and skills to the younger generations. States selected such persons on the basis of their accomplishments and of their willingness to convey their knowledge and skills to others. The selection was also based on the

value of the traditions and expressions concerned as a testimony of the human creative genius, their roots in cultural and social traditions, and their representative character for a given community, as well as their risk of disappearance.

UNESCO's Digital Archiving Project has been recording and archiving intangible forms of cultural expressions, including HCs, to preserve the images and sounds of these cultural expressions. The programme offers a wealth of publicly online multimedia archives, where HC are shown to be practiced, documentaries, oral testimonies, as well as, scanned documents and journals. The prominence of this resource is testified by a number of individual projects on HC descriptions that follow UNESCO's principles, according to [81] i.e. "Turquoise Mountain in Afghanistan on craft Traditions" [101] , "National Carriage Factory on Australian crafts" [102] . UNESCO defines a procedure for the inscription of CH elements[2].

Literature of the **preservation and curation of HCs** started to emerge recently, with only a few studies treating the topic in an integrated manner, given its multifaceted nature. Efforts towards appropriate treatment have emerged, through the collaboration of a wide range of experts by UNESCO, providing a theoretic basis towards the representation of ICH [81] . A seminal work in towards **defining a heritage craft representations** can be found in the ICCROM report on Heritage crafts and their conservation [17] . This report is enlightening towards understanding craft dimensions relevant to craft representation. The report sheds light upon the fact that Heritage Crafts and crafts in general, encompass both **tangible** and **intangible** dimensions. This is a central point of departure of Mingei, as it identifies the need to capture both Tangible and Intangible Heritage.

In crafts, **tangible** and **intangible** dimensions are interwoven. Craft is an activity of artefact creation from materials, through the skilled use of tools or machines. The **creation process** includes **manual effort, dexterity, skills, and know-how**. There is a **professional** aspect as to the income obtained from this work, which is related to the quantity and quality of the product. The objects involved in this process can be elements of tangible heritage. Heritage crafts are associated with **contextual knowledge** such as history, tradition, social and economic impact and other that fall in the realm of Intangible CH.

In [113] , before the 2003 ICH convention, UNESCO provided a guide for the collection of **data for the documentation of HCs**. Through is technically outdated (i.e., dates before the invention of digital imaging) and provided travel guidance for the times before the Internet and mobile telephony, it is essential in the **selection of the fundamental elements to be recorded**, specifically for HCs. In that study, craft products are the first topic of interest. Next is the process of craft making, craft roles, and a stepwise **verbal** and **visual** record of craft steps. Third, this study strives to formalise contextual knowledge on trade and promotion of craft products, through economic data. Questionnaire type forms are provided for these three topics, in an effort to formalise and eventually input in a "data bank" (nowadays, a knowledge base, or inventory). Though requiring update as to technological recommendations, the forms in Figure 1 provide clear indication of the **fundamental data topics and photographic documentation to be recorded for HCs**. An important collection of questionnaires is included in this resource, which the interested reader is encouraged to consult. Thus [113] played a significant role in the thematic organisation of knowledge in Mingei.

[2] https://ich.unesco.org/en/procedure-of-inscription-00809

Motivation stems from compatibility with internationally treatment of CH due to craft and the potential of re-use of Mingei CH documentation results.

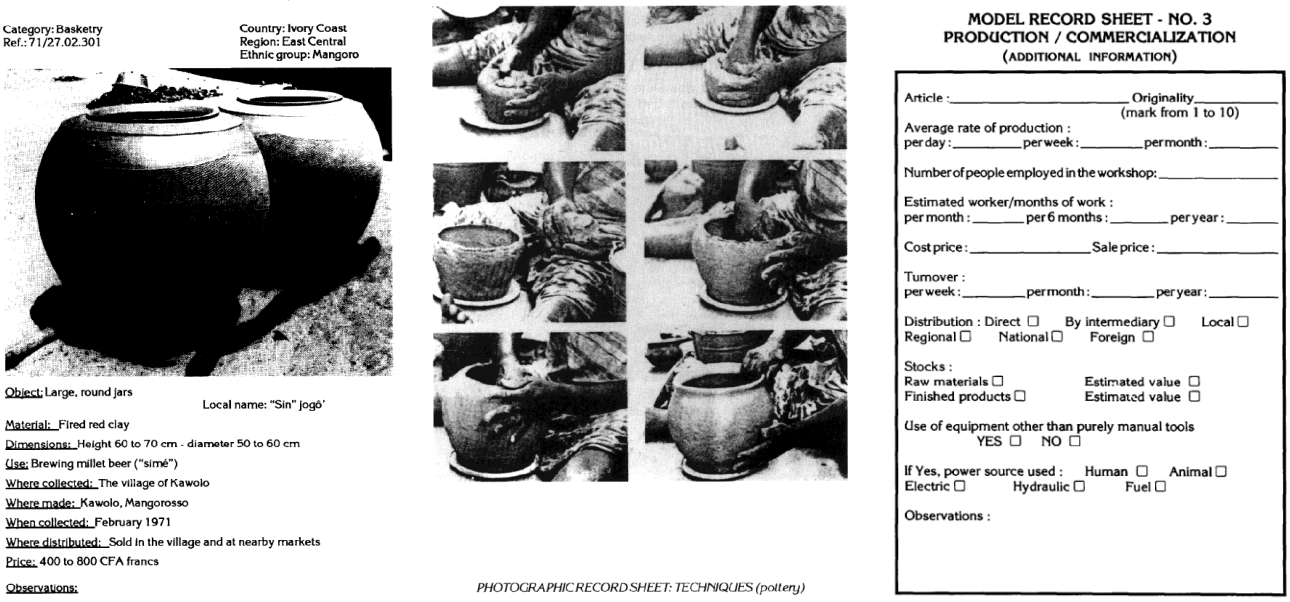


Figure 1. Knowledge collection forms (images from [113]).

In the proposed protocol, [17] and [81] serve as a foundation in understanding the craft dimensions to be represented.

2.7 Intellectual Property Rights

After the UNESCO Convention on 2003, ICH has been recognised as a component of the collective identity of a community or social group. The laws for the protection of tangible heritage have been long established, as property laws were, and still are, directly applicable [154] . ICH stresses the importance of reproduction and transmission of practices for elaboration and adaptation by future generations [151] . In this perspective, digitisation of ICH regards the human activity that drives the production of craft items. As Bortolotto points out there is an extension of the CH domain from monumental to Living Heritage [153] .

2.7.1 Human Rights

The UNESCO Convention considers solely ICH as is it compatible with existing international human rights instruments, as well as with the requirements of mutual respect among communities, groups and individuals, and of sustainable development.

ICH is an element of the collective identity of a community and is related to freedom of thought, conscience, and religion. The relevance of ICH with a collective identity of the community of its bearers is underscored in UNESCO 2003 ICH Convention to provide *"a sense of identity and continuity"*.

Practices in conflict with fundamental human rights are not protected under the ICH Convention. In addition, remorseful past among communities and nations had impact on people's collective memories and heritage. Dialogue and respect, is mandatory to perform objective and scientific work on ICH preservation. In [152] , *"soft laws"* are proposed to support human rights, as a new generation of cultural rights.

2.7.2 Ownership

Starting by the overall, overarching topic of heritage, Kuutma reminds us that, *"heritage is about the regulation and negotiation of the multiplicity of meaning in the past, and it is about the arbitration or mediation of the cultural and social politics of identity, belonging and exclusion"* [159] . Similarly, Machuca mentions that, "*cultural heritage is a product decanted from the living process of culture and has specific historical and social modalities. The concept is associated with that of the historical formation of the modern state and its appropriation processes and notions of public and social property" [162]* . But firstly, how do we perceive the past, and what could this mean to the present in order to preserve something belonging and coming from the past? In negotiating this relationship, Lowenthal suggests that, *"the richly elaborated past feels firmer than the present, for the here and now lacks the structured finality of what time has filtered and ordered"* [161] . The filtering and ordering of the past is made in an individual, as well as collective level. One of the components connecting us personally with the past is the feeling of familiarity with ourselves and our surroundings [161] ; that is, when we feel secure in a familiar environment where our habits can continue and thus we can remember and connect with things of an earlier time. But Lowenthal acknowledges more parameters that apply to the individual, as well as collective level: (a) reaffirmation helps us appreciate traditions, (b) identity which is built through emblems of the past, and (c) ownership which is characterized by the collection of things of the past; the bigger the collection, the stronger the connection of the owner with the past.

But who owns then the past, and which is their connection with heritage and the present? [159] [162] suggested above that there are social politics taking place in this negotiation and usually states take advantage of the past and its considered heritage to build the identity of a nation, and consequently of its inhabitants. But what happens when migration takes place among nations? Whose heritage is then negotiated and practiced in everyday life? Before developing these ideas, it is important first to reveal the distinction (although inseparable) of tangible and intangible cultural heritage. Tangible cultural heritage refers to objects/things (i.e. monuments, scripts, tools). Machuca [162] explains for intangible cultural heritage that it has a two-fold aspect; on the one hand, there can be myths or beliefs that represent a symbolical way of being, and on the other hand, there can be skills and know-how that represent the practical way of being. But, for example, in order to perform rituals or a craft, ceremonial objects, clothing, tools, materials must participate with the performer. Therefore intangible is directly dependent on the tangible, and the other way around. In other words, the tangible is created and/or used through or with the intangible. Cultural heritage then seems to be determined by both its tangible and intangible dimensions to be formed and conserved through the years.

Kuutma [158] further insists that property and ownership of heritage have deeply social and political implications that are denoted in the form of rights that a person or group has. More importantly, she points out that, *"ownership reflects the nexus of specific relationships, but it appears to be easier to understand rights over things that rights between people"* [158] . The rights

over things or people refer to the intellectual property rights that a person or group can claim concerning cultural heritage. Humans, their traditions, beliefs, practices and know-hows are the centre of intangible cultural heritage. They are a 'living heritage'. Preservation of the intangible is what makes the preservation of tangible even more valuable for the history of communities. In other words, "diversity of culture reflects diversity of peoples; this is particularly linked to intangible cultural heritage, because such a heritage represents the living expression of the idiosyncratic traits of the different communities" [160] .

Regarding the issue of geography, Bortolotto [157] offers two aspects where spatiality is negotiated when heritage is concerned. More specifically, she refers to problematic aspects of the 2003 UNESCO Convention for the Safeguarding of Intangible Cultural Heritable. As she mentions, *"on the one hand, [spatiality] refers to the area defined by the relationships between human and non-human actors, in which heritage is situated, and with which it interacts at cultural, aesthetic, historical and/or anthropological level.…On the other…space has a political connotation, in connection to the geographical region bounded by national borders"* [157] . As she concludes, these spatiality aspects are particularly problematic for a Convention that wishes to safeguard intangible cultural heritage in a worldwide level because when, for example, an intangible practice appears in several geographical areas (either by indigenous development or by cultural diffusion) and the states involved are confronting each other, problems arise because the identity and heritage of a nation is negotiated [157] .

Referring back to 'living heritage', it is important to explicitly note the fact of constant recreation that characterizes the intangible aspect of cultural heritage. To explain better this aspect we will refer to Kuutma [158] where she speaks about the Seto community in Estonia and the tradition of *leelo* singing. *Leelo* traditional singing was originally transmitted through the parents, and composed and performed by a lead singer. If others would start singing along, then the creator was recognized and approved by the community. Nowadays, because of cultural changes in the overall Estonian community, *leelo* learning and singing has taken a rather exclusively collective aspect from its beginning; that means, *leelo* is performed nowadays in a choir and is approved by committees. Furthermore, in the past the lyrics that are instantly created were inspired by the occasion taking place. *Leelo* was performed in everyday life, or publicly for the village, and on special occasions such as weddings. Today *leelo* has become a trademark of traditional singing (it is also inscribed in the UNESCO List of Intangible Cultural Heritage) and is thus performed in festivals. This example outlines a recreation of an intangible cultural heritage that has faced transformation through the years, on the one hand, regarding the content of its lyrics, and on the other, the relation between its individual and collective levels.

2.7.3 Agency and Appropriation

IP issues on ICH intersect with issues relevant to who has the agency for to create documentation and how it is generated. For this reason, the ICH 2003 Convention dictates the participation of the bearing communities in the documentation process. Still, even when documentation is generated in a fashion respecting the community from which it is derived, its use by people outside the community can still be problematic [163] .

Cultural appropriation and commodification of traditional knowledge are recognized issues in the field of ICH [164] [165] [166] [167] [168] .

When these take place outside the community of practice, it raises a question of ownership and the rights the originating community may hold over it [155] . Moreover, ICH presentation outside the community may give rise to appropriation issues, if the originating community would regard the medium or context of presentation objectionable [155] .

Archaeological artefacts and sites have long served as symbols of national identity. Archaeological sites constitute the physical manifestation of cultural heritage of all human societies – they are not only cultural heritage but also intellectual creations [169] .

2.7.4 Legal frameworks

There are three kinds of property: (a) property consisting of movable things, such as a wristwatch or an automobile; (b) immovable property, namely, land and things permanently fixed on it, such as houses; and (c) intellectual property, such as creations of the human mind and human intellect. Because it is a product of the human intellect, this kind of property is called “intellectual” property [170] .

As with cultural heritage, there are various types of intellectual property. Intellectual property is usually divided into two branches, namely “industrial” property and “copyright.” Patents, registered designs, and trademarks are referred to as industrial property rights, because they are associated with industry and commerce. Copyright relates to artistic creations, such as poems, novels, music, paintings, and cinematographic works [171] .

There is already a significant amount of research and discussion on issues surrounding intellectual property, ownership of cultural materials and intangible heritage. IP laws for the protection of ICH have been a topic of ongoing investigation [172] [173] [174] .

Once authors of joint works are recognized, group rights were recognized in order to enforce the individual rights of the authors in a group.

2.7.4.1 Challenges

A component of difficulty is the plurality of national legal systems [175] .

IPR is often in conflict with collective ownership of ICH. Though a traditional item is the creation of an individual, the knowledge to create it was transmitted as Heritage from previous generations. Granting IPR to a specific person is unsuitable for collective cultural phenomena, as practitioners feel of such rights belonging to the whole community. Issues in invoking IP laws for the protection of ICH have risen due the orientation of pertinent laws upon individual rights rather than collective or community rights [176] .

Another issue that has become a matter of debate is the definition of what is public domain. The definition of WIPO is *“the scope of those works and objects of related rights that can be used and exploited by everyone without authorization, and without the obligation to pay remuneration to the owners of copyright and related rights concerned – as a rule because of the expiry of their term of protection, or due to the absence of an international treaty ensuring protection for them in the*

given country" [177] . If traditional knowledge comprises "public domain", then it may be freely used.

Conversely, communities oppose that their tradition is "public domain", but their own heritage. To this end *"Indigenous people are entitled to the recognition of the full ownership, control, and protection of their cultural and intellectual property. They have the right to special measures to control, develop and protect their sciences, technologies and cultural manifestations, including human and other genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral tradition, literatures, designs and visual and performing arts"*. [178] (art. 29)

Despite the apparent efficiency of these measures for the protection of intangible cultural heritage, in the specific case of traditional craftsmanship, they risk privatizing something that does not belong to a specific person, but rather to a community or a group of people. Even if craftsmanship is held by individuals, these holders are not the only owners, because this cultural heritage is settled on knowledge, cultural capital, and natural resources that have been accumulated, maintained and passed on through several generations.

2.7.4.2 Collective Intellectual Property Rights

In the literature, solutions such as collective trademarks granted to representative entities have been proposed [179] . A number of countries have own legislation for the protection of traditional expressions. However, no uniform scheme has been so far adopted at the international level. Paterson and Karjala conclude that, "traditional concepts of Western law – contract, privacy, trade secret, and trademarks – can take us a long way in the desired direction" [150] .

The global community today is inclined towards the legal protection of cultural heritage as intellectual property [171] . The scope what is considered IP today is much broader than recent years. Several states already provide specific legal protection of traditional cultural expressions as intellectual property in their national laws or regulations.

Upon this issues, in [180] a people's stewardship system is proposed, which is been gaining ground during the last decade in the CH communities. The insight into a cultural commons provides a new framework for the governance of traditional craftsmanship, alternative both to private exploitation and to State intervention [171] . Intellectual property rights, copyrights, patents, trademarks, and trade secrets allow their owner to control the use of intangible resources, contribute to remunerating the creator, and incentivize new researches and creations [181] .

So far, Collective Intellectual Property Rights (CIPR), like Geographical Indications and Collective trademarks [183] seems to be the more appropriate measure fitting the characteristics of traditional craftsmanship and the structure of their ownership. CIPR attributes the control and the ownership of these complex skills and knowledge to a community or a group of people. Therefore, this collectivity is enabled to defend its craftsmanship, as well as to use, maintain and transfer it. If CIPR seems to be a very suitable measure for the safeguarding of traditional craftsmanship, its practical functions presents some limits. In fact, to work properly, they have to be linked to something more precise than the craftsmanship, e.g. a production process, a brand, or a sale point [182] .

2.6 Contribution of the Mingei protocol

Despite the **cultural significance**, the need for **preservation**, the extensiveness of **HC related tourism**, and the pressing **educational needs**, efforts for HC representation and preservation are **scattered geographically and thematically**. Challenges include the wide span of HCs in **tangible and intangible** dimensions, as well as, their **multiple**, contextual, geographical and temporal **dimensions**.

In contrast to other domains of CH,

- a **systematic** way of documentation and
- a **semantic** representation of knowledge

due to craft as CH, are **not defined**. **Missing** is a systematic way to collect, discover, and organise the required knowledge for a digital representation of craft that links together multiple resources that may be already available, with new ones.

This **does not mean** that

- HC documentation does not exist. As reviewed in Section 2, a vast amount of effort has been, and is being, devoted to this topic.
- HC documentation guidelines do not exist. As reviewed in Section 2, some guidelines and theoretical taxonomies of knowledge have been published.

Based on the legacy of prior work, the Mingei protocol contributes with:

- Guidelines on representing more craft dimensions than state-of-the-art approaches, by including the representation of tangible and intangible HC dimensions.
- Establish **representations of HCs** that associate **digital assets** and **semantic annotations**.

Novelty and innovation are identified as follows.

- A tractable, step-by-step **method for craft representation** and digital preservation for HCs.
- A systematic way to **associate heterogeneous knowledge** components related to craft as CH.
- A method to digitally **represent knowledge** pertinent to HCs.
- Content-based **annotation**, **understanding**, and **retrieval** methods will be provided for knowledge elements related to a HC. These elements include historical evolution, geographical, and contextual knowledge, contributing to CH research.
- A system and guidelines to author **narratives** that present a comprehensive picture of a craft.
- A method to **present** HCs in **multiple formats** required for HC *inscription*, *educational material*, *storytelling*, and the provision of experiential ways to *access* HCs.
- Tools for creating **experiential presentations**, for HC conservation and safeguarding, education, and thematic tourism, based on the represented content.

Multiple information types, people, and disciplines contribute to the collection of knowledge for a HC representation, as well as, the provision of instructions, guidelines, and best practices. The

Mingei protocol provides a **blueprint and practical instructions** for this **collaborative effort**. The proposed protocol defines the **format, order, and interdependence of steps** for achieving a HC representation, such as the acquisition of digital assets, the acquisition of contextual information, as well as, the semantic annotation and linking of digital assets. The goal is to **represent knowledge** about a HC in a **meaningful**, **preservable**, and **usable** fashion for stakeholders. The use of diverse, yet complementary, pilots on HCs will necessitate a generalizable and extensible protocol.

3. Overview of approach: The Mingei HC Representation Protocol

3.1 Where does the protocol come from?

During the FP6 Programme of the EC, the MINERVA digitisation programme and several other projects that continued its legacy (see Section 2.2).

The **first generation** of digitisation projects focused on the digitisation of tangible heritage, first in 2D and more recently in 3D. In these approaches, digitisation meant the faithful representation of the material properties. Digitisation regards the "factual" occurrence of an object, as a material event, with measurable dimensions and material properties. Today there are still open challenges, such as multispectral and multimodal digitisation, as well as the digitisation of non-Lambertian materials, including transparent and translucent ones. The boost of technological capabilities obtained from this has facilitated the work of curators and Heritage Professionals, in documenting assets and made possible the development of online repositories of shared and semantically interlinked content. In the particular case of information carriers, such as historic documents, digitisation regarded material part of the item. The digitisation of the "intangible" component reached up to OCR transcription, without accessing the semantics of the digital text.

The **second generation** of digitisation projects touched the topic of intangible heritage digitisation. These projects focused mainly on the digitisation of CH due to the performing arts. As in the first generation, the focus was on the faithful recording of human activity, in terms of motion and audio. As such, when we talk about the digitisation of performing arts, we refer to audio, video, or 3D motion digitisation. Like in the case of tangible heritage, the expert commentary (i.e., whether it is a dance or poem of cultural significance), is left to the expertise of the curator.

Like in the case of OCR for the transcription of photographs of text into digital text, one could think of "transcribing" meaningful articles of activity from the recording. For audio, this is what speech recognition or musical transcription do. However, not all performing arts have established a notation, to transcribe performance. The example of Labanotation, is characteristic. Labanotation a notation method for human motion. It is not the only one. Other examples include notations by Stepanov (1892), Schillinger (1934), and La Sténochorégraphie (Saint-Léon, 1975). It could be possible to devise geometrical mappings from generic, continuous 3D motion representation (i.e., 3D coordinates) to such symbolic notations. Whether this would be helpful, is answered by weak usage of the notation in practice, as dancers do not find Labanotation intuitive and, thus, difficult to use.

Mingei follows all of these principles as its legacy. Cultural Heritage due to crafts occurs in both tangible domains. We, thus, treat crafts adopting the digitisation principles by which CH has been digitised in the past and propose new ones for intangible aspects not digitised in the past. Methodologically, we treat crafts as a performing art with a tangible outcome. In particular:

- We treat digitisation of craft products, by tangible heritage digitisation principles.
- We treat digitisation of the physical activity of the craftsperson, by intangible heritage digitisation principles.
- We treat digitisation of knowledge on craft processes, by the generic formalisation of processes.

- We propose novel ways to represent contextual information, through the representation of socio-historical information as narratives.

3.2 Craft dimensions

In the literature, CH is often distinguished between tangible and intangible. Though crafts are considered intangible heritage, the way that this heritage is manifested is through matter and, in particular, its transformation into articles of craft. As noted in the UNESCO page on Traditional Craftsmanship *"Traditional craftsmanship is perhaps the most tangible manifestation of intangible cultural heritage"*.

In this context, we look at craft dimensions closer, in order to better understand the content we need to represent. In particular, we also follow the Tangible / Intangible distinction, but also look closer at the space and time where these two meet. We thus propose the following refinement, as illustrated in Figure 2.

Artefacts, tools, and sites, belong traditionally to the **tangible** domain. As such they are physically transmitted in time through preservation, conservation, and restoration processes. They are digitally documented using words, photographs, and 3D digitisation. Typically, digitisation of tangible heritage regards artefacts and sites and is of **static** nature.

Intangible heritage is well defined in the UNESCO 2003 convention and better specified for craft in [17] . In the intangible domain of crafts, we find "meaning" such history, collective memories, values, and aesthetics and "processes" which refer to the way of making craft products, *in the context of a community*. Intangible heritage is regarded as an intellectual process that is performed by living humans. It is often referred to as "Living Heritage" and is preserved through documentation, safeguarding, transmission, continuation, and development.

We call the area between the tangible and intangible dimensions, as the **"Make"** dimension. During a creation event matter is transformed into craft articles. This transformation is achieved by the actions of a person. The way of creating the artefact or the motif of its decoration may refer to an intangible domain, as it may, for example, depict a story of oral tradition or a regional symbol. To implement this transformation the human uses tools and performs actions. These actions are continuously gauged by the senses of the practitioner, who takes decisions during the crafting process. This area include is relevant to **dynamic** scenes and is relevant to dimensions found in the performing arts, such as human motion. We thus approach the creation event as **a performance with a tangible outcome**.

	Matter - Tangible	Make - Perform	Mind(s) - Intangible
Scope	Objects & spaces Documents Recordings	Physical events, Embodiment, Senses, Qualia, Perception & Action, Gestures, Dexterity, Skill	Process, Method, Know-how History, Tradition, Identity, Values, Significance, Aesthetics
Physical Content	Pieces, Tools, Materials Workshop & Environment Content carriers	Craft practice, tool usage, techniques, machine operation	Literature, Testimony, Instructions Verbal & Visual & Semiotic content
Recordings	Objects & Environments Material scan Photograph, 3D, material	Actions & Events Dynamic scan Recordings of performances	Semantics and Semiotics Thick Representation Cause & Context, Narratives & Icons
Transmission	Preservation Conservation Restoration	Ethnography, Choreography Apprenticeship, Training Education, Re-enactment	Safeguarding & preservation Documentation, conservation, investigative knowledge discovery
		Present Exprerience	Past & Future Memory & Imagination

Figure 2. Craft dimensions (image from [184]).

3.3 A step by step approach

The proposed protocol can be described as a series of steps (see Figure 3). In STEP 1, we wish to acquire documentation in the form of digital assets that relevant to the representation of a craft. Based on these assets, knowledge about a craft will be formed (STEP 2). This knowledge is to be semantically represented availing a digitally preservable representation of a craft (STEP 3). This representation will provide the foundation for curating narratives (STEP 4), which are to shape the presented content. This content is to take the forms of informational tools, multimodal presentations, and experiences (STEP 5), which will be used for the purposes of HC preservation, Tourism, and Education (STEP 6).

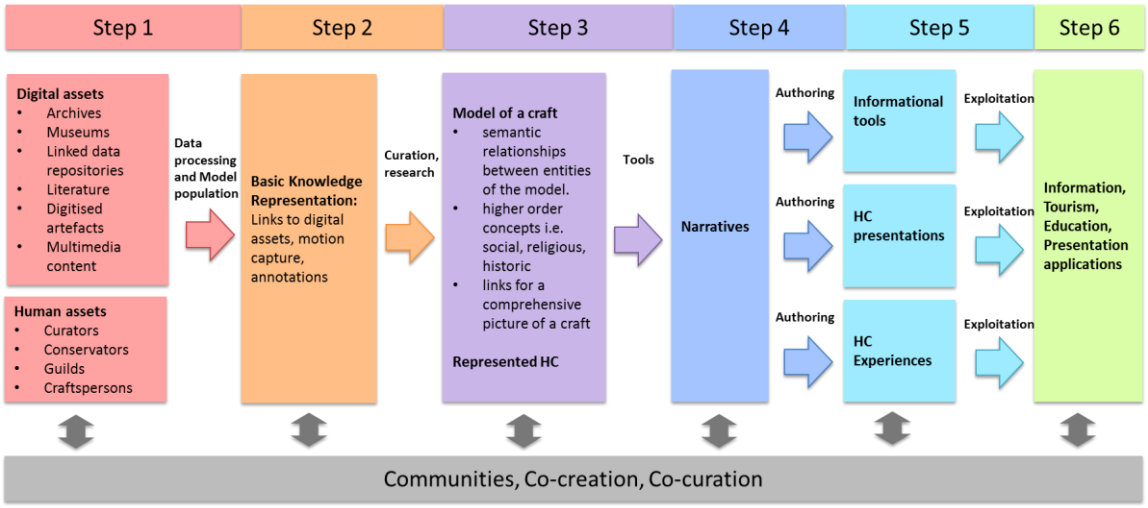


Figure 3. Illustration of protocol steps (image from [184]).

Executing the steps of the protocol linearly would mean that the entirety of digital assets would be acquired a priori. However, it is possible that knowledge acquired in the second step may refer to non-digitised items, which are only then identified, and may needed to be digitised as new digital assets in the context of the first step. Moreover, additional, more sophisticated digitisations of an asset may be acquired later on, if judged so by CH professional. Thus, although the flow of information is presented linearly in these steps, it is executed **iteratively** by revisiting earlier steps, as new insights are obtained, through knowledge collection, curation, and broadening of involved stakeholders. Thus, the protocol allows the iterative revisit of previous steps and the enhancement of their outcomes. The steps shown in Figure 3, illustrate the input required for each step and the result obtained when completing it.

The **first steps** of the protocol are relevant to **representation and conservation**, while **applications** created in the latter steps of the Mingei protocol contribute to craft **preservation**. For this reason, Steps 1, 2, and 3 are planned to occur in iterations, potentially leading to the continuous collection of new knowledge and data that continuously enhance the HC representation. Moreover, the curation of an object may take an **arbitrary amount** of time, i.e., because research might be needed to date an artefact or to discover its creator. As digital assets should be able to be **directly used** by a basic HC representation, the Mingei protocol allows updates of descriptions.

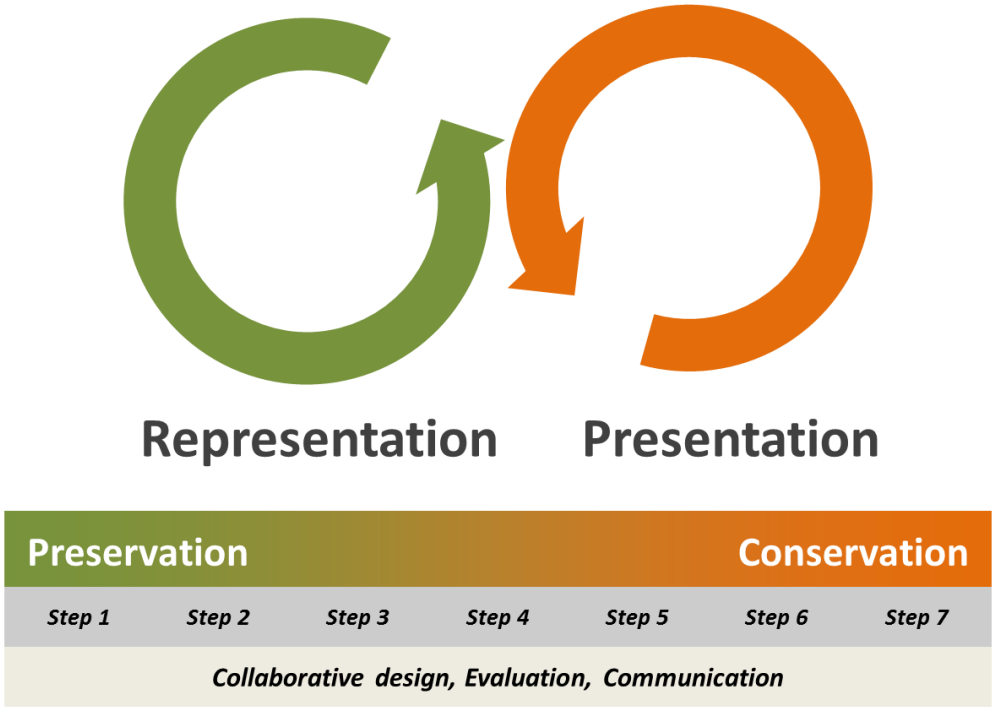


Figure 4. Craft representation and presentation are iterative processes in the Mingei protocol, relevant to preservation and conservation of HCs (image from [184]).

3.4 Working with communities

Communities are at the heart of safeguarding intangible cultural heritage The 2003 ICH Convention places communities at the centre of all its safeguarding activities and requires prior and informed consent of the community or group concerned. Community involvement is required in the

preparation and implementation of safeguarding programmes who must be willing to cooperate in the dissemination of best practices.

Collaborative creation, or co-creation, is the catalyst for finding out what is significant for craft representation among CH professionals, craft practitioners, and other stakeholders. Among them, technical partners can provide ways or identify limitations on what information can be digitised and represented, based on the available resources. As the execution of the three steps is iterative, collaborative implementation of the protocol is too. In other words, co-creation sessions can be used to revisit and deepen a basic understanding or craft description.

The Mingei protocol maps the contribution of **human resources** and **stakeholders**, proposing its collection through workshops, co-creation activities with stakeholders, and collection of testimonies from LHTs. Co-creation: (a) runs through the life-cycle of the project and provides insight and initial pointers to guide knowledge collection and (b) entails activities, whose goal is the optimisation of collaboration and knowledge sharing among partners of different backgrounds.

3.5 How is a HC represented?

The Mingei project proposes a craft model that captures craft and that is accessible and retrievable to human users and that it is also machine interpretable. Though useful for documentation and inventory, it is not sufficient only to document knowledge elements as records in a data base. Rather we represent its context of practice through time, the expression of local tradition with a local craft instance, the impact of a craft instance in the lives of people of a region, and in the relevance of a craft instance to the history of a place or region.

The Mingei representation regards **craft instances**, that is, the expression of a craft at some regions and during a time interval. Crafts are continuously **evolving** due to a wide range of factors that include technological progress, economic interest, material availability, fashion or artistic trends, and other. **Craft evolution** can be modelled by multiple craft instances, which may share characteristics.

This presents the Craft Ontology (CrO for short) developed by the project Mingei for the representation of craft instances. CrO is an application ontology [131] obtained by integrating several existing ontologies, notably:

- the CIDOC-CRM, a top ontology and an ISO standard forming the conceptual backbone of the CrO;
- the Narrative Ontology [133] , a domain ontology focussed on the representation of narratives;
- the FRBRoo, a domain ontology for bibliographic records, resulting from the harmonization of FRBR with CRM;
- OWL Time, a domain ontology recommended by W3C for the representation of time.

In addition, CrO includes extensions to the above ontologies needed to model specific aspects of reality relevant to Mingei, such as for instance event schemas.

CrO also uses the Semantic Web languages for modelling knowledge, in particular the:

- Resource Description Framework (RDF) for basic knowledge representation;
- OWL 2 DL for ontology modelling;
- Simple Knowledge Organization System (SKOS) for expressing terminologies;
- XML Schema for datatypes;
- RDF Content ontology for text modelling.

For the implementation of the knowledge base, Mingei uses on ResearchSpace, a cultural heritage research platform that introduces modules for CIDOC-CRM compatible data creation and access. The ResearchSpace platform supports a wide range of resource types and provides features that support CH research, including a **Semantic Web Database** a semantic database system which can be used to define and share knowledge patterns with the community. The platform provides **semantic search**, based on contextual relationships, to implement search on the represented knowledge. The representation **conforms to internationally established standards in the CH domains**, in order to re-use and complement existing online repositories and enable the re-use of new content created by Mingei.

The Mingei representation, through the CRM, offers several properties for contextualizing events. These properties can be grouped as: **Where** and **When** an event happened, and **Who** (persons) and **What** (things) were involved in it. This representation is formatted so that it can be presented through multimodal narratives. The narratives are of several types, for users with stories of different length, cultural depth and narration language.

3.6 How is the representation created and accessed?

A collaborative approach is followed in collecting and creating knowledge, to ensure that complementary stakeholder perspectives are included in the representation. An online platform, the Mingei Online Platform (MOP), provides authoring access through an online, Web-based GUI. This GUI facilitates this process and user collaboration, allowing different access roles. Thus contributions are provided online, in order to:

- enable collaboration of multiple contributors, including communities and experts from multiple disciplines
- maximise the outreach to the general audience, particularly in the technical domain of mobile computing which is becoming increasingly wide-spread

The presentation modalities used by Mingei pilots, access this representation to retrieve content. Besides access through pilots the Mingei knowledge base serves as a **repository of knowledge** which can be collaboratively and increasingly enhanced. The CrO conforms to the best practices for semantic interoperability, in the context of the Linked Data paradigm that the Mingei project adopts for the data that it collects or creates to reach its objectives. A policy followed by Mingei for assigning International Resource Identifiers (IRIs from now on) to the resources it manages. The policy is given by the following principles:

A new IRI from the Mingei namespace is minted for every resource referenced in the Mingei Knowledge Base. This IRI will have the form:

http://www.mingei-project.eu/resource/N

where:

- http://www.mingei-project.eu/ identifies the Mingei namespace, and
- N is a unique progressive number, identifying this resource in the Mingei namespace.

In this way, each resource is assigned a unique number N, regardless of the class where the resource belongs, which gives rise to a unique IRI. For the resources that are "popular" and have other identifiers in Wikidata, in VIAF or in any other knowledge base, connective links are asserted in the Mingei knowledge base.

3.7 What is the format of a craft representation?

Human comprehensible representations are not limited to text or verbal communication. Visual aids, such as maps, diagrams, illustrations, and animations are valuable in the transmission of knowledge. Demonstration and simultaneous explanation of the visual content is a very informative way to obtain understanding of manual processes and is often contained in documentaries of craft practice. This Mingei **representation** exhibits:

- **Machine interpretability** and formal definitions are required to implement solid and reliable knowledge bases that can support not only inventorisation, but search and collection based on content, context, and semantic interpretation for CH research.
- **Human comprehensibility** is achieved by appropriate rendering of narratives that are based of this representation.

3.7.1 Communication of craft knowledge

Instructions and stories require the perception and imagination of their receivers and, in the case of instructions, their judgement as well. The communication of both instructions and stories include verbal and visual descriptions.

This communication most often entails an abstraction, meaning that it contains only the essential information for comprehension of the story or instruction. In the case of an instruction, such as *"rub this piece of wood with a sandpaper, until it is smooth",* includes detailed actions (find sandpaper, hold sandpaper properly, locate wood, repeatedly rub sandpaper on wood, sense wood for smoothness, etc.) that are abstracted from the verbal content, as the received is expected to share the same contextual knowledge with the sender.

Verbal descriptions (of relevance to Mingei)		
Medium	***Encoding***	***Abstraction***
Oral and written tradition	**Verbal** Spoken and written words, literature, legends, and myths.	Comprehended words are used to mentally re-create the stories told in these words.
Instructions	**Verbal and visual** Spoken and Written words, Books,	Comprehended within the craft context and

	Comics, Leaflets, Demonstrations, Tutoring	referring to the set of craft objects, gestures, and processes.
Scripting	**Code** Punched cards, music score, point paper design	Script is code that describes the intended interaction with the machine interface. Code increases repeatability and production.

Besides language, visual perception has been employed in the description of locations, events, and processes. In contrast to photographs, **visual descriptions** (i.e., drawings) provide an **abstraction** or summarisation of a scene or event. The table below shows this relationship between visual descriptions and recordings.

We call **a visual abstraction** a visual asset, such as a drawing on an animation, which encapsulates events lasting more than one moment, usually at a single location. A visual abstraction can be a manipulation of realistic imaging, so as to facilitate its understanding.

Visual descriptions		
Medium	***Abstraction***	***Techniques***
Drawings	Space and structure	Pictorial cues to depth, i.e., perspective, shadow.
	Time	Artistic depiction of scenes and motion.
	Spatial overview	Artistic (cubism), technical (map, top, bottom views).
Comics	Time and space	Juxtaposed frames, artistic depiction, visual annotation, text and combinations of the aforementioned techniques.
Recordings (mainly visual, no abstraction)		
Photography	Time instant	
Video	Time and space interval	
3D scan	Spatial region or volume	
Motion scan	Time interval	

Verbal communication assumes that the sender and the receiver share the perceptual systems of the same type. All basic senses (touch, vision, hearing, smell and taste) can be relevant to craftsmanship. Additional senses that have been discovered in the last decades are also relevant:

- **Balance**, equilibrioception, or vestibular sense is the sense that allows an organism to sense body movement, direction, and acceleration, and is critical in attaining and maintaining postural equilibrium and balance.
- Proprioception provides information on the movement and relative positions of the parts of the body.

- **Thermoception** is the sense of the flux of heat or cold at the skin and internal skin passages.
- **Hygroreception** is the ability to detect changes in the moisture content of the environment.
- **Chronoception** refers to how the passage of time is perceived and experienced. **Chronopeception** has not been associated with a specific sensory organ.

3.7.2 What is the content of a craft representation?

3.7.2.1 Craft practice

Digitising an activity is a way to record the action on materials by hands, tools, or machines to make artefacts and products. This recording is usually human comprehensible (i.e. video) or can be visualised (i.e., skeleton visualisation of MoCap recordings). Optimally, the recording contains a verbal **explanation** of why actions take place in a specific way and **instructions** are provided for an **apprentice** to follow.

Description of craft practice is relevant to the actions that practitioners perform. By **descriptions of craft practice** we mean the content that a person would communicate to another, in order to describe an experience or to instruct upon the performance of a task. This type of communication assumes a common code or language, i.e., such as verbal communication, demonstration or illustrated instructions. As such the treatment of **language** takes into account both native tongue and craft-related vocabulary.

Verbal communication or description is not the only way knowledge is transmitted. Illustrations contribute in this effort and are often used to convey tasks or situations, beyond language and for a very broad variety of uses (i.e., illustration of aircraft safety or furniture assembly instructions). Demonstration of the master for the apprentice is also central in informal craft education for centuries.

Following verbal or visual instructions, assumes the ability of the receiver to perceive and interpret the environment in the same way. The semantic representation of craft thus requires the understanding and utilisation of both verbal and visual content.

3.7.2.2 Craft context

By contextual information we mean the aspects associated with a craft instance, which describe the history of the craft, its local community, at a time period.

Stories that provide context assume the possibility of the student to mentally recreate the described situations and environment of the plot.

Descriptions, is usually verbal content that anthropologists, historians, ethnographers, sociologists, and economists would write of say, about the studied craft instance. Additional content such as visual or audio is also essential in the understanding and documenting this content. The wide multdisciplinarity of the required theoretical expertise underscores that craft is not an isolated activity by a compelling activity of society with multiple types of impact.

In Mingei we semantically represent context in the above domains. In this case, digitisation refers not only to the digitisation of verbal content as digital text, but also to the semantic representation of contextual knowledge.

3.7.2.3 Meta-data

Each digitized asset is endowed with several kinds of metadata (descriptions) each characterising a specific aspect of the asset and supporting the corresponding set of functions. Depending on the asset and on the role the asset plays in the craft process, the following categories of metadata will be collected and represented in the Mingei repository:

- **Technical metadata**, describing the digitization process and the resulting digital object from a technical point of view, such as employed digitisation techniques, tools, equipment, algorithm, and place, date, actor of the digitisation; format, size, and other technical parameters of the produced digital object. This description can be expressed in terms of a standard such as the Ontology for Media Resources [49] .
- **Semantic metadata**, describing the object from the CH point of view, that is in relation to the craft process, its steps, actors, tools, materials, and the like. This description will be expressed in the CrO Ontology developed by the project.
- **Descriptive metadata**, describing the object for interpretation or discovery purposes, such as title, various forms of textual descriptions possibly in different languages, classification of the object in relevant terminologies, keywords and phrases, and the like. This description will be expressed in avoice standard bibliographic format, such as Dublin Core.
- **Preservation metadata**, describing the object for the purpose of preserving it in the long-term. Such description will be expressed in terms of a standard preservation ontology, such as the ISO Reference Model for an Open Archival Information Systems [50] .

This comprises all the factors and characteristics which define the craftwork article and give it an identity. It must also be concerned with the worker who creates it and the context of its production, distribution and commercialization. It also deals with the craft workers' social, economic and political environment. For each investigation, the main thing is to know which of these facts it has been agreed to record.

3.8 Intellectual property management and protection in Mingei

As reviewed in the literature IPR management and ownership is a perplex topic and a not fully solved one yet. Our approach towards this is the following:

- Inform contributors on the type of licenses they have at their disposal and their impact in the ways that their contribution may be used.
- Enable contributors to select the license under which the avail their contribution.

In Mingei, the aforementioned licenses regard the six types of Creative Commons licenses[3].

[3] The types of CC licenses usage https://creativecommons.org/licenses/

As the Mingei Online Platform is a collaborative platform, our solution is to annotate every contribution to the knowledge base with an appropriate licensing scheme as identified by the contributor. This is supported by the IPR schema of our underlying representation through the CIDOC-CRM. In this way, access to content can be rules by appropriate permissions regarding the intended use of the content.

At the same time, there is an EU legal framework for personal data protection (GDPR), the Mingei tools provide the possibility of anonymization. On the other hand, we found out that the majority of contributors wish to be acknowledged, particularly if this is regarded as a professional merit. For this reason we have create two types of informed consent. The conventional where data are anonymised (i.e., faces are blurred, voice are distorted etc.) and the one that complies to the recommendation of UNESCO for Living Human Treasures.

4. STEP 1. Human resources and digital assets

In this step, we select the topics that will be researched and eventually transformed in digitally represented knowledge.

4.1 Orientation

This orientation regards to a great extent the use of the acquired assets and collected knowledge. The collection of knowledge some orientation is required that is to be communicated even to technical members of the craft digitisation team.

We recommend that before a digitisation and representation effort is planned that a basic orientation is achieved on the topics of the craft instance, the community, and the location. In this way, prior work and collected data provide a foundation, for the understanding of basic concepts and facts about the craft instance. Prior knowledge on the topic can be a motivator and facilitator of discussions with practitioners. This type of preparation, also called “desk research” or “secondary research”, is recommended as a point of departure. In this context the following basic concepts are recommended for familiarisation.

- Handicraft practice and craft roles.
- Identification of craft community and stakeholders.
- Relevant contextual knowledge in the domains of social sciences, history, economy, and culture.

Literature regarding crafts is available in a plethora of online resources. Encyclopaedias can provide generic context, but also provided references to the original sources and literature. An encyclopaedic background establishes a preliminary orientation, including a vocabulary of basic terms. From this point of departure, further research can provide documentation, bibliographic assets, and online resources. Valuable starting points for this task are Encyclopaedia Britannica, Google Books, the UNESCO Digital Library, and the UNESCO Intangible Cultural Heritage portal, where the repository of inscriptions of the items Representative List of the Intangible Cultural Heritage of Humanity can be found. Literature survey should include results of heritage projects, scientific journals, and scientific literature. We comment that although Wikipedia is not a reliable source for citations, it is quite useful in retrieving basic information such as photographs of monuments, addresses, and so on, which are in most cases available through a Creative Commons License.

Digital assets in online repositories may already exist in digital format. Relevant resources include portals and online communities relevant to the craft and can help discover new stakeholders. Valuable starting points for this task were found in Europeana, the UNESCO World Heritage Centre, the UNESCO Intangible Cultural Heritage portal, and the Google Arts and Culture portal. Before starting another collection of data, it is important to map and consider utilising existing digital assets.

More specific sources stem from curated material on expressions of the craft or similar expressions of that craft in other places and times. These can be museum guides, catalogues, magazines, essays, theses and studies. Photographs and illustrations in literature or photographic collections

(museums, newspapers, information services, travel books), as well as video (documentaries and ethnographic films), are useful for a prior understanding the creation process.

Background or context survey can also involve the **consultation of local experts as consultants** that are available to participants for obtaining general knowledge and get better sense of the scope of the subject. Identification of experts and participation in background research can provide an objective expert view on the craft.

4.1.1 What are the elements of interest?

In broad terms the digital assets to be collected are relevant to the following topics:

- The craft practice, which involves physical items, actions and processes
- The craft context and any related activities
- **Physical items** may refer to materials, artefacts, and manufacturing tools or machines, protective or traditional clothing relevant to the craft, and the physical environment or workshop. The representation should capture the both the physical nature as well as the semantic of role and use of these elements in the craft instance. Individual artefacts that are of significance (i.e., historical) should be identified.
- **Actions of craft practice** refer to the use of hands, body, tools, and materials. **Craft processes** are sequences of actions, often including decisions and include curated explanations of workshop geography, mapping of activities, context, and linked processes. Both in [81] and [113] the documentation of the craft tasks as fundamental descriptors are underscored. As the creation process is central to the craft, Mingei provides additional tools for digitally capturing it and semantically representing it.
- **Contextual information**

Quantitative data regard the measurement of quantities relevant to craft practice such as the number of workers, production & economic figures (i.e., employment, creation of added value), social figures (i.e., population), and type of business or organization (financial, economic, professional, administrative and commercial). The questionnaires and forms of [113] we advised in the selection quantitative attributes. **Qualitative data for specific objects** regard the appearance and affordances of objects, processes or concepts. They are descriptive elements for the representation of objects, such as shape, technique, or even felt properties such rigidness, smoothness, or texture. The questionnaires and forms of [113] we advised in the selection quantitative attributes.

Qualitative data for crafts refer to cultural, social, historical or religious significance, aesthetic qualities, and originality. These topics of this form are produced following the approach and guidelines by UNESCO in [81] . The collected knowledge should (at least) respond to addresses basic knowledge requirements stemming from this approach. An initial orientation to evaluate the obtained process craft representation relates to the importance of this craft and is summarized in the phrase "What Makes Craft Unique?" As a continuation of this question, there are the following critical questions:

1. What is the cultural significance of the craft?

2. What are unique aspects of the craft that need to be preserved?
3. How is knowledge being transferred?
4. Who are the craftspeople?
5. How do they perform their craft?
6. What is the future perspective of the craft?
7. Why these craft take place in this geographical region?

Relevant preparatory **guidelines** are:

- Make a **vocabulary** of terms, verbal definitions, and visual descriptions. This should include the materials, tools, and products of a craft. Follow terminology consistently and update the vocabulary with new terms.
- **Organise data** in terms of steps of craft **roles** and **steps**, the **materials** and the **actions** upon them, using **tools** or **machines.**

Authoring contextual knowledge elements relates to the creation of events for pertinent fabulae. Relevant preparatory guidelines, ordered in terms of priority, are as follows:

- Organise data **geographically**, when studying the expression of craft at some location.
- Organise data **temporally** and in terms of individual events.
- Organise data **biographically**, in terms of persons, enterprises, communities, or larger social groups.
- Associate **links** to digital assets and **sources**. Collect **multiple assets for each** knowledge element.
- Add textual **notes** for individual issues that must be taken care at a **later** stage.

We found that **spreadsheets** of high practical value in this task, because notes, data, and links can be easily associated in a tabulated and indexed format. Multiple sheets of information facilitate thinking in multiple dimensions. In Figure 5, we show views of our spreadsheet we are using to collect knowledge on the Silk pilot.

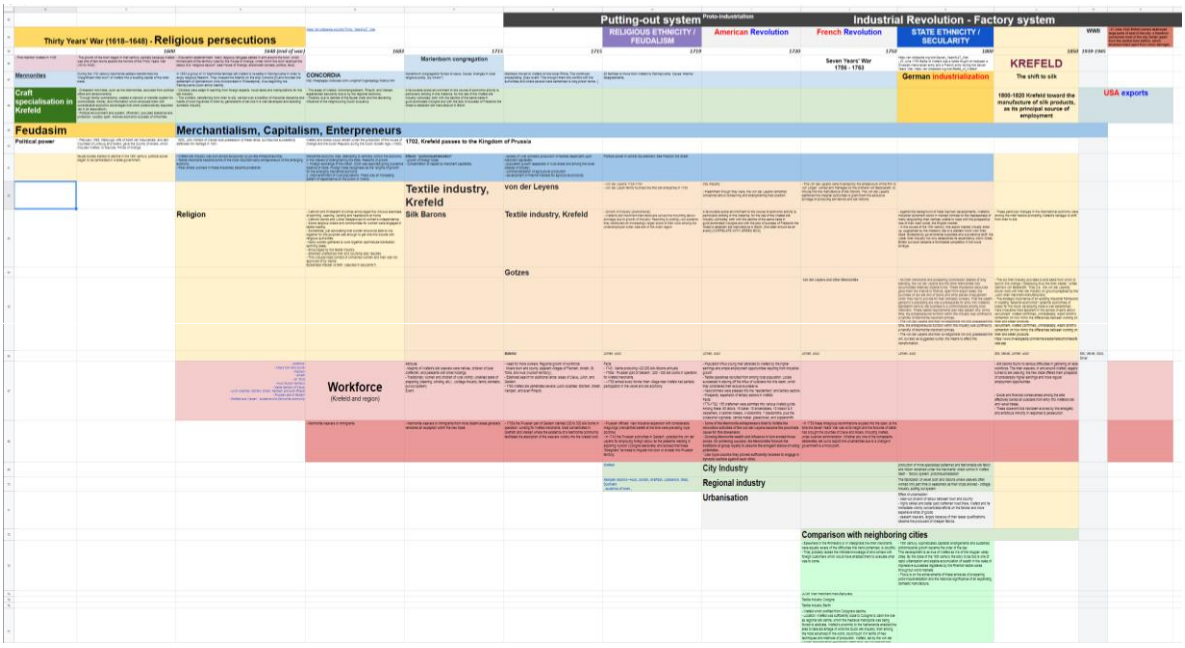


Figure 5. Note collection spreadsheet on the historical context of the textile industry in Krefeld (image from [184]).

4.1.2 Institutional collaboration

In order to fruitfully collaborate with a CHI, association, or community relevant to the craft of study, the collaboration framework needs to be determined and a **common understanding** between involved partners should be achieved.

A preliminary step in this task is to **establish institutional communication** and **understand collaboration goals** of partners. This involves the acquisition and sharing of contact information, as well as, further logistic information, such as what are the optimal communication times and the communication tools. A mapping of staff roles and contacts per each partner is quite useful, in order to communicate with the appropriate person or department with respect to the task in hand. Notably, this step involves a mapping of the financial and legal signatories or advisors of the partners involved.

During initial communication with an institution, **translation needs** among partners and communities should be assessed. Correspondingly, translators available to partners are to be planned and involved. Translators would preferably be aware on the context of each institution in order to be able to provide translations of either craft or technical terminology. As such, a translation agent from each partner would be optimal.

4.1.2.1 Legal issues, Authorisation

Upon establishment of communication, the **collaboration** with the CHI, association, or community is to be **specified** and made clear to all partners. An agreement on the use of Intellectual Property Rights regarding the produced digitisations, information, presentations, and knowledge is to be specified and agreed by the institutions. For this purpose a Memorandum of Understanding or a

Consortium Agreement are to be prepared by collaboration of legal signatories of institutions and formally agreed upon. In this context, the DESCA consortium agreement can serve as a valuable template for the Consortium Agreement.

Acquisition of assets can relate with the IPR management. Appropriate actions for their satisfaction are to be included even in the collection of images from the Internet. A way for the treatment of this issue is to resort only to open (i.e., Creative Commons) data. However, this is not always possible, i.e., in cases of proprietary data.

4.1.2.2 Ethics, Health, and Safety

As the representation of the craft involves **human participants** it is mandatory to satisfy a number of requirements. Ethics, Data Protection, and Health & Safety requirements, are an integral part of research from beginning to end, and ethical compliance is pivotal for the success of the digitisation project and the accessibility its result. Compliance to these requirements is not only to respect the legal framework, but aims the provision of high quality research, ownership, and sustainability of results. The table below provides the requirements for this research in the EU and should be adapted according national laws & regulations of the locations of the digitisation project.

Approval of designated **Ethics Committees** is a prerequisite, for conducting research with human participants. The designated Ethics Committee for the digitisation project should be identified and contacted at this stage. No interaction with human participants is to take place, unless pertinent Ethics Requirements are satisfied. Compliance to data protection laws as well as health and safety regulations is determined by identifying the environments and modalities of digitisation, in collaboration with the designed ethics committees and relevant health and safety boards. In Table 1, pertinent requirements and relevant materials are summarised.

Table 1. Requirements for conducting research with human participants and relevant materials.

Requirement	**Material**
Ethics	European Commission's ethics self-assessment guidance, Ethics Appraisal Procedure, and for CH projects the guide in [4].
Data Protection	GDPR law and additional national laws.
Health and Safety	Usage guidelines and safety warnings of devices used in the digitisation project, EU and national laws for the transportation of goods, use of machinery, and manned or unmanned vehicles.

4.1.2.3 Individual partner requirements

Individual partner requirements are to be investigated as it is possible that community members belong to a sensitive population. It is important to consider that **Living Human Treasures** can be of old **age**. As such, individual requirements of sensitive population groups need to be considered and applied. These requirements regard both the ethics of engagement to members of this group [84] , which may be suffering of age-related diseases, and consideration of pertinent requirements in the design of project outcomes [85] [86] .

4.1.2.3 Institutional assets and material

Communication with a CHI, community, or association can involve a description of the **physical assets** and collections of these institutions. These are to be noted as they can provide an initial orientation of the relevant assets to the craft that will be identified as relevant for digitisation.

The topic of **insurance** for artefacts that are to be handled or digitised should be brought up and planned if relevant, according to the conventional practices followed by content and asset owners.

CHIs and craft communities often have **curated material**, already prepared in the form of literature, guides, brochures or even interactive multimedia presentations. Typically CHIs have a catalogue of their items and may digital collections, along with pertinent metadata. In initial communications, it is important to specify these assets, as potential assets for the knowledge collection of the digitisation project.

4.2 Human resources

Human resources are invaluable in the description and explanation of craft **practice** and **context**. In this process, digital assets serve a range of purposes, from note-taking, digital recordings or reconstructions. The **human resources** relevant are craft practitioners and communities, as well as CH professionals, to provide knowledge on craft practice and context. Human resources can explain and demonstrate the making of artefacts, identify the required skills to do so, and recommend a teaching process.

In order to create a representation that presents a craft comprehensibly we need to assume the first person perspective of the practitioner. This does not regard only handicraft tasks, but also the context of belonging to a community and the traditions followed within craft practice. Thereby, practitioners and members of craft communities are our guide in understanding the socio-historic context relevant to the development of a craft over time.

Thereby the outcome of working with HC communities and practitioners is the representation of (a) the first person knowledge required for understanding or practicing the craft and (b) the emic understanding of the context of being member of a community that bears the particular form of heritage.

This outcome is definitive for the entire representation of the craft instance. While the next steps of the protocol address **how** stories and methods are documented and represented, in this step, the craftspersons decide **which** stories and methods are relevant and meaningful in order to present craft content (methods) and context (stories). Thus, the primary part of Step 1 is to identify topics of knowledge required and the corresponding assets required for the documentation of these topics. In the secondary part we follow this collection of topics and acquire the pertinent digital assets.

Working with HC communities towards this goal, involves Heritage and Communication Professionals on the methodologies of collecting knowledge on the topics that need to be covered. To achieve the goal of topic identification we follow a twofold approach:

1. We employ co-creation workshops, where HC communities are facilitated in the definition of the methods and contextual elements to be represented.
2. We employ ethnography, participant observation, and interviews to comprehensively document these methods and contextual elements, according to scientific requirements.

In Mingei, an approach toward this task is proposed that requires **co-creation** with practitioners and involves physical co-presence in workshops and demonstrations as well as **ethnography and interviews** to capture context and the whole group of events that correspond to the practice of a craft. These two approaches, are elaborated in Mingei-D1.1 and Mingei-D2.2, respectively.

In other words, the first part of Step 1, provides the "storytelling" scenario. For craft processes, it defines the setting (i.e. a workshop), the processes that are followed, and the relevant traditional elements. For craft context, it identifies the relevant stories from global & local history, traditional elements, collective memories, and values carried through the expression of craft in craft products, but also in the tradition of communities.

The type of these elements may vary greatly, as some may be verbal (oral tradition), visual (traditional art), or social. The latter is exemplified through the social tradition of the citizens of Aachen, Germany. Aacheners greet each from afar with a stretched out little finger. The name of this gesture is "Klenkes" and its origin lies in needle production industry that used to flower in Aachen, where faulty needles were removed with the little finger. A statue of two persons demonstrating the gesture exists at the centre of Aachen. Similarly, in Krefeld where one pilot of Mingei takes place, the statue of a weaver is one of the central monuments of the city. Such artistic expressions and symbolic references underscore the significance of craft in the formation of **collective memories, values**, and **identity** in a community. As such, it is the community members that can best describe this emic perspective. The task of scientific collaborators is to accurately and multi-modally encode the content entrust as Heritage.

The outputs of this process are:

- A vocabulary of artefacts, basic materials, tools or machinery involved.
- A mapping of the fundamental craft tasks and processes.
- A timeline of the craft instance within the general concept of history, including a temporal mapping of craft instance evolution reaching today.
- Contextual and conceptual knowledge on the studied craft.
- References to original sources.

In the remainder of this sub-section, we overview the most principals topics that are directly relevant to the documentation of a craft. These lists of topics have been collaboratively created in Mingei. Their purpose is to serve a guide towards the primary topics of investigation and, in this way, provide a point of departure for co-creation and ethnographic collaboration activities.

4.2.1 Craft practice

- **Physical items**, such as artefacts, tools and materials that are relevant to the craft instance.

- **The creation process**. In this respect, assets are required to represent craft processes comprehensively are to be extensively mapped in steps, annotated, and described.
- **Reference assets** for the presentation and exemplification of the physical items identified in the vocabulary.
- **Testimonies** and **demonstrations** by practitioners.
- **Historic and symbolic objects** that are of significance to the story of a craft or its relation to a place or an event.

The outcome of collaboration with cultural partners in Mingei is an analytical way to verbally and visually represent a craft process and decompose it into simpler actions. In this collaborative process, we identified the need for a representation that is **intuitive to the practitioner** and analytical enough for the semantic representation of the process. In the next steps, we use this representation to model craft processes, associate pertinent digital assets, and present them to pertinent audiences.

In Mingei, processes was encoded as a sequence of actions and reviewed by the community of practitioners, producing the final representation after a number of iterations.

To that end, we found storyboards useful for (a) illustrated scripts that decompose actions in simpler ones and (b) validating this transmitted information with the craft community, collecting feedback, and identifying parts of the process that need may be underrepresented.

4.2.2 Craft Context

- Literature, archives, documentaries, curated material, and testimonies.
- Stories on the traditional, social, economic, and historic context of the place and community that craft is expressed.
- Technological history of inventions relevant to the craft.
- Personal stories of communities, craft practitioners, and stakeholders.
- Local history.
- Oral tradition.
- History of local economy.
- Social history, social groups, collective memories and values.
- Biographies of notable actors and history of notable enterprises.
- Stories of specific assets of historic or cultural significance.
- Stories of the significant and historic items.
- Transcendence in the realm of art and history of local art.
- Relevance to artistic movements.
- Impact of global events on the craft.

Creating the list of topics on craft processes and context and their elaboration leads to the identification of assets (whether tangible of intangible) that are required to be digitised for the representation of the craft instance. The role of HPs and communities is central in (a) **identifying the assets relevant** and (b) **characterising their significance**.

Having in mind the affordances of the project budget, it is recommended that stakeholders in collaboration with technical partners are to determine and prioritise the digitisation modalities and

targets. If the data to be collected are more than the capabilities of the digitisation project, then the human resources are essential in conserving technical resources. By characterising assets as to their cultural significance and urgency due to endangerment, a prioritisation can be provided for an initial, representative corpus of data, which can serve as a foundation of additional and on-going digitisation efforts.

4.2.3 The craft digitisation team

To ensure correct collation a relevant authority should be involved in the coordination of the project, mainly to indicate the appropriate and most relevant sources and human resources that can provide knowledge on the topic of study. In addition, the role involves maintain contact with the financing bodies, regional authorities, and craft sectors at local, regional and possibly international level.

Filed investigation is entrusted to experts with varied backgrounds (ethnologists, researchers, archivists, craft workers, statisticians). Nevertheless we have been found that if project orientation is thoroughly prepared by experts in the beginning, some stages of the work can be carried out by non-expert workers with some training either at brief workshops or by collaborating experts.

Technical experts and people used to working in the field are preferable to bureaucrats, and any motivated and enthusiastic amateur can be of significant helps, in a subject (s)he enjoys. Other relevant professions include museum workers, workers at rural centres, students working for qualifications in ethnography or museology, experienced craft workers, artists, photographers and collectors.

Photography and video acquisition skills are also important as the material collected is intended to be published. Depending on the mission, the possibilities of including a translation and/or a driver should be considered.

4.3 Digital assets

We consider as **physical assets** the objects and events, which we wish to have **recordings** of. Examples of physical assets are a pot, the brush used to decorate it, the soil, clay, and paint utilised, the stool and the wheel of the potter (which, actually has a treadle too). In addition, we also consider as a physical assets the measurable physical events related to the transformation of soil to artefact. There are all transmissions of energy over time and space, such as light (photography), sound (audio), temperature, or even biosignals such as force, breath, or heart rate. As such when a potter demonstrates the creation of a pot, or provides an interview, we also consider as physical assets the recording of their words and gestures. We also consider as assets articles of literature, such as a pottery books, and media, such as documentaries[4].

4.3.1 What is a digital asset?

[4] We will not consider the memory of the potter, whether memories of sensations, learned skills, or abstract knowledge, as a physical assets. The reason is that we do not have a way to identify, record, and understand the pertinent biosignals. Currently, these are not directly digitised as physical events.

The digitisation of the tangible world regards is the faithful recording of the physical properties of the aforementioned objects and entities, including their change over space and time. Besides artefact, tools, and materials, objects include book and scripts that carry verbal content. Spatiotemporal changes include the actions of the potter, the manipulation of objects, and transformation events, such as firing or decorating a clay body. Moreover, other actions such as speech carry verbal content.

Our **digital assets** are the output of the digitisation of all the aforementioned physical objects and events. In other words, digital assets are **recordings** of the physical world, along with the associated, technical meta-data to interpret them appropriately as computer files. Digital assets may regard to digitisation of the aforementioned entities and events, as well as objects that are carriers of information such as audio-visual assets, literature, and records.

There is of course more information indirectly availed in a recording besides the functional gestures of a painting activity, such as the selection of decoration, whether the pot should have one or two handles, et cetera. In this step, we study the accurate measurement of the physical world in digital records which, together with their technical meta-data, we call digital assets. At this step, digitisation refers to capturing the visual appearance, or other physical properties, but not meaning, such as for example whether the decoration symbolises a flower or a bird.

As such, the basic forms of information encoded in the digital assets are **verbal** and **visual**, each of which may be recorded in multiple types of media; i.e. words can be written or spoken.

- **Audiovisual digitisations.** Recordings of objects and events, such as tools, artefacts, practice and practitioner descriptions. These assets are called *primary* if they are the direct output of a sensing modality (e.g., a photograph) or *derivative* if generated by the analysis of primary asserts; e.g., transcription into speech to text, or binocular reconstruction from two images.
- **Verbal digitisations.** Recordings of spoken or written words, mainly images of written or printed matter, audio recordings, and digitally-born text.
- **Hybrid assets** are recordings that combine the aforementioned modalities, such as a video with audio that contains speech or a document that has both text and images.

4.3.2 Asset types

The **most relevant digital data types** are:

- Text
- Photographs
- Video
- Audio
- 3D reconstruction
- Human motion digitisation

Additional digitisation types of humans, matter, and actions (e.g. thermal, multispectral, X-ray), provide measurements of more material properties that photography can capture. Such properties

are surface reflection and transmission properties, chemical composition, its degree of viscosity at a certain temperature, and other.

FORTH has created a **novel modality for the scanning of digitisation** of textiles in ultra-high resolution. It is presented in **Annex 1**.

We provide some examples of **primary digital assets** from the Mingei dataset

- Digital text of curated text, literature, and testimonies.
- Photographs: historic photographs, photographic documentation of artefacts, printed matter, records.
- Audio: interviews of glassmaker and mastic producer.
- Video of craft practice.
- 3D reconstruction of a workshop from a laser scan.
- 3D reconstruction of an artefact from a handheld scanner.
- Motion capture of craft practice.

We provide some examples of **derivative digital assets** from the Mingei dataset

- A 3D photogrammetric reconstruction from multiple photographs.
- The digitisation of human motion and object manipulation from a video.
- The conversion of audio to text and the conversion of images to text (OCR).
- The subtitling of a video.
- A born digital document with text, images, and video.
- A combination of aerial, terrestrial, and indoor scan from three different modalities.

4.3.3 Combination of 3D assets

Multimodal digitisation refers to the digitisation of the same object by multiple, different modalities, to measure multiple, complementary properties of the object that are not available by a single sensor. In multimodal digitisation, the **spatial registration** is required. If motion is digitised by multiple modalities, their **synchronisation** is also required.

The Interactive Editor has been implemented in the CONNEXIONs H2020 project (GA No. 786731), by FORTH. This editor is re-used in Mingei.

One of the most common cases of multimodal digitisations is that of 3D reconstruction of an environment through multiple modalities, which creates the need for the spatial registration of the partial results. This is currently a task carried out with tools that require some expertise in the treatment of 3D data[5]. In Mingei, such cases are workshops or craft practice sites which include simultaneously indoor and outdoor areas, such as a building structure.

In Mingei we have customised work that FORTH did in the past to facilitate this processes for a user of the Mingei platform. This editor is a tool that provides functionalities for combining multiple 3D scans and editing a 3D scene. Central to the capabilities of this editor is the ability to register partial

[5] I.e., MeshLab, CloudCompare, Unity, Maya.

and heterogeneous scans. The component supports GPS standards and is compatible with online GIS systems.

In Mingei we have customised the GUI so at to be the same with other 3D tools that are provided by Mingei, such as the Annotation Editor presented in the Step 2. A view of the user interface is shown in Figure 6. **In** Mingei this editor is used to:

- **Combine reconstructions** from multiple scanning modalities.
- **Synthesize simulated environments from digital assets**, for craft **workshop** simulations, as well as, for the **installation environments** of demonstrators. Using the 3D model of the installation environment, designed systems are first viewed and evaluated in VR, before final installation

Figure 6. A 3D editor for the combination of 3D digital assets (image from [184]).

4.4 Implementation

The first technical action should be the establishment of backup and safety of storage for digital assets. Backups should be multiple and stored at different locations, or if possible, on a cloud repository. This primary organisation of the acquired data is temporal and personal that is stored per person submitting the information, per modality and per day or session of acquisition. It is important to establishments this data in safe storage, until the data are properly organised.

The second action is to organise assets in a way that facilitates their use. This organisation is recommended to take place in a copy of the original data, to avoid losing data due to human error. If material samples of exceptional or characteristic pieces have been acquired for further analysis in the laboratory, these should be treated in consultation with the wishes of the owner, the conservator of the collaborating heritage institution, and scientific experts of the digitisation team, in that order.

Then the collected material is entered in the knowledge base. At this point, this material comprises of formative and field notes (some in digital format) and digital data. These items are either digitised or transcribed to the knowledge base, as “media objects”. Media objects are the way the MOP treats digital assets. In Figure 7, a conceptual entry for a digital photograph is illustrated along with the MOP form for linking this image to the knowledge base.

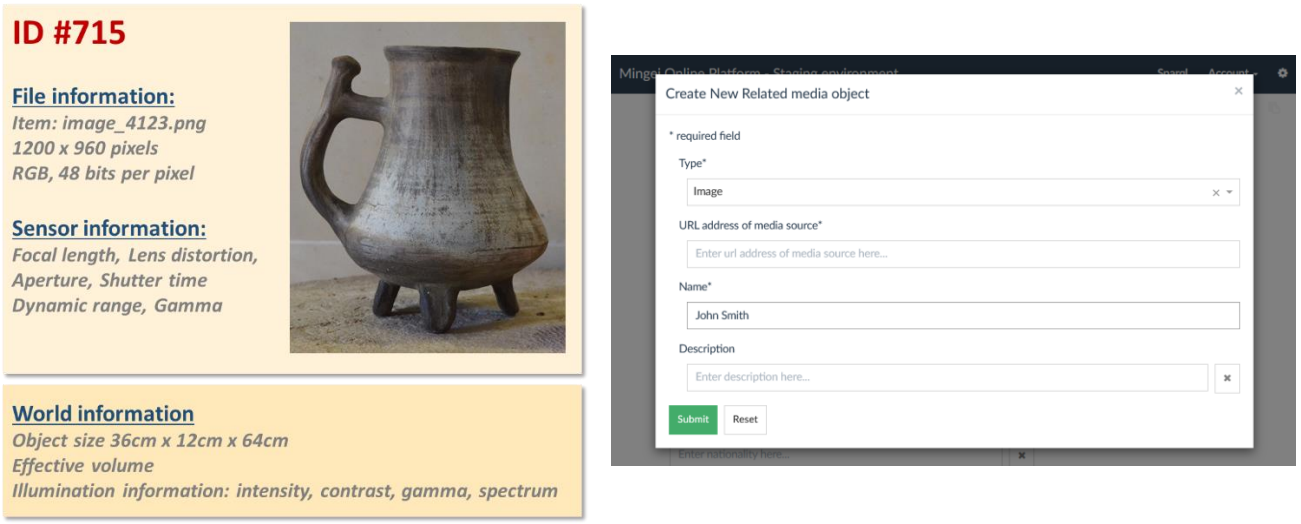


Figure 7. Conceptual illustration of digital asset and technical meta-data (left) and MOP media object entry form (image from [184]).

5. STEP 2. Knowledge elements

In this step, basic craft knowledge elements are formed. Knowledge elements include curated information about an element of knowledge and links to digital assets. This information is encoded in **knowledge statements**. Involved entities include objects, actors, actions, processes, materials, concepts, tools, times, and places.

Forming a knowledge element requires a comprehensive understanding of the assets and its digital representation (digital asset). This process is a basic **digital curation** process. Digital assets are represented in the knowledge base through knowledge elements, which associate digitisation data with the result of a curation process that yields metadata, annotations, and descriptions.

The developed **knowledge base** includes references to curated material, such as literature, other types of verbal content, images, and audio segments as **justification** or **primary sources** of knowledge base entries includes.

The digital representations of entities and relationships are encoded in the knowledge base. Collectively, the classifications and links formed can be considered as the “semantic metadata”. The entries in the knowledge base are the product of digital curation and are represented entities, attributing authorship.

5.1 Rationale - Knowledge representation

The collected knowledge will be represented formally. A formal knowledge representation is a digital encoding that captures the collected knowledge domains, as structured data. Formal representations yield machine-interpretable statements, taxonomical structures (concept hierarchies), and relationships between concepts and entities. Using formal representations we are able to encode the links between knowledge elements and semantics, in a machine interpretable manner too. In this way, solid and reliable knowledge bases that can support inventorisation, search, and access based on content, context, and semantics.

To achieve our goal, we need to bridge the ***gap*** between the knowledge, ***as provided by persons***, and the collected knowledge, ***as encoded in a formal, machine interpretable representation***.

Intuitively, a knowledge element is what we would read about an object in the catalogue of a museum as well as the pieces of information refer to by the story a museum guide would tell about this object. This story may relate to the creator and owner(s) of the object or, due to its decoration, relate to the collective memory of a historic event, a custom or rite, or symbolise a shared social value. We present a simplified example in .

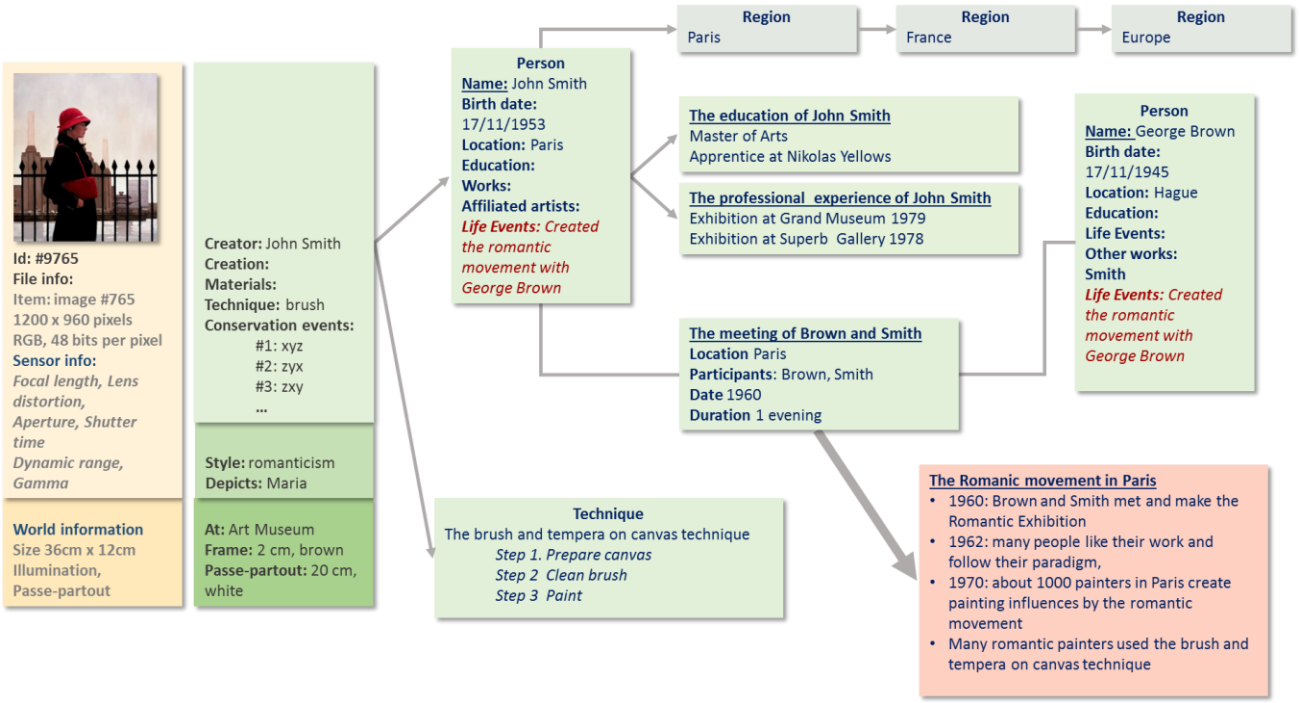


Figure 8. Illustration of knowledge representation relevant to a painting (image from [184]).

Technically, a semantic knowledge element, or **knowledge element** for short, is a statement encoding a simple proposition. To make the following discussion more concrete, a knowledge element will be equated with an RDF triple in the abstract RDF syntax. In doing this, no generality is lost as the Resource Description Framework (RDF) format is a *de facto* standard used to encode more advanced knowledge representation languages such as RDF Schema, OWL and its profiles.

We employ two kinds of statements:

- *Classification statements* that assert that the resource identified by IRI is an instance of a class.
- *Relationships*, or *links*, that asserts that an element stands in a relationship, of some type, to another element.

The main types of the involved **entities** are objects, sites, actors, places, events, actions, processes, concepts. These entities are formally described by statements using classes and properties of the CrO. Such properties account for the content, form, and significance of an entity and, where appropriate, its spatiotemporal placement. The descriptions are formed based on the material collected in STEP 1 and derived knowledge, due to the curator.

5.2 Surfaces, objects, and sites

Besides the data encoded in the digital asset, the representation of surfaces relates semantic properties of an object. Such properties are its shape, its material composition, the technique or style employed to create it, its articulation in parts, geo-reference information, and other.

When the knowledge element regards a site, we are interested in world locations, in other words latitude and longitude. Altitude could of interest as well. Combinations of both reference systems

are also important. The reconstruction of a monument is encoded in a 3D representation but also georeferenced. Qualitatively, 2D representations fall the category of “maps” while 3D representations fall in the category of object and site 3D models.

5.3 Places: geographical locations and regions

Locations on the Earth are defined as points which have with 2 coordinates, latitude and longitude. Regions are polygonal representations upon the surface of the Earth. We call both “places”.

A semantic property of a place is whether there is, or was, a name associated with it. For named geographical locations, we use a data base of location names (GeoNames). The coordinates and further semantics, such as hierarchies of city, region, and state inclusion, are also available through this resource.

More refined representation of locations may require addresses or even arbitrary user-defined locations on Earth that are not included in the database. The coordinates of these locations are provided through the digital curation process and supported through a GIS system.

Either one of Earth coordinates or location names suffice for the representation of events. It is recommended to always associate GPS locations with names when these are available, in order to facilitate spatial, hierarchical reasoning.

A common modelling simplification in database names is that entire regions (e.g. a city) are associated with a single point location. This may be sufficient for some cases, but an overly coarse approximation in others.

5.4 Persons, parties, and social groups

Ontologies on life of persons can lead to very broad representational requirements, depending on the profession and life of a person. Naturally, some attributes are common for all human beings, while in Mingei the profession, communal activity, and traditions of a place are of close relevant to the contextualisation of a craft. Of relevance is also the participation of persons in communities, guilds, social or artistic movements. In our case and in this step, we record and represent basic information on the life and times of a **person**, such as occupation, places of visits, time and place of life and death, and **key events** relevant to the topic of study, such as education, professional activity, collaborations with other persons and so on.

The case is the same for **social groups**. At this step, groups are represented agnostically as to their type. That is the role of the social group of interest as, say, a guild, a village community, an enterprise, the Bauhaus movement, or the legislative authority of a state, are defined later on – In Step 3. As in the case of persons, **key events** are associated with social groups. Such events can be the foundation of a company, the meeting and collaboration of two artists that triggered a movement, the passing of a law that establishes the monopoly of silk ribbon production to the industry of one city, or a law the exempts the producers of some rare agricultural product from military service or tax.

The selection and focus of key event description and representation adheres to the selection of topics, stemming from Step 1 and in more specific that of collaborative design of the targets of knowledge collection and representation.

As an example, we entertain a simplification of the record we would keep for a person, in this case the historic figure of Charlemagne. Figure 9 illustrates (a simplification of) the basic knowledge element for a person. The element supports multiple appellations as a person may be known by many names. The life and death of a person are events and so are the occupations of a person as events, during time interval. Occupations of heraldic nature have additional attributes, in this case a successor and a predecessor, which are modelled as links to the knowledge elements of the corresponding persons. Other events relevant to this person are a number of military campaigns he performed. Using the mereological representation of events, a mereological nature of events, an broad events, such as the "Italian Campaigns", can contain links to individual campaigns and individual battles per campaign. The figure illustrates a sub-event of the occupation of Charlemagne as emperor and, in particular his coronation. In turn, this event points to a digital asset that depicts the coronation event. Other digital assets are linked directly to the knowledge element of a person. A characteristic case is the image or images of a person. Registering multiple images of a person is useful not only to document different phases of a person's life. When the depiction is artistic (rather than photographic) the style of the depiction can be relevant to contextual information. Among other events of Charlemagne's life we are interested in an event of minor historical importance (the acquisition of a Persian elephant), but whose story made its way to oral tradition and gave rise and folkloric motif found in garments and textiles event today.

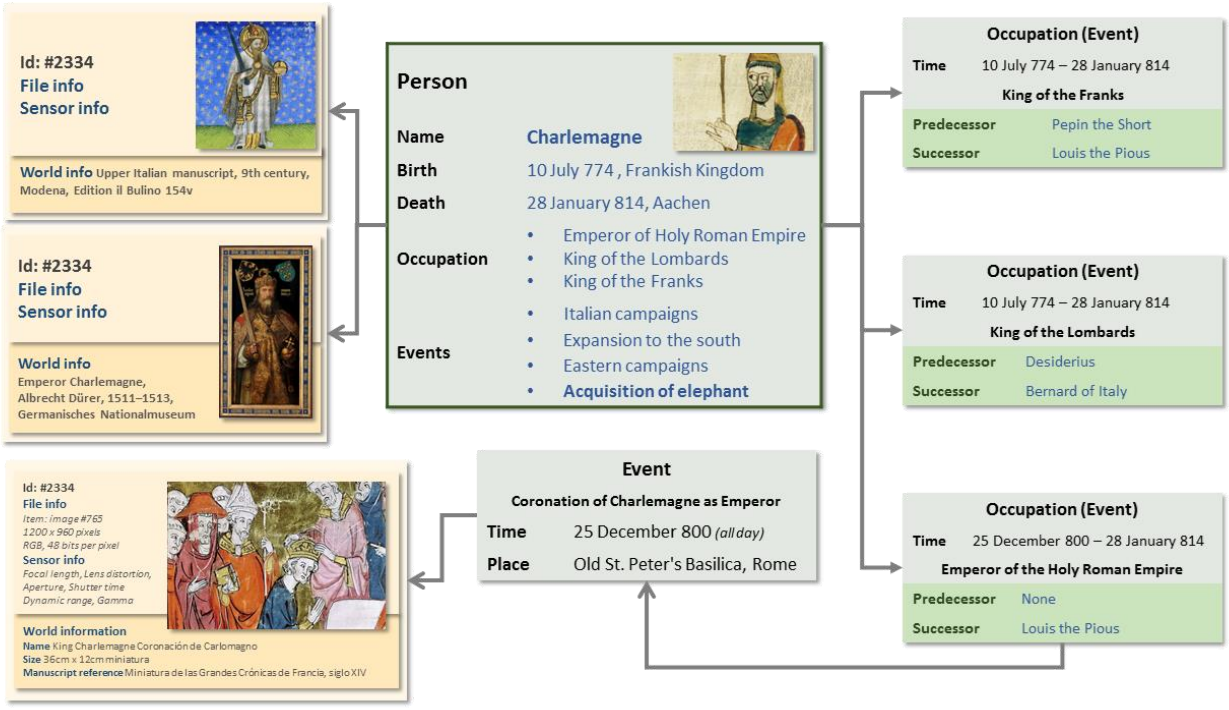


Figure 9. Illustration of a subset of knowledge elements related to the life of Charlemagne (image from [184]).

One can justly say that this is a very narrow perspective of Charlemagne's life and times. The reason is that we did not attempt to model the biography of this person, but rather than document the context of the traditional motif. There is no barrier in revisiting the knowledge element for Charlemagne in order to elaborate on other aspects of his life, for other purposes of study.

5.5 Semiotics

Though significant tools exist for the representation of verbal semantics, the topic of associating visual data with semantics, or semiotics, has been less explored.

In verbal content, words and phrases correspond to semantics. In static visual data, some spatial regions are associated with specific meaning, such as a sign. Similarly, dynamic visual data contain scenes of interest, because of the occurrence of an action. The demarcation of parts of an object, a process or an event (sometimes called parsing or articulation), contribute to the understanding of an object or activity. This way, parts of an object such as an ornament, or parts of a scene such as a gesture can be isolated, represented, and studied. Most importantly, they can be directly associated to knowledge elements of the CrO that represent craft actions.

The reason for annotation of static and dynamic data is twofold:

1. Object pieces and activity parts need to be represented in a meaningful way for practitioners. As such, besides technical features of data we strive to capture their interpretation for humans.
2. To date there is no reliable method that can do so fully automatically and fully reliably.

Recent advances in Machine Learning have broadened the capabilities of object and activity recognition methods. However, we cannot yet rely on the generic and automatic object and activity recognition[6]. Nevertheless, when the problem is constrained to a smaller context, such as that of a particular craft, useful recognition **aids** can be provided that reduce user interaction by proposing recognition recommendations.

A multitude of annotation editors exist for documents, images, and videos. State of the Art – on image annotation tools A first approach towards this need is the ELAN a video annotation editor [97] , which is a valuable tool for the annotation of audio-visual interviews in a controlled setting. Recently it has been upgraded to Opencast Annotation Tool. These are sufficient for conventional media, such as images and video.

We propose have implemented two annotation editors that cover needs which are not currently covered by other pieces of software. The proposed editors regard the annotation of 3D digital data, visual and MoCap data.

5.5.1 Static scenes

An Annotation Editor for 3D models was developed to cover the requirements of associating parts of 3D digitisations. This requirement stems from the need to provide location-specific information

[6] Dengsheng Zhang, Md. Monirul Islam, Guojun Lu, A review on automatic image annotation techniques, Pattern Recognition, Volume 45, Issue 1, 2012, Pages 346-362, ISSN 0031-3203, https://doi.org/10.1016/j.patcog.2011.05.013.

upon points and regions of an object or site, such as for example a workshop. In objects, we may wish to indicate which piece of a carafe is the handle or indicate a motif or symbol upon a piece of pottery. The Annotation editor

a) Enables the specification of geodesic regions of interest upon 3D models, a feature not available in pertinent editors that offer only point-based annotation.
b) Integrates the annotation output in the knowledge base, associating it with the knowledge element that encompasses the corresponding digital assets. In this way, annotations from multiple experts about an object can be collected.

The Annotation Editor provides a user friendly annotation user interface for the spatial mark-up of 3D models. Feature (a) above is demonstrated in Figure 10. In the figure, the photogrammetric reconstruction of a marble sculpted temple is shown, through the 3D GUI of the Annotation Editor. In the example, the user wishes to annotate an approximately circular piece of the ornament, which symbolises a flower. By navigating in 3D, the user is able to find a view which facilitates convenient observation of the target. The user circles roughly the region around the ornament and the 3D & RGB content are utilised to accurately segment the target (intuitively, it is the opposite of the “magic wand” tool, in image processing programs). This simplified greatly the interaction of the use, particularly in the 3D case. The component is described in Mingei-D4.2.

Figure 10. Region-based annotation of a 3D reconstruction (image from [184]).

5.5.2 Dynamic scenes

Animation Studio is the tool that we utilise to associate fragments of digital assets to craft actions and gestures, in order to associate them with their corresponding semantic description, in Step 3.

Animation Studio is an application to **visualise**, **edit**, and **annotate** 3D animation files. Input may be from MoCap or visual recordings. The tool enables viewing the 3D animation from arbitrary viewpoints. When video is available, it is shown in correspondence with the 3D animation. The tool allows the user to isolate animation and video segments, for further annotation. The tool, allows the synthesis of composite animation and video files from isolated segments. In Figure 11, it is show to be used in the isolation of a weaver pushing his foot on the treadle of a loom.

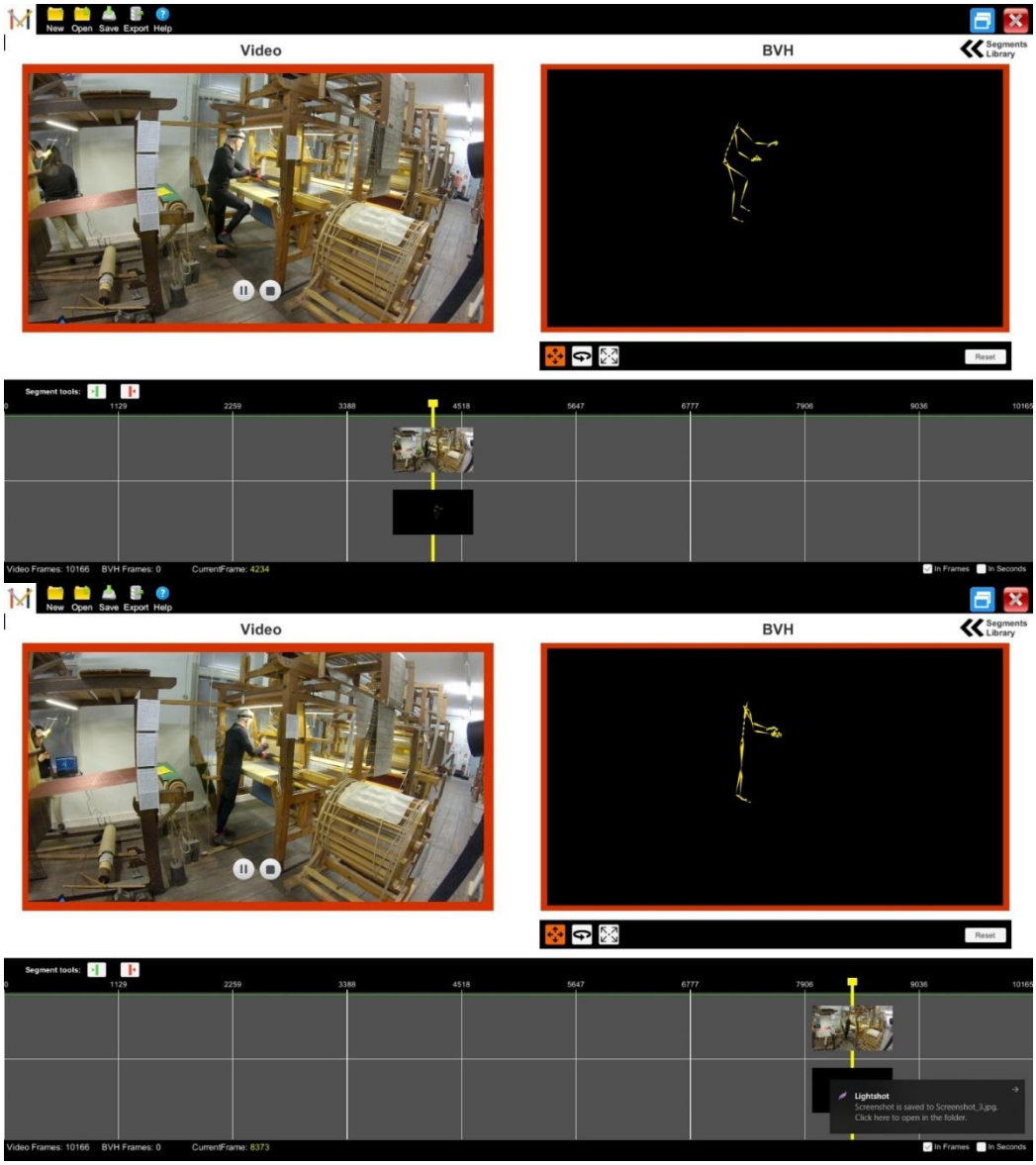


Figure 11. Animation Studio is used to isolate segments of 3D and video animations (image from [184]).

5.6 Events

We consider events as the changes of state in cultural, social or physical systems brought by phenomena or influenced by other events. Thus, the definition of an event requires at least two observations of this state in time.

Events are basic elements of stories in general and, in particular, to the type of "stories" we wish to capture in our craft representation. Knowledge elements of the event type are employed to represent:

1. **Socio-historical** context relevant to the expression of a craft instance.
2. **Actions** in craft processes, following a well-known approach in the philosophy of language [52] .

Respectively these correspond to:

1. Changes in social and economic systems due to historic events.
2. Changes that take place in a craft process, such as material transformation into artefacts.

In terms of knowledge representation, the principal components of an event are:

- Time
- Place
- Participants

As such, the representation of an event entails its association (or "linking") with other knowledge elements that represent persons, eras, and locations. We illustrate these associations with lines that interconnect them with knowledge elements, in our illustrations. As discussed later on, these associations may be unidirectional or bidirectional, be of individual types, and have attributes.

It ought to be pointed out that these associations are knowledge elements as well. The represented knowledge through the information of these associations, is a product of the digital curation process.

5.6.1 Time and mereological relationships

We consider events to regard at least two moments in time. Thus we consider events to occur in time intervals delimited by an order pair of points in time. Depending on the required granularity of representation, some events may be considered to have a zero time length although that they actually have a brief duration.

An event may include other events as parts, enabling hierarchical decompositions of events into simpler ones. We employ three types of temporal associations between events:

- **temporal** links; these links express the relationships between the time intervals of events.
- **causal** dependency links. These links are unidirectional as they express the order of action and induced effect.
- **inclusion** links, express the mereological relationships between events such as whether an event in included or is part of another event.

In the remainder of this subsection, we present the representation of historical and action events, through simplified examples. The input to this representation process is the output of Step 1, and in particular the craft processes and roles, the stories that document the socio-historic context of the craft and the digital assets and technical meta-data.

5.6.2 Historic events

We wish to represent the event of building acquisition transaction, because it is the home of a craft workshop that we study. The building was built but its original owner and then sold to another person. More specifically, the building was an equipped textile manufacturing workshop and was sold along with the equipment. At this step, our basic element encoding is that of the “cold-fact” events, without annotation on the significance of the event. In other words, we do not yet assert causality dependencies that would require critical study or inference. For example, the fact that this building was the home of a business for 100 years and that the story of this business reflects the story of the Krefeld textile community and industry, are encoded in the representation in the next step.

In Figure 12, we illustrate with yellowish hues the digital assets gather from Step 1. To document the event we need the basic knowledge elements about the place of the event, the date and time and the participants. These are illustrated below, as the records for H. Gotzes, G. Diepers, and an address at Krefeld, Germany. We underscore the description of the building, which goes from generic (building) to more craft-specific (workshop). The location is a knowledge element that happens to be referred to by other entities, besides the event of study, such as the construction of the building or its renovation (shown only for illustration). The figure also illustrates the use of the geographical database of GeoNames. Given the association of this location with Krefeld, it is possible to reason that this location is in Germany and in Europe.

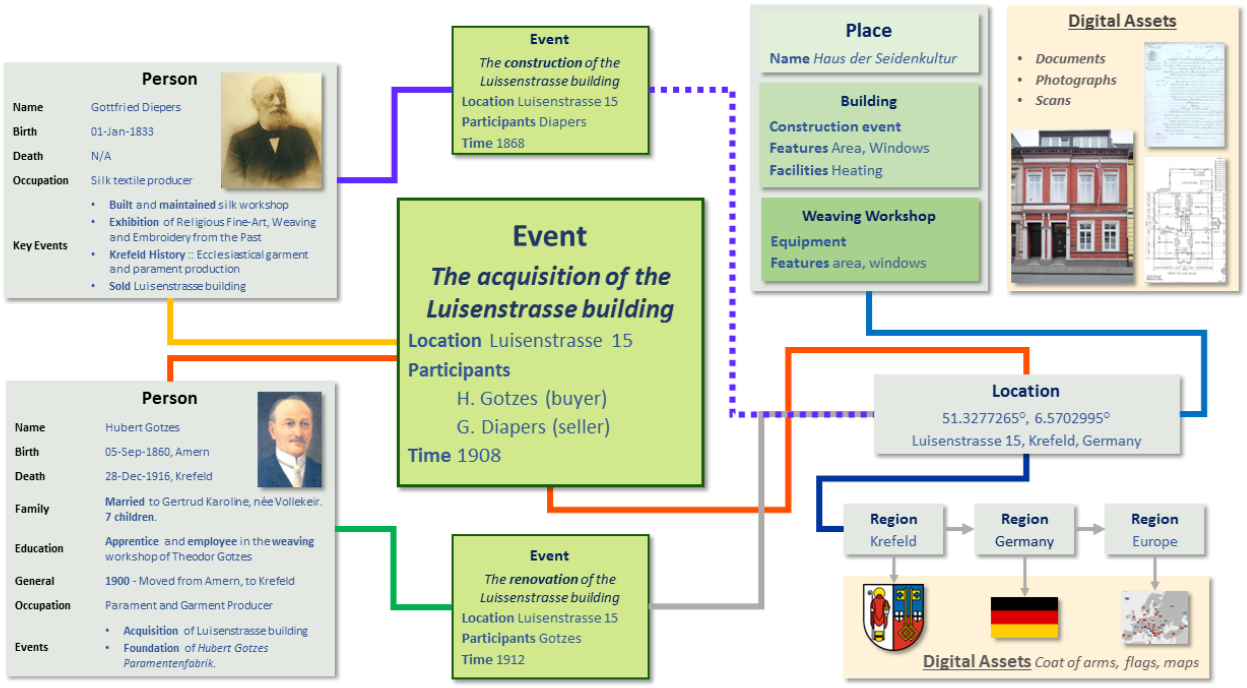


Figure 12. Illustration of the representation of an event (image from [184]).

One of the most common practical considerations occurs when the time or place of a historic event is not precisely known. In these cases, we propose to use the best approximations we have, whether it is the name of a region or country or the number of a decade or century, until a better approximation is found. In such cases, the respective fields are marked in the Mingei knowledge as approximate.

5.6.3 Actions

Actions refer to abstract events, such as “the press of a button”. As such, there may have been many occurrences of this action in the past and many more could occur in the future. As actions are members of the Event class, they may also be mereologically organised in sub-actions. In our example, the pressing of a button includes its pressing and its release.

Craft actions extend the class of generic events. Thus, besides the attributes of event, craft actions include links to additional knowledge elements, to represent the use of tools, the required conditions, or skills required to carry out an action.

Craft processes are combinations of actions. We model craft processes, at the next step. In this step, we create the basic knowledge elements, upon which our representation of processes will be built. The basic knowledge elements of craft processes, or actions, are treated as events. As such, they can be associated with participants, places, and time. In abstract events absolute time is not of relevance. However specific time quantities are relevant, such as the time needed to fire a clay body. Similarly, location is often not relevant, while the **type** of the environment is, such as whether the place is a workshop,.

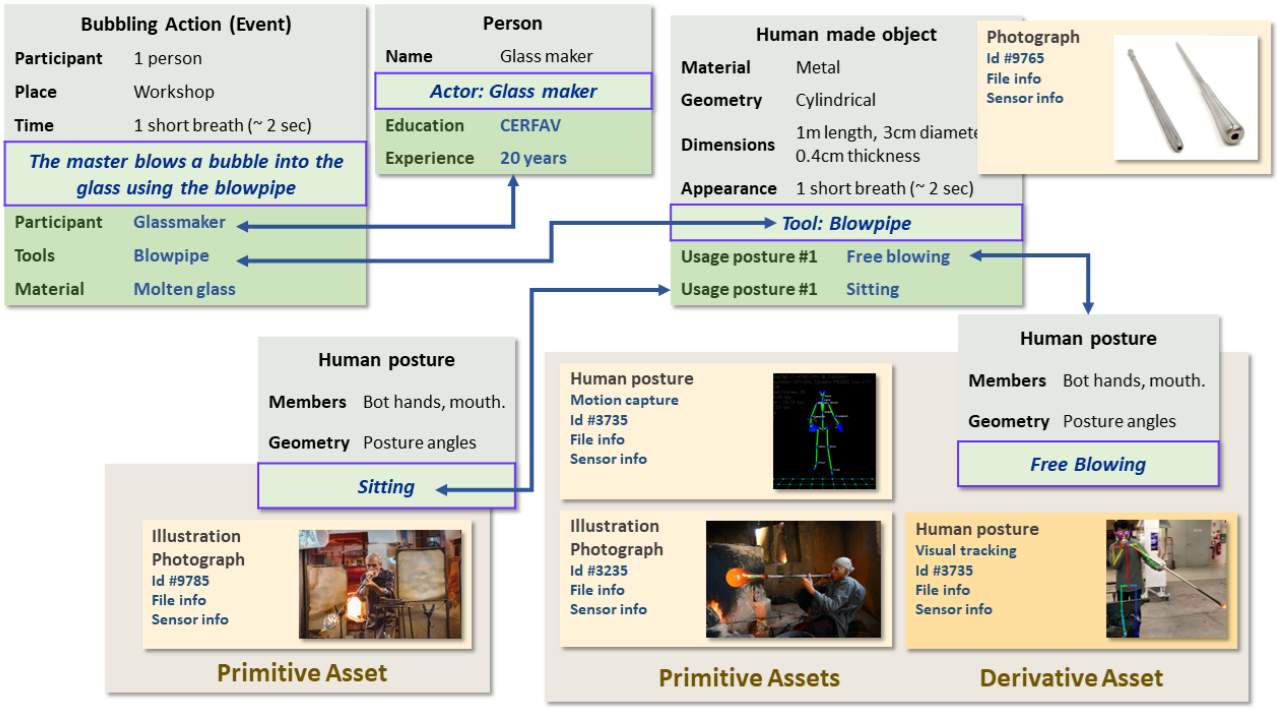


Figure 13. Illustration of a representation of a craft action (image from [184]).

In Figure 13, we illustrate the event representation with an example from the glassworks domain. In this case, the term "bubbling" refers to a glass-forming technique, where the practitioner inflates molten glass into a bubble with the aid of a blowpipe. In the illustration, we see the representation of the event, linked to the required knowledge elements, including also a verbal description of the action. The association of digital assets with knowledge elements is essential for our representation. Besides the verbal description of the action, we associate digital assets that exemplify the actions. This is quite similar to the utilisation of digital assets to exemplify objects. Of course, these recordings are instances of the abstract action and are as such represented.

Thereby, the Bubbling action is associated with:

- One participant or certain skill that is, one person that qualifies as a glass maker.
- A workshop that the action will take place.
- The material in a specific condition, as input. Notice that the molten glass is the output of some other action. That action should include heating, in order to bring the material to the state of melting.
- A tool and, in particular, the blowpipe tool.

The knowledge element is a reference element and not a specific blowpipe. Nevertheless, we link to a representative photograph for illustration purposes, acknowledging that the photograph is the recording of a specific instance of the blowpipe abstract class.

The blowpipe is a tool associated with specific usage postures, let us say two: one standing for free blowing and one sitting posture and using stabilising supports. In turn, these postures and action performances are documented by (i) a semantic description and (ii) digital assets that exemplify the

posture and the action. In our example illustration below, the first case is linked to three digital assets. The two of them are primary assets, as they are direct video or MoCap recordings. The third is a derivative asset provided by the processing of the video.

5.6.4 Diachronicity

Contextual representations require in craft evolution requires *diachronic* treatment, in the sense that they do not refer to only one moment in time. Such a representation is requited, in order to follow evolution of craft instances over time, in relation to relevant socio-historic, economic, or physical events. Time-varying properties are important because their changes can represent the effects of events.

Variation over time can be spatial, such as the seashore due to tide and erosion, or the borders of an empire. Socio-historical events may exhibit larger complexity. For instance, the island of Chios has been ruled by the Republic of Genova from 1363 to 1566 and by the Ottoman Empire from 1566 to 1912; in 1912 Chios became part of Greece. We can then think of Chios as being an entity constituted by (at least) three segments in time.

5.7 Implementation

Dedicated forms for the composition of knowledge elements are available for each individual type of knowledge element, supported by the Mingei ontology. Examples of the implementation for knowledge element entry of the Mingei Online Platform for authoring knowledge provided in Figure 14. The design of GUI and usage are elaborated in Mingei-D4.2.

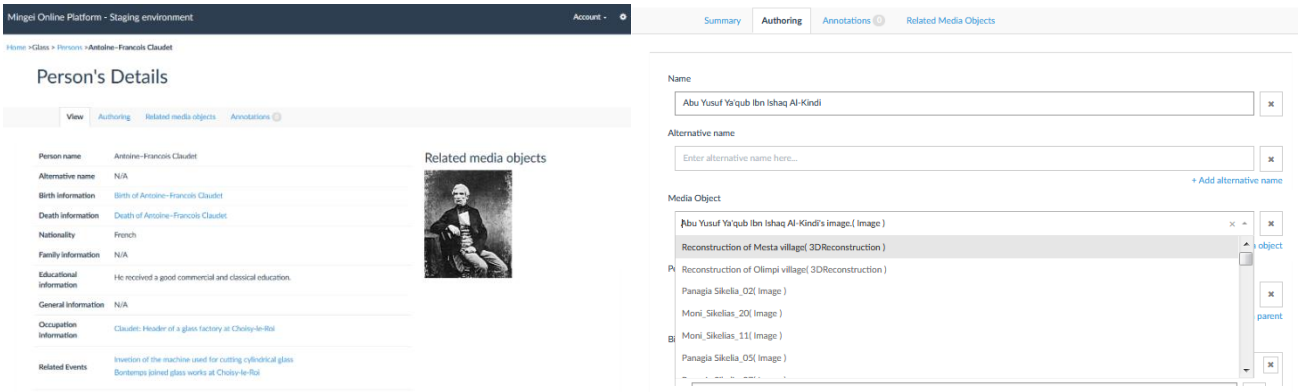


Figure 14: Screenshot of MOP authoring elements components. A knowledge element representing the life of a person (left) and a location authoring form that is associated with a relevant media object (right) (images from Mingei-D4.2).

6. STEP 3. HC representation

In this step the individual entities represented in the previous steps are associated into the representation of the craft instance. The knowledge that is represented follows the classification of Section 3.2

- Tangible: artefacts and sites
- Make: Craft actions and processes
- Mind: Contextual knowledge

6.3 Matter: objects and sites

The material items that concern us in direct relevance are materials, tools, machines, products, information carriers and sites that are related to the craft practice and its context.

Basic Table of Main Technical Data

	MATERIAL	TECHNIQUE	OBJECT
Vegetable	- Grasses, straw, leaves, fibres, bark, roots	Basketry, espartoware, weaving, plaiting knotting Building	Mats, articles for household use, agriculture, hunting and fishing Furnishings, decoration Clothing (hats) Costumes (for dancing) Instruments, toys
	- Wood	Joinery Carpentry	Utensils
	- Fruits (nuts, coconuts, calabashes)	Carving + paperwork	Art Objects Furniture, housing
		Openwork, Engraving, Carving, Painting, pokerwork	Various utensils Decorated objects
	- Vegetable fibres (hemp, flax, cotton, raffia, sisal, coco fibre)	Weaving, plaiting Dyeing Sewing	Various textiles Clothing Decoration, furnishings
Animal	- Animal fibres (silk cocoons, wool, hair)	Weaving, plaiting Dyeing Sewing	Various textiles Clothing Furnishings Decoration, housing
	- Skins, leather	Tanning, dyeing shoemaking, leatherwork saddlery	Various utensils Harness Housing, decoration Clothing
	- Bone, teeth, horn	Cutting, engraving Carving Jewellery-making	Weapons, instruments Decorated and decorative objects Costumes
	- Sea creatures (shells, coral, mother-of-pearl)	Cutting, engraving Jewellery-making	Jewellery, costumes Decorative objects
Mineral	- Earth, clay, ochre	Pottery, ceramics Building Dyeing Sculpture	Various utensils functional or decorative, Furniture, housing Costumes Instruments, toys
	- Stone	Cutting Building Sculpture	Weapons, utensils Housing, decoration Costumes
	- Metals (pure, precious, alloys)	Casting, forging Jewellery-making (pouring, hammering, lost-wax, engraving, chasing)	Weapons, tools Various utensils Accessories, mechanical parts Statuary ritual objects Costumes, jewellery Instruments, toys

Figure 15. A material-based classification of basic craft categories (image from [113]).

6.3.1 Materials

One of the principal ways to classify and taxonomise crafts is through the material(s) that they use. A typology of materials is the point of departure and indicates the types, names, and qualities of materials per craft. Such a reference is provided by UNESCO in [113]. An overview of this taxonomy

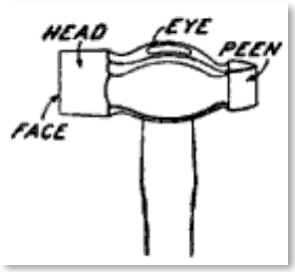
is shown in Figure 15, classifying craft as to their origin into animal, vegetable, and mineral, associating techniques and objects to each type of material.

Nevertheless, such guides are for a general orientation. Each craft has its own subdivisions of materials and, thus, this taxonomy on craft materials is useful, as a preliminary guide. Individual craft disciplines have more specific vocabularies. In many cases nowadays, the naming of materials is standardised by legislation, based on their composition and other features. For example, the Regulation No 100/2011 of the EU Parliament defines the precise fibre names and related labelling, in this way.

Besides composition, indigenous or high-quality nature of raw materials contributes in the reputation of derivate craft products.

6.3.2 Tools

We extend the generic class of object to specialise for items and craft products. The knowledge elements formed in Step 2 that correspond to objects, provide information about the type of object, its dimensions, etc. The feature that is added in this step is related to the use of objects, whether tools, machines, or products, within the context of a craft.



Parts of tools are important and are annotated at this step. In this way, we can represent which part of an object is the handle, how is the striking part of a hammer called (face). The inset figure illustrated the parts of a hammer[7].

Another property that is represented is how the object is held and, eventually, used. We, thus, annotate the 3D model of the object with the information of grip points. As an object may be used in multiple grips, singlehanded or bimanually, multiple grip points are allows (but only up to two hands). Contact points may form regions upon the surface of an object, such as a drinking glass whose usage location is anywhere upon its rim.

We use an extended notion of “grip” to treat objects used by other body members than the hand(s). We call object “contact” points the class of contact points, which include grip points, but refer to all body members. An example is a treadle, which is used with the foot, or a glassmaker’s blowpipe, which is used with the mouth

In addition, for each object we define a coordinate reference frame. This is essential so that later on, we can associate grip postures with tools and demonstrate their grasping or usage. The coordinate system may of arbitrary choice, but it is more practical to be selected at the middle the 3D bounding box of the object. It is also of practical utility to select bounding box to be the one with the least volume, meaning that it should be aligned with the principal axes of the object.

6.3.3 Products

[7] Image from: https://en.wikipedia.org/wiki/File:Peen_hammers.png

A significant proportion, or even the majority of craft products, is utilitarian items. As such they have several attributes in common with tools, such as usage locations, parts, etc. Craft products have also artistic dimensions. From these dimensions, they inherit respective attributes, such as material composition, association with specific style etc.

The specific materials of craft products are also of representation importance. The origin or preparation of raw materials, can be relevant to their reputation and, thereby, the valuation of the craft product. Sometimes the process for preparing a material is a well-kept secret, such as the colouring recipes for glassworks, in Murano, Italy.

The techniques used to create and decorate an object, as well as whether it is handmade are further attributes of its classification.

Last but not least, crafts carry Heritage, whether this is a local tradition, collective memories and values, or local components such as style and choice of materials or colours. Thereby, craft products are associated with the origin and community of production. Their visual content, such as motif or decoration, may refer to a component of local tradition, such as a legend, a historic figure, a location or origin, or the symbol of a collective value.

6.3.3 Workspaces and sites

In terms of material digitisation, workshops, workspace environments, and other craft sites (i.e., material preparation sites) are reconstructed, similarly to other environments, whether indoor, outdoor or both (see Mingei-D2.2). The digital acquisition of such spaces in useful to capture typical or historic sites that are related to the craft of study.

In terms of digitising intangible aspects, it is important to represent that

- Workshops are associated with pieces of equipment and machinery they contain
- Several types of craft workshops exhibit a spatial arrangement of this equipment, which is designed to facilitate craft practice.

Geography of workshops is a methodology used during the fieldwork with the craft community to understand the relation between the body, the tools, the matter and the space when the craft is performed. Using the general frameworks of the “operational sequences” of action [127] the ‘choreographic’ dimension of movement can be mapped in the 3D reconstruction of the workshop as fundamental characteristic of a craft practice. Because craft knowledge is mostly non-verbal, this methodological tool is very useful to define and document the technical gesture of a craft.

Understanding of the geographical environment whether rural or urban has been often relevant to various expressions of a craft, such as whether the minerals, flora, or fauna are appropriate for the production of raw materials, whether there is a waterway that facilitates trade, or whether a community has to follow a fortification architecture for their settlements, in order to protect their products from piracy.

6.2 Roles and Actors

Many crafts are practiced by a single practitioner. Nevertheless, since the antiquities and until the recent past, families created utilitarian items for their own use. One of the most common ones is cloth, while the respective wool or cotton was produced at the family's own cottage. Distribution of work within a family or community was often gender and age based.

Informally, craft roles can be thought as positions in team sports; e.g., a goal keeper, a centre back etc. Each role is associated with a set of jobs, governed by different difficulties, and requiring different skills.

During the 15th century, the "putting out system" or "cottage industry" set the basis of mercantilism. In the late 17th and the early 18th century, a change started to take place in Europe. Cottage industries started giving way to industrialized craft workshops, which targeted maximization of production through role specialization and the use of machinery, typically of substantial size that could not be hosted domestically. New roles appeared due to the knowledge and experience required to use a piece of machinery that was specialized for a specific task. This proto-industrial system gave its way to the factory system after the Industrial Revolution, introducing additional roles in the domain of human resource management and marketing.

The concept of on-the-job training leading to competence over a period of years is found in any field of skilled labor. Up to the recent past, the training of practitioners was performed through apprenticeship. In many cases, a license to practice in a regulated profession could only be obtained through a formal apprenticeship, which had the legal form of a contract. Apprenticeship lengths vary significantly across sectors, professions, roles and cultures. People who successfully complete an apprenticeship in some cases can reach the "journeyman" or professional certification level of competence. Although journeymen have completed a trade certificate and are allowed to work as employees, they may not yet work as self-employed "master craftsmen". A master craftsman was an elected member of a guild. Eligibility criteria were to produce a sum of money and a masterpiece before joining the guild. If the masterpiece was not accepted by the masters, he was not allowed to join the guild, possibly remaining a journeyman for the rest of his life. Nowadays, the role of journeyman is more closely described by the term assistant.

In our representation both the entity of a role is associated with the tasks to be performed by the corresponding role.

6.3 Actions – Event schemas

Artefact creation is represented as a set of interrelated processes. In turn, processes are comprised from actions. **Actions**, or **event schemas**, are abstract events and they can be hierarchically and recursively decomposed into simpler sub-actions. The (proper) execution of an action is an event that follows the schema of that action.

A mereological representation of an event schema gives the way in which events conforming to that schema are decomposed into smaller events, which are linked to the original event. The decomposition can be applied to sub-events, leading to a hierarchy of schemas that starts from a coarse description down to a fine analysis of very simple actions. This coarse-to-fine analysis follows perspective of the practitioner. The decomposition of actions into sub-actions is in a one-to-one correspondence with the practitioner descriptions obtained in Step 1. In particular, the

decomposition of actions follows the verbal description of the practitioner. We stop the decomposition, until we reach the level of detail of simple actions that a practitioner can identify by name. The finest sub-actions are gestures, such as “grasping a hammer”, or “one strike of the hammer upon a nail”. That is, we decompose actions from coarse-to-fine representation, until we are able to explicitly identify the actors, objects, and basic gestures that actions are comprised of.

Actions are associated with the knowledge elements that represent the tools, gestures, machines etc. required to create a sufficiently detailed representation of the action. Moreover, actions that entail tool or machine usage include at least one preferred gripping posture for that object.

The coarse-to-fine decomposition **simplifies** the **association** of semantic descriptions with visual representations. Using the segmentation of visual data into actions, we associate the semantic representation of actions, with corresponding media segments that contain the demonstration of this action by a practitioner. In handheld tools, a proper grip is usually critical. To represent tool gripping we use the same approach as illustrated in Figure 16. Defining gripping postures is facilitated by the MoViz editor that is presented in Mingei-D5.2.

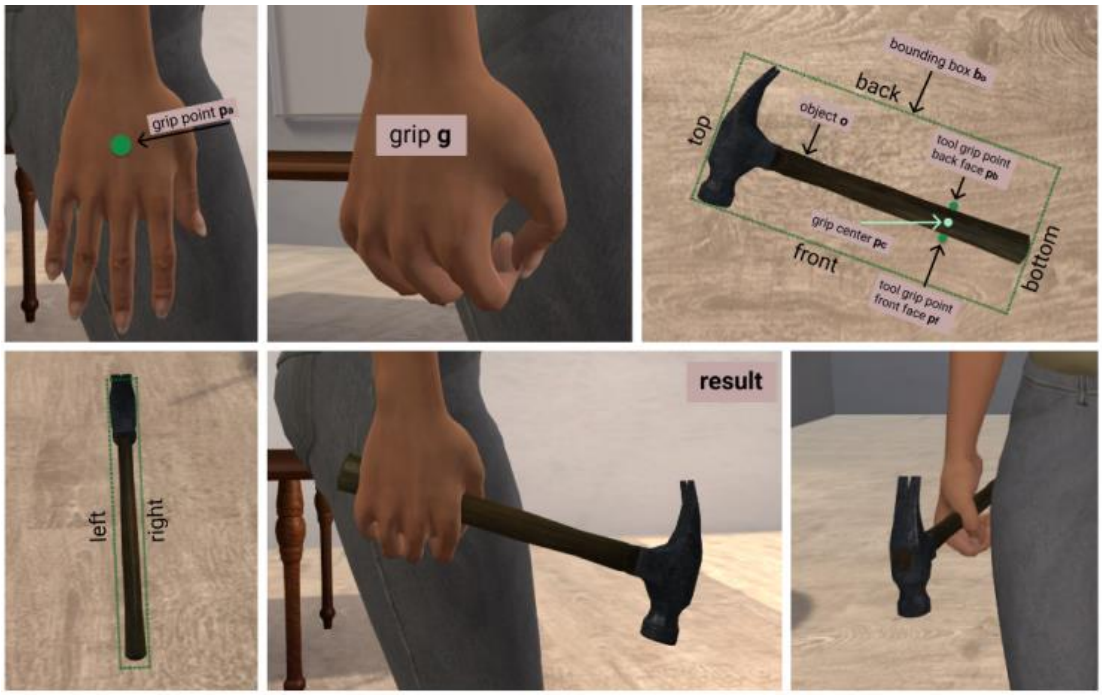


Figure 16. Modelling tool grip (images from [185]) .

Composite spatial arrangements can be also represented as a set of postures of specific actors. In the weaving example below, the actors (hands and shuttle) are found in 3D and their relative spatial arrangements of gripping postures posture is encoded, as rotations and translations is 3D space. In this task, derivative digital assets have an important role, as they include the estimation of the 3D pose of hands and objects from images or MoCap recordings. In Figure 17, this is illustrated. The 3D model of the shuttle (left) is detected in the video and its location estimated in 3D space (middle, right). Correspondingly hand poses are estimated in space. The right panel shows these estimates and predicts the occluded parts of the shuttle, to facilitate its pose estimation. See Mingei-D5.4, for the utilised hand and object detection approaches.

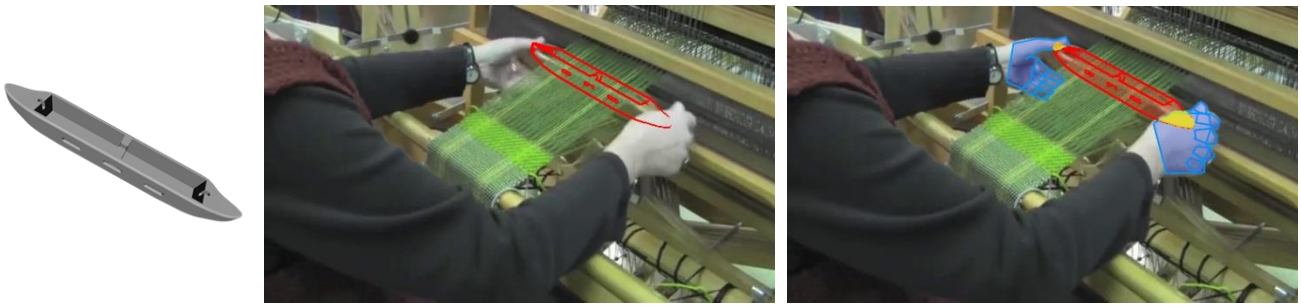


Figure 17. The hand-weaving workspace and its actors (image from [184]).

6.4 Process schemas

Craft processes are represented as the organisation of actions of craftspeople. In Step 1, the relation of human, tool and material were observed in detail to describe the process analytically. Analytical description leads to representation of craft processes as **process schemas**. Process schemas are descriptions of the structures of activities that typically manifest following the same structure. Examples of such activities are wedding ceremonies, musical fugues, or soccer games. An occurrence of the schema is a set of (occurred) events that conforms to the schema. Certain events have all the same structure. Process schemas are **descriptions** that give the structure of events.

The elements of process schemas are hypothetical actions, organised in processes. Inside a schema, actions are related to each other temporally, causally, and hierarchically. The implementation contains also links between the actions and conceptual objects. The digitisations of craft activities are recordings that contain these actions. Knowledge element digitisations are linked to conceptual actions as their instances.

We borrow this notion to represent craft processes, which follow a pattern. A process schema can be thought of as a recipe. It contains the actions that must successfully be performed to obtain the result. Though abstract, the schema may determine specific quantities, such as time, weight, length, temperature.

The activity of a practitioner hammering a nail is an “actual” event. The actual event conforms to the event schema that describes the hammering of a nail. The patterns of events that represent craft processes are called *process schemas*.

6.4.1 How are process schemas represented?

Axioms are used to express the knowledge about a phenomenon. Event schemas are represented as groups of axioms that describe event structure. Such **axioms** regard the:

- **Mereological representation** of events and properties in sub-event and sub-properties
- **Rules** that govern the craft process, e.g., there is a *exactly one* first half-time, but at *most one* overtime in a soccer game, in a soccer game,
- **Temporal order** such as that the first half is *before* the second half, in a soccer game.

Relative **temporal** relationships are represented using the 13 relationships of Allen's algebra on time intervals, which is mapped to relationships in the CRM vocabulary (i.e., *equal in time to, finishes, is finished by, starts, is started by, occurs during, includes, overlaps in time with*, etc.). The relative nature of the representation does not prohibit the use of specific time quantities, such as for example the amount of time needed to fire a clay body.

Of relevance are also **relative spatial relationships**, such as the layout of tools on a workbench or the machinery in a workshop. Like abstract temporal representations, specific quantities can be represented.

Like in so many other activities, in crafts there can be more than one way to perform a task. We call a **technique** is way of carrying out a particular task. Techniques may differ in the gestures performed, the tools employed, the materials utilised, whether a machine was employed etc. A technique may have been developed and practiced by an individual, or be a regional (local) technique or, finally, one of many universal techniques to achieve the same task. To treat the representation of multiple techniques, we use the same concept. Thus, we represent individual techniques by creating **individual schemas** for each one of them.

6.4.2 An example schema

We provide an example of choose a wool fabric manufacturing process. Very simplistically and for the sake of example, we model the process in two steps

1. Spin cotton into thread (Spinner)
2. Weave threads into textile using a loom (Weaver)

and focus on the second.

The weaving process is decomposed by weavers into 3 actions, which are repeated to produce each thread of weft [1]:

(i) **Shedding**: warp threads are separated to form a shed by stepping on the treadle,
(ii) **Picking**: weft is passed across the shed by shooting the shuttle across it, and
(iii) **Beating**: weft is pushed against the fabric by pulling the beater.

These above **textual descriptions** were created collaboratively in Step 1 and (a) identify the machine interface components and (b) human body members involved. The physical interface components of the loom are the shuttle, treadle and beater. The human members involved are hands and one leg or two legs, depending on the type of the treadle.

In Figure 18, we illustrate the representation of the process. In the left one sees a verbal and schematic description, which is compatible with the description of the practitioners. In the middle, we see a frame of the associated scene segments that contain each action of the process. In addition, the corresponding human motion is visualised by superimposition of the motion skeleton on the image frame. On the right, the semantic representation is visualised.

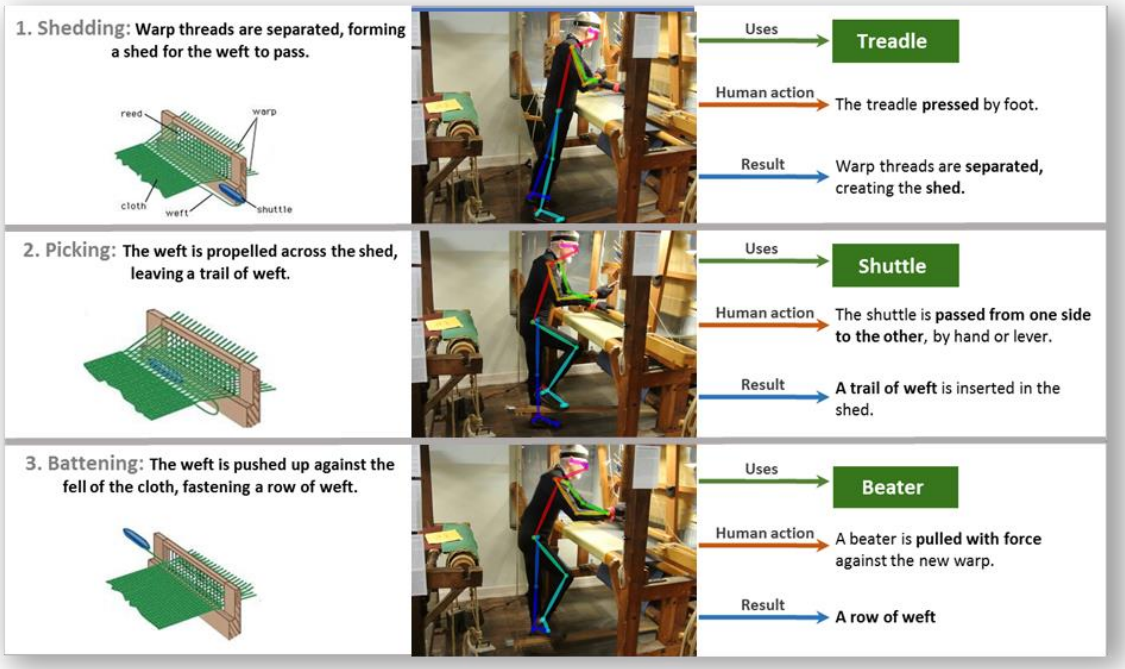


Figure 18. A process schema comprised of three actions (image from [184]).

The proposed representation associates

- Visual data from sensing modalities.
- Verbal semantics of objects and actions in the recoding.

By doing so, we can use the semantic representation to access the corresponding visual data by content. Most importantly, the annotation of visual data with semantics is the first step of training a computer to recognise pertinent objects and events.

6.4.3 Judgement and decisions

A characteristic component of many processes is that they may contain branching points, as to the steps that are to be followed. The decision to take one action or another relies on the judgement of the practitioner and can be influenced by a range of factors.

The outcome of such decisions may vary as to the time scale. For example macroscopic decisions, such as agricultural, refer to a course of action over the next months, based on observation of the previous months. On the other hand, the work of a glass worker may require taking decisions in very short time, because they are related to the constantly changing temperature of the glass.

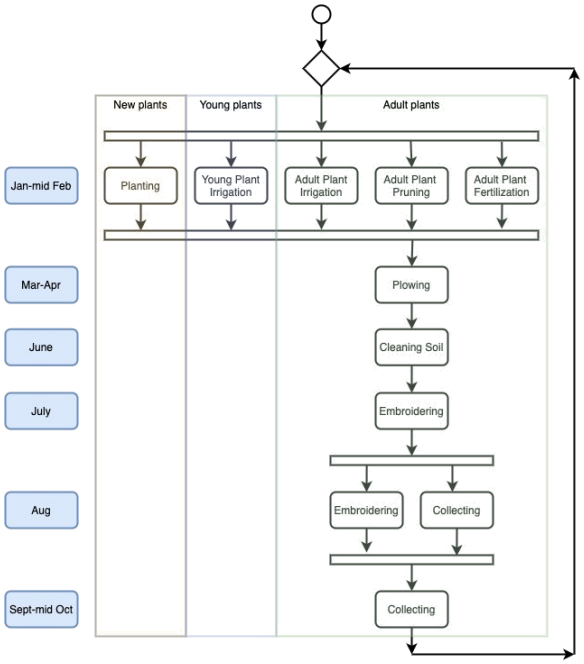


Figure 19. Annual mastic cultivation process (image from [187]).

The elements of process schemas are hypothetical actions, organised in processes. Inside a schema, actions are related to each other temporally, causally, and hierarchically. The implementation contains also links between the actions and conceptual objects. The digitisations of craft activities are recordings that contain these actions. Knowledge element digitisations are linked to conceptual actions as their instances. The Mingei Online platform facilitates the description of craft process, analysing them in steps and defining the temporal or logical relationships between them. Each step and sub-step can be further analysed, thus enabling the modelling of craft processes, whether linear and simple or complicated with a deep hierarchy of actions.

For each process the curator fills-in a title and a description. By default, the execution order for any process step is set to be “Any”, not imposing any restrictions at first. All steps are listed in the order in which they were provided (see Figure 20). Once a step is listed, the curator defines its execution order, edit, or delete it. The tool provides support for additional material to describe each step in the form of textual guidelines, images, instructional videos, as well as the option to preview the graphical visualisation of the process as it has been defined in the form of UML diagrams.

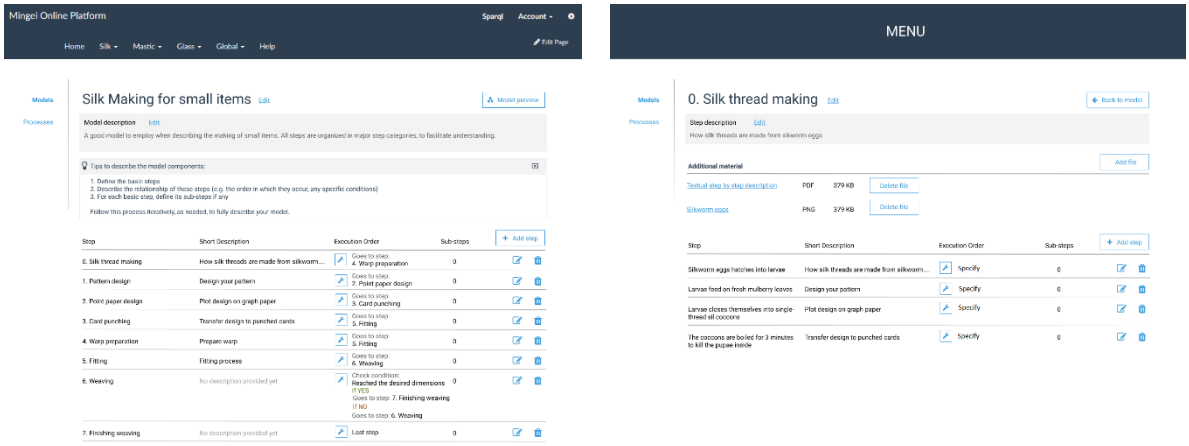


Figure 20. Example of a process (left) first level of (right) sub-steps of the first step (images from [188])

The execution order options that are provided by the tool are explained in Table 1 below.

Table 1. Execution order options.

Order option	**Short description**	**Parameters**
Goes to step	Sequential ordering of steps	Next step
Goes to parallel steps	Connection of steps that run in parallel	• Steps that will run in parallel. At least two steps have to be defined.
Waits for	Connection of steps that run in parallel and definition of the next action once they are all completed	• Steps that have to be completed before taking a next action. • Definition of the action that will follow, by selecting an order option for the next action (goes to step, goes to parallel steps, waits for, condition checking)
Condition checking	Denotes focal points in the process, where the craftsman will check if a condition is met before proceeding	• Condition that is examined • Execution order of steps if the condition is met • Execution order of steps if the condition is not met

In Figure 21, the steps of defining the most complex option, that of condition checking, are illustrated. The figure illustrates the steps of dynamic GUI adaptation depending on the order option selected.

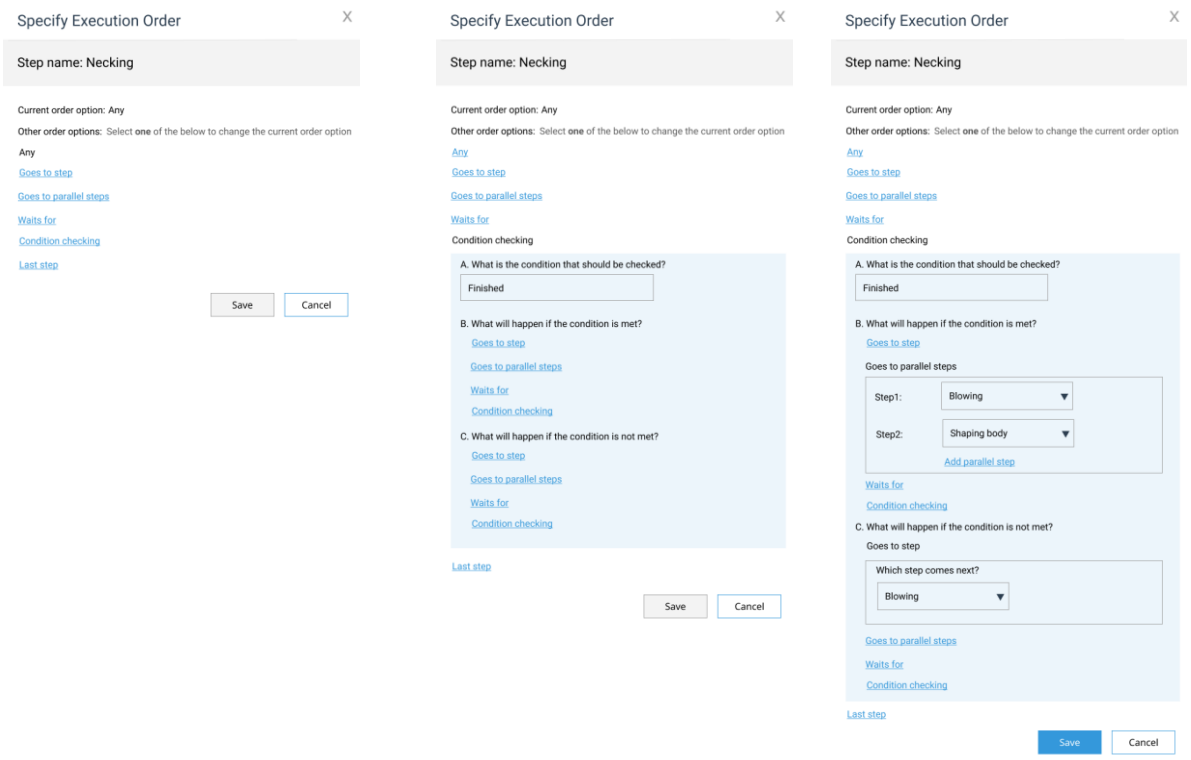


Figure 21. Definition steps of condition checking (images from [188]).

A problem in the full representation is that it includes the judgement of individual, which as discussed earlier currently comprises a limitation. In addition, some basic measurements, such as force, can be challenging to obtain using visual or even MoCap modalities. In this context, assets that contain digitisations of the original sources are more than essential. They are a way for an observer to understand or re-enact the experience of the practitioner. Through semantic linking the Mingei ontology associates the representation of actions, with the original assets (literature, testimonies, documentaries, etc.) upon which this description is based.

6.5 Craft context

Craft context representation is based on stories that are built from events and knowledge references, to represent social, technological, economical, or cultural changes, which relate to the representation of a craft instance. In Mingei, fabulae are our building blocks for creating a representation that documents and captures the set of stories that required to be covered, in order to provide a comprehensive picture of the socio-historic context of a craft instance.

Stories that are of direct relevance to craft representation are historical events that have influenced the history and economy of social groups, technological advances, and artistic movements.

6.5.1 How do we represent history?

The term *fabula* has been introduced in Narratology to denote the series of happenings, in chronological order, that together make up a narrative. A fabula is an **abstraction** that **represents** a set of **facts** that have happened in the world and which entertains a contextual topic in a

chronologic form. More precisely, a **fabula** is *a set of coherent phenomena or cultural manifestations occurring in time and space.* Intuitively, fabulae are representation of stories, from an objective point of view, in a chronological order.

Fabulae represent the history of what has already happened and are comprised of events. These facts are **connected** to each other in a way that makes them a **story**. The fabula is conceptual. By telling or writing it, we are only reciting narratives of "what happened", by whom, where, which way, etc. This fabula may encode causal relationships, as to why something happened; i.e., the Industrial Revolution resulted in a reduction of the number of weavers. All these existed in reality as part of the fabula, but the fabula is gone forever, all we have are narrations and documents that we use to reconstruct the fabula. As Umberto Eco quotes, "*Stat rosa pristina nomine, nomina nuda tenemus*[8].

A fabula differs from a sequence or graph of events that reports on the history of a topic. The difference is that beside temporal and mereological, events can be connected by one more important type of relation:

1. A **mereological** relation, relating events to other events that include them as parts, e.g., the birth of Dante Alighieri is part of the life of Dante.
2. A **temporal occurrence** relation, associating each event with a time interval during which the event occurs. We formalize these relations between events using the Allen's temporal logic.
3. A **causal dependency** relation, relating events that in normal discourse are predicated to have a cause-effect relation in the narrator's opinion, e.g., the eruption of the Vesuvius caused the destruction of Pompeii.

6.5.2 Representing fabulae

Everything the curator creates is based on narrations and research. These include not only the **causal relations**, but also the **selection of the events** that are part of the fabula

Let us call Danae the curator of the representation of a fabula. Danae may be a person or a program. Danae looks at several narrations of the story. These narrations may be testimonies or published research, in which Danae might have participated. Then, Danae builds a representation of the fabula. In so doing, she gives an account of what happened in reality (the fabula), based on the studied resources. Danae transduces the words, images, gestures, from the narrations she read, watched, or listened and expresses them as logical statements.

In this way, a logical reconstruction of the fabula is created which can be digitally stored in machine interpretable format. This reconstruction of the fabula includes Danae's account of events, encoded in the causal relationships that she has established. In Mingei, this transduction, or fabula authoring, is provided by stakeholders, based on the study of the manifestation of the HC to be represented. A **critical part of the representation** process is a **digital curation** process.

6.5.3 The added value of historic consistency

[8] The primigenial rose exists only in the name, we possess only bare names.

An assumption that we make during the protocol application is that historical events provided by experts are accurate. The ontology sanctions as inconsistent contradictory properties on events, for instance that an event is at the same time a cause and an effect of another event. This is in fact an inconsistency if the contradictory statements are asserted in the context of a single narrative, and this is clearly unacceptable. In contrast, if the contradictory statements are asserted each in a different narrative, then no inconsistency arises, the two narratives simply give different accounts of the same story, which is not at all an inconsistency.

Given this assumption, multiple fabulae can co-exist in the knowledge base focused on different and multiple topics of study. Nevertheless some fabulae may refer to the same events and other knowledge elements. As such, prior existence of knowledge elements reduces the work of authoring of new ones. Let us consider the event of the invention of electricity. This event had impact on the expression of many crafts. For example, in ceramics and glass-making, the use of wood furnaces caused the creation of smoke. In turn, this made workshops to be placed outside the town or village, which is not the case anymore, after the invention of electricity. Thus, the invention of electricity is an event that is relevant to the context representation of at least two crafts (pottery and glassmaking).

In this way, events that supersede the context of a specific craft can be directly linked in multiple fabulas describing the context of multiple crafts. We are interested in identifying craft context relevant to European history and, conversely, the impact of craft evolution on European history. Thus, the representation is used to enter general events beyond the immediate craft context, such as the Industrial Revolution, which contribute in the documentation of others as well as a part of European history.

6.5 Implementation

The outcome of this step is the set of fabulae and processes that represent a HC. These are authored on the MOP. In Figure 22 the initial panels for authoring a fabula and a process schema are shown. Analytical presentation of the GUI with respect to the use cases, is provided in Mingei-D4.2.

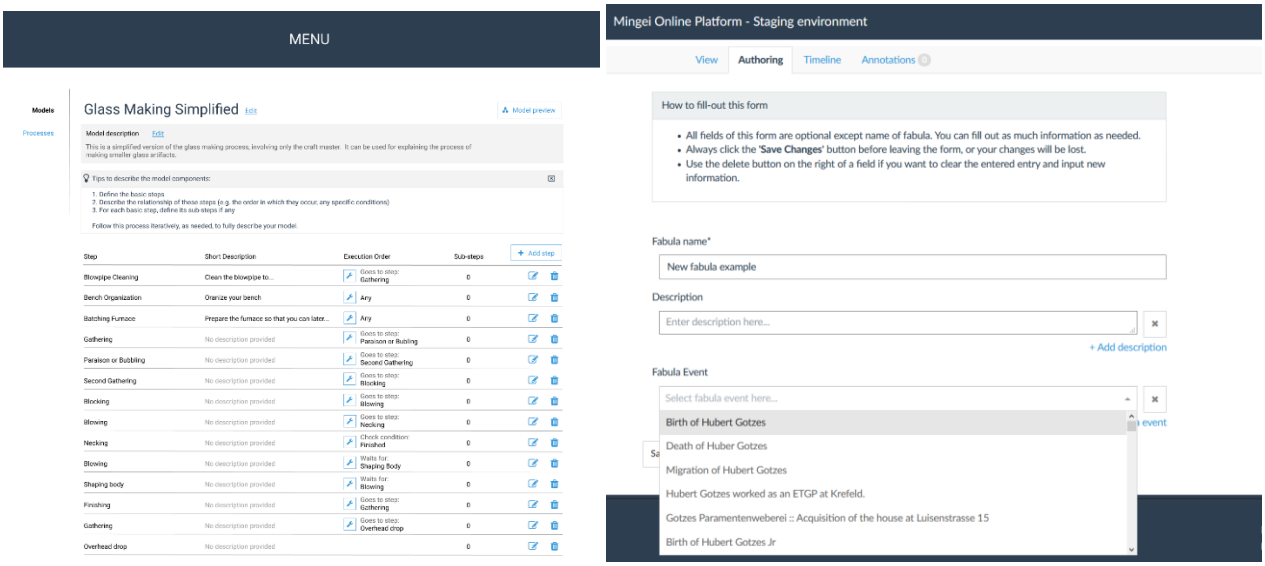


Figure 22. Left: editor for an ordered list of actions that comprise a glassmaking process. Right: fabula authoring form, showing list of events that can be linked to the fabula (images from Mingei-D4.2).

7. STEP 4. Narratives

In this step, we create the stories, which will be used to present a comprehensive picture of the represented craft. The craft representation contains two types of stories: event schemas that represent **craft processes** and fabulae to represent **craft context**. Using this couple of methods we create storytelling and educational content that covers tangible and intangible craft dimensions and provide a comprehensive picture of craft processes and context.

Whereas in the representation of knowledge our concern was to formally represent knowledge, in the step we focus on presenting knowledge in a human comprehensible manner.

In this task, we follow again the layout of narratives, as seen from the practitioner perspective. For processes, this is insured by the demarcation of process actions by the practitioners. For craft context, we obtain multiple narratives from multiple perspectives and work with the communities for the appropriation of their presentation. As in Step 1, the collection of stories and processes is provided in the form of topics of interest to be presented, though co-creation and anthropologic research. These narratives are reported in Mingei-D2.3.

The accuracy of the delivered content in the knowledge base is central. The stories to be presented are derived from the craft knowledge, collected in the previous steps and stored in the knowledge base.

7.1 Narrative representation

The primary content of these stories is the verbal content of the narration. This content is created through accessing the representation of the events that comprise the story and retrieving the associated knowledge elements, about the people, places, and objects that are of relevance.

The presentation of a story can be delivered in multiple ways, for various audiences, and through a multitude of presentation modalities. We systematise the production of these stories, using the concept of the narrative. A **narrative** is an abstraction that includes one or more narrations of a fabula, as created in Step 3. A **narration** is a way to tell the story that is encoded in the fabula. A narrative consists of three main elements:

1. A **fabula** or a **process representation**
2. **Media objects**, utilised in narration.
3. A **reference function** that provides an ordering of a subset of events in the fabula. The sequence of events as ordered by the reference function enables derivation of the **plot**.

Similarly, a **motion-driven narrative** is an abstraction that includes one or more executions of a **craft process**.

The events or event schemas that are references through the narrative, are associated with knowledge elements and digital assets, which can be retrieved to illustrate the narration. Thus, in this step we create and organise the content that will be utilised in these presentation. Through the reference function, narrations are associated with events and, in turn, with knowledge elements

and media objects. This way, craft narratives are linked to digital assets that can be used in the narration or serve as references to the sources of information provided in the narrative.

Individual **narrations of a narrative** may differ as to a range of aspects. Prominent ones are:

1. Individual narratives focus on different subsets of events that comprise a fabula.
2. The narration is adapted per user interest, language, age, or special needs.
3. Narratives are adapted to the specific medium and its format.

7.2 Content organisation

The organisation of events in the knowledge base and its search capabilities can be used as an aid in the creation of accurate narrative. To explore potential presentations and narratives, we provide temporal and spatial organisations of events that can be the basis of narratives.

A **temporal organisation** registers events on a timeline. Narration segments are deployed along channels the temporal dimension of the presentation, in a historic plot. In this way, the presentation of narration segments can be visualised on a timeline. Individual channels correspond to individual sources of audio or video input. The author of the narration may select which audio and video segment is played along with the narration. Events can be accessed in the form of a timeline where the operator selects the events to include in the narrative. The events populating the timeline can be the result of a search. In the example of Figure 107 shown is such a case, where the timeline shows events that occurred in Krefeld and at which any member of the Gotzes enterprise participates.

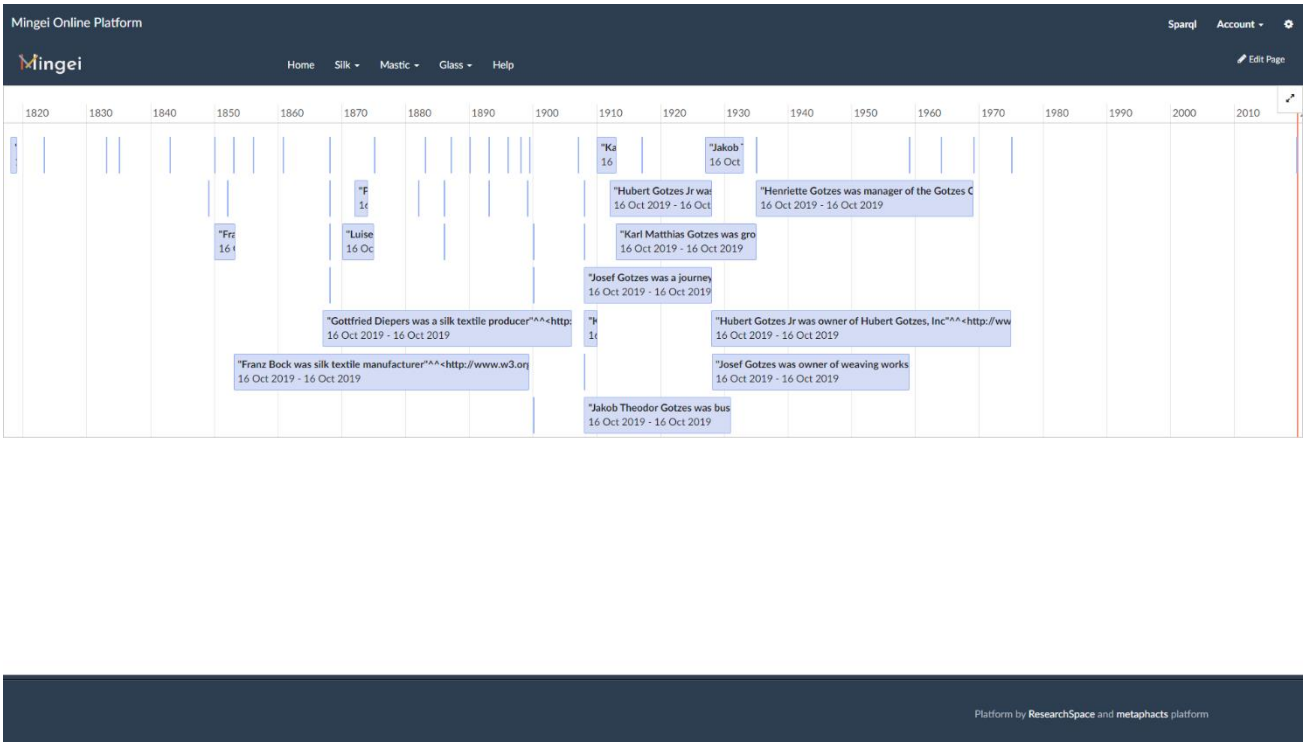


Figure 23. A timeline of events (images from [188]).

The **spatial dimension** registers events and narration segments upon a spatial reference. This can be either a geographical region or a mapping of a craft workshop. In this way, narrative segments can be associated with regions upon a map structure (that of a geographical region or that of a workshop) and be presented in an exploratory nature.

Like in the temporal organisation, the results shown in the example below are the result of a query. The resulting page is shown in Figure 110. Shown are events related to the narrative of the Krefeld industry, during the 19th century. Naturally, the majority of events are located in Krefeld. But, the location of the rest of events are not at all random. They are situated along the Rhine waterway, which facilitate trade across cities. Neighbouring Aachen is relevant also, as it was of the first locations to connect by train to Krefeld.

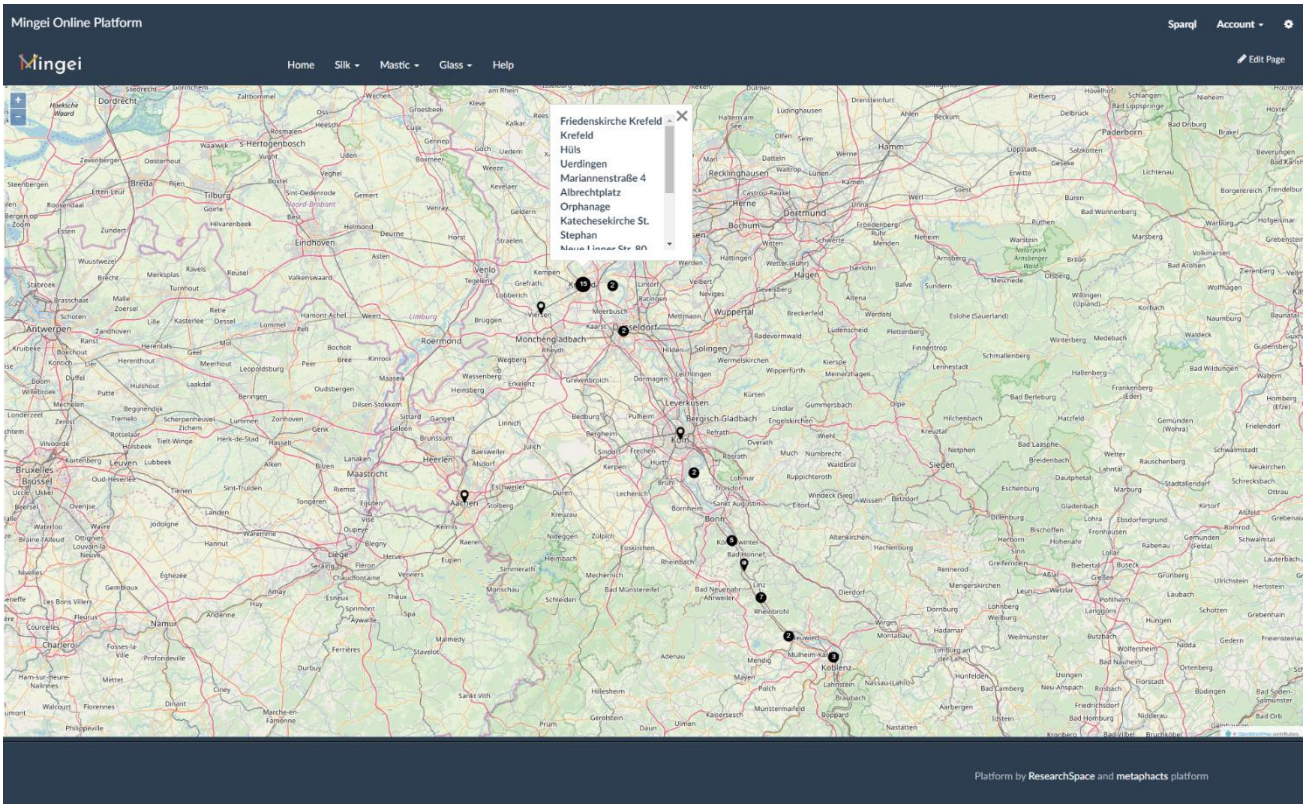


Figure 24. Access a narrative as a geographic map (images from [188]).

7.3 Motion-driven narratives

Motion-driven, or process, narratives are narratives that present craft process schemas. Thereby, human actions and their effects are of relevance.

Besides show audio-visual recordings of the process, to further facilitate and support human interpretation, objects and actions are reproduced in 3D, in a Virtual Environment (VE). In this VE, human action is re-played from motion recordings and Virtual Humans (VHs) animations. In this way, the human motion and handling of tools and machine can be seen from multiple viewpoints and better understood.

The induced motion of the machine interface components is inferred, from motion recordings of the human operator and context-dependent knowledge on the machine. The analysed craft processes are represented in the form of a motion vocabulary of the studied craft, where each of its entries is a craft action. Our contribution lies in the proposed approach, for the transfer of knowledge about machine usage from the physical to the digital world.

Typically process narratives follow a temporal order, much like the presentation of recipes. Still, the authoring of narratives does not provide any restriction in presentation order. This is useful in order to present processes occurring in parallel, by more than one person.

7.2.1 Human motion

An initial inspection and analysis tool supports the incorporation of human gestures into narratives. Human Motion Analyser is a software tool for analysing and editing recordings of human recordings, which may original either from MoCap or visual tracking. The component is in detail in Mingei-D5.5, Section 4.

This Visualisation and Analytics tool is used to process the output of Animation Studio from the previous step. Where Animation Studio provides segmentation of input into “scenes” that contain individual craft actions, this tool focuses on the particular gestures and human movements contained in this scene.

Thereby, a central component of this tool allows focusing interest into the individual body members that are relevant to the gesture. This is achieved by isolating motion in selected parts of the body member hierarchy. Thereby, in tasks that are performed in a sitting posture, leg motion can be “silenced”, so that focus of presentation is in the hands.

A basic utility of this tool, conversion or repair is usually required in the input of motion recordings. The most frequent ones are:

- Conversion of reference system or conventions
- Noise filtering and interpolation of missing data

Basic derivative quantities such as velocity and acceleration can estimated, visualised, and exported for further analysis. An indicative illustration is shown in Figure 25, where the motion of a weaver is analysed. The right figure shows the trajectory of the motion in 3D from an arbitrary viewpoint that is selected by the user. The motion trajectory of a motion is superimposed over time while acceleration and velocity are computed in each point of the trajectory. In Figure 25, the motion of a mastic cultivator is remapped back to the original video.

It is noted that this component targets the visualisation and editing of direct content of the animation recording. As such a simplistic representation (a “stick figure”) of the human is provided, intended for better legibility and clearer observation of the joints of the animated figure. Moreover, such a representation facilitates the automatic visualization of motion in 3D space and the visualisation of analytics, as well as the facilitation of joint and limb selection. In the next step, these animations are remapped to realistic avatars, in order to provide a more engaging visualisation.

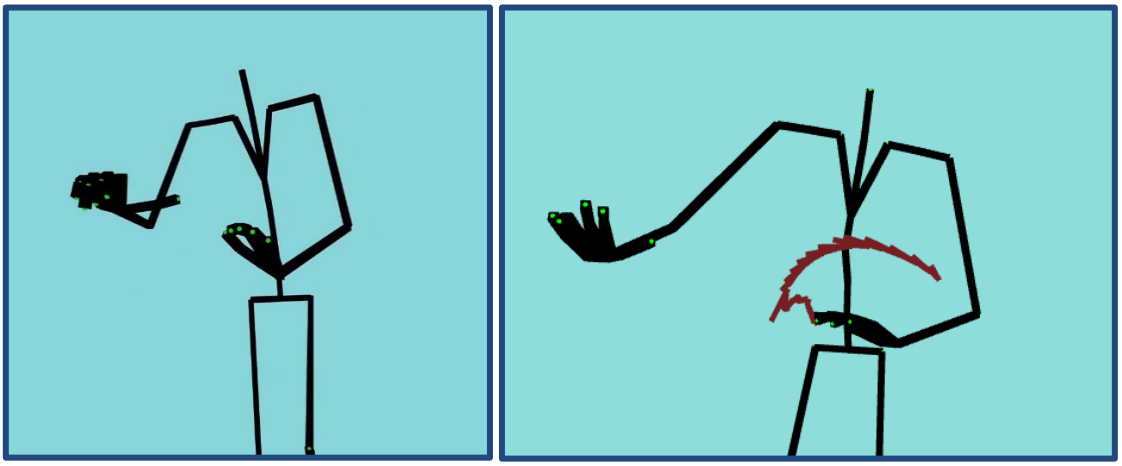


Figure 25. Visualisation of human motion recordings (images from [184]).

Figure 26. Visualisation of human motion recordings (images from [184]).

7.2.2 Machine usage

The involvement of machinery in the development of crafts dates since the antiquities, just to reference the potter's wheel and the various types of looms that have been developed by civilizations across the world. We, thus, represent not only the motion that a practitioner performs, but also its context within an action of machinery or tool operation.

In particular, we utilize the recorded motion to create an effect on a digital model of the machinery and, thereby, illustrate its operation by the specific practitioner. Moreover, elemental movements can be transformed to be remapped to similar types of machinery.

Modeling and simulation of machine operation is a well-studied in mechanical engineering. In our case, it not our goal to model the internal workings of a machine, but reproduce the action of the practitioner. Thus, we model the physical interface of a piece of machinery. In other words, the parts that the practitioner physically operates, such as by pressing a treadle or pulling a lever. This modeling is in one-to-one correspondence with the semantic modeling of the process defined earlier, in Step 1 and as represented in Step 3.

We propose a generic way to represent the physical interface of machines, in a meaningful way that captures the "physical" semantics of the action. Such a way is provided by the Archimedean abstraction of Simple Machines, model any of the basic mechanical devices for applying a force, such as an inclined plane, wedge, or lever. The concepts decomposes any piece of machinery in a set of elemental machines that cannot be further simplified. The advantage of this choice is that simple machines are few and associated with a simple physical model (Newtonian mechanics) that is intuitive and usually taught in school.

We implement Simple Machines in the digital world by enhancing the virtual objects (i.e., 3D models) with "motion rules" that represent the physically feasible motions of the component during operation. In this way, recordings of human motion can be virtually applied to the modelled elements of the machine and set them in, physically consistent, virtual motion. These models, or Fundamental Machine Components (FMCs), are implemented using articulated 3D models, enhanced with the appropriate rotational and translation degrees of freedom to model conventional kinematics of rigid bodies[9].

The MoViz editor that has been developed in Mingei encompasses these functionalities in a user-friendly GUI; it is reported in Mingei-D5.2. Below we demonstrate an example application on a weaving action from the example of Step 3. Using MoViz, the components of the physical interface of a machine, are associated with the body members of the Virtual Human. The avatar and the piece of machinery are "situated" in a common virtual space, such as a workshop. The interaction of the avatar with machine interface is simulated, by importing the motion recording and a model of the machine component.

In Figure 27, the physical interface of a loom beater component is illustrated, along with the description of operation and the predicted effect. A possible grip are of this object has been represented in Step 3, using MoViz and illustrate in Figure 28.

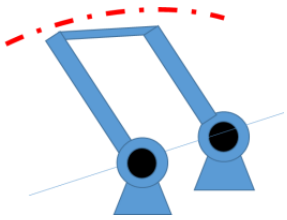
Name	Action	Effect	Model
Battening	**Beater** is **dragged** with force on the new warp.	A row of weft **fastened**.	

Figure 27. A motion-driven narrative of a weaving action. In the figure, the dashed line plots the feasible trajectory of a loom beater after application of practitioner force (images from [184]).

[9] B. Horn, Robot Vision, ISBN: 9780262081597, 1986

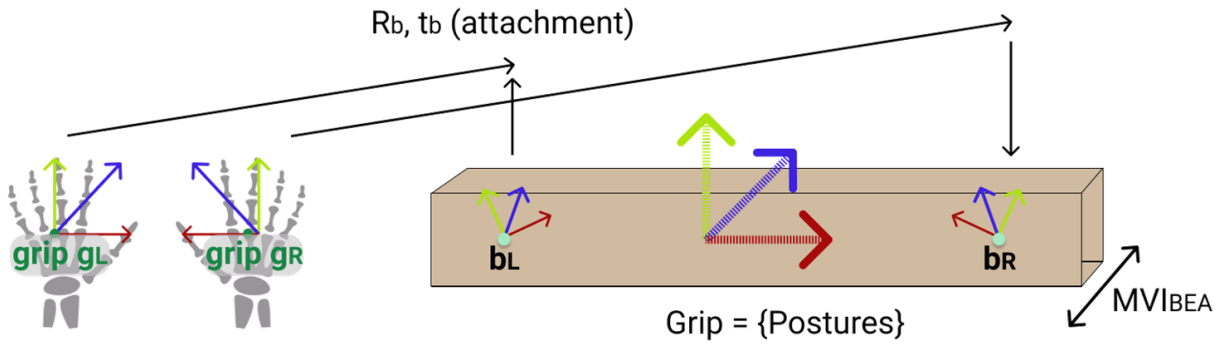


Figure 28. Bimanual gripping posture for a component of a loom's physical interface, or beater (images from [184]).

In Figure 29 (left, middle), the beater component is shown at its two extremal positions. This is the component at which the recorded motion from the weaver's hand will be mapped. In Figure 29 (right), the incorporation of the component in the model of the loom is shown, in blue highlight.

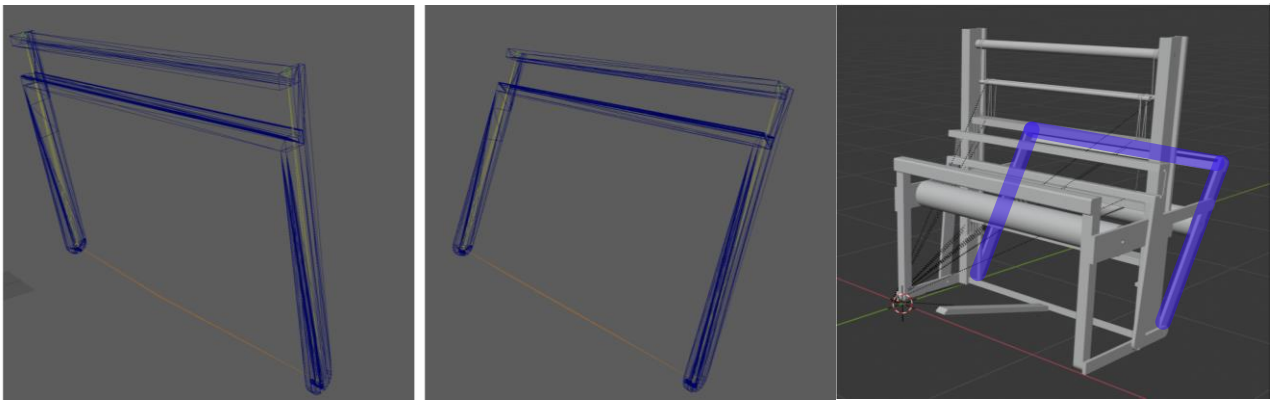


Figure 29: Loom beater model (image from Mingei-D5.2).

In Figure 30, the rendering of the virtual human operating the loom is shown. On the left, shown is the virtual re-enactment of the recorded activity. The detail on the right shows the motion of the second component of the physical interface, the treadle, which is represented using the same procedure.

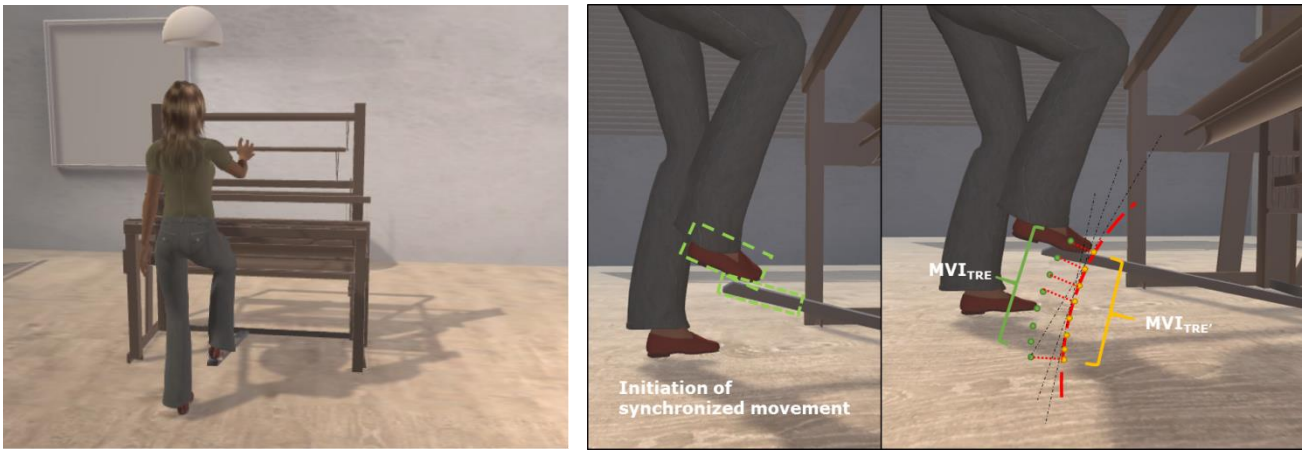


Figure 30. Visualisation of induced motion on a loom treadle (images from [184] .

7.3 Narrations & narration channels

In Mingei multiple media are employed to deliver narrations, starting from verbal and visual and reaching up to immersive and interactive narrations. A narration medium is utilized to communicate the story to the audience.

Our primary communication channels are **verbal** and **visual.** Conventional narration media are voice, text, audio-visual media, and their combinations. Of relevance to motion-driven narratives are the formats of theatrical script and storyboards, as they accommodate a description of the environment, such as a workshop, or an outdoors environment.

The narration of fabulae is implemented using narrative fragments in the fabula. The content of these fragments originates primarily from the digital assets related to knowledge elements. A benefit of using the knowledge base is that updates on knowledge can be propagated the pertinent narratives, without requiring their recreation.

Directing the spatiotemporal arrangement of content in channels entails the selection of which content is presented when, for each channel. Of primary importance is the selection of the medium which determines the way that verbal content is formulated. A primary distinction is through **static** media that can be read or explored and **dynamic** media that either stream or interact with the audience. Correspondingly, different narrations of the same story are created, which are tailored for the respective media and the presentation modalities of the next step. In Figure 31, shown is the primary form for creating a narrative based on a fabula or process schema and the way that events are presented within the fabula (see Mingei-D4.2 for details).

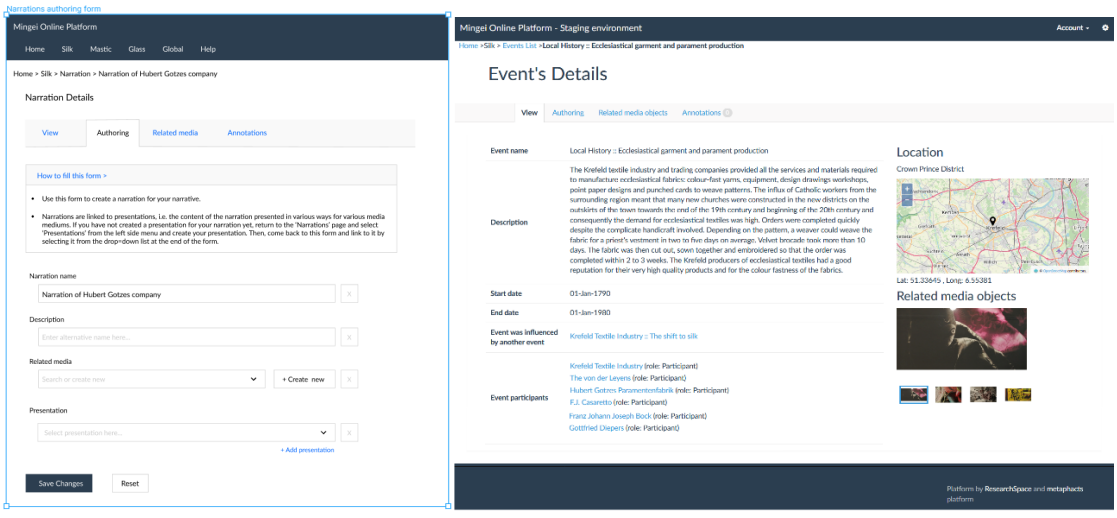


Figure 31. Configuring narration content and parameters (images from [184]).

8. STEP 5. Presentation

In this step, a range of presentation modalities of relevance to craft presentation and presentation are presented. These modalities are tailored to present different dimensions of a craft expression. Thereby, they matched to task of relevance in the context of Mingei pilots and demonstrated.

For these presentation modalities, the MOP is utilized as an infrastructure to provide content to the presentation tools. This content can be digital assets, knowledge elements, narratives, and demonstrations, each one provided through an IRI in the linked knowledge base.

The type of audience is of relevance to the way of presentation. For this reason, co-design with users and stakeholders is critical in the definition of narratives and channels that best suit each type of audience intended. Co-design and evaluation with practitioners and communities ensures that

- Correct knowledge is preserved.
- Knowledge is presented with appropriation to traditional context.
- Contributors have ownership of the outcomes of the representation.

This organisation of documentation is determined by the community based on the insights obtained through collaborative design that is to determine the appropriate and effective ways of communicating craft concepts.

The choice of narration medium is relevant to the use of the content, the intended audiences, and the experiences to be rendered. Depending on content type, an appropriate **narration channel** is required. A narration fragment can be presented in more than one channel. For example, a piece of text may be presented in written or audio form. In turn, audio narration may include dialogue, which can be recited by a single or multiple speakers etc. At the same time, music can be played in the background at an independent audio channel. A mixer may modulate the levels of individual audio channels along time.

8.1 Documentation, informational and narration modalities

HC representation and narratives are availed through the **Mingei Online Platform** that provides access to both *general* and *scientific* audiences. Both access types support appropriate querying and browsing capabilities on the HC representation. These capabilities are provided both in

- a human comprehensible manner through an online, Web-based Graphical User Interface, and
- a machine interpretable manner through open and established standards in Semantic Web technologies, for knowledge representation and interlinking.

Research access to the Mingei Online Platform exposes query mechanisms for digital assets and semantic information. Composite queries are also available, such as ones targeting the monitoring contextual information in time, or comparative assessment of HCs.

Machine interpretability ensures that the collected knowledge and digital assets can be accessed through third party applications without the need of the Mingei Online Platform. In this way,

content can be directly imported and re-used in these applications. Besides conventional digital assets, the Mingei knowledge base contains semantic representations of narratives and motion-driven narratives that can be queried and systematically accessed by software clients.

8.2.1 Craft overview

In Mingei, we offer the tools to facilitate the authoring of content for informational applications. Following, the narrative-oriented and motion-driven narrative organisation of content in Step 4, in this subsection we treat the presentation of content for documentation and informational applications. We recommend a few basic such concepts for such outputs that are availed by the Mingei platform.

The primary presentation method is documentation that maps the contents of a craft representation and provides and overview of the craft and its context. This is provided as a digital, online presentation that provides initial orientation on the craft and its context at the form of an introductory narrative, which provides an overview of the craft instance, in an overview narrative. From this presentation, all narratives, assets, and events are available, in multiple views.

Such are a temporal (time-line), geographical (map-based), event based (calendar), object-based (galleries of artefacts, tools, etc.), person based (galleries of key actors), and so on. All of these are available through “templates” in the Mingei platform. This output is automatically generated based on the digital representation of HC instance, using pre-formulated queries and formatting instructions of output. Informational applications can also retrieve this content online through the Semantic Web interface and use it in their own fashion. Other templates can be customised in research access to documentation and digital assets of artefacts and artefacts collections, to facilitate authoring of curated material for exhibitions and publications.

The example below, shows such a composition used in the Silk pilot. The hyperlinked video, in https://youtu.be/zENuV_1KCxk, reviews an online page customised for access through a computer or tablet. Accordingly, dedicated formats are being developed for narrower screens, through CSS technologies.

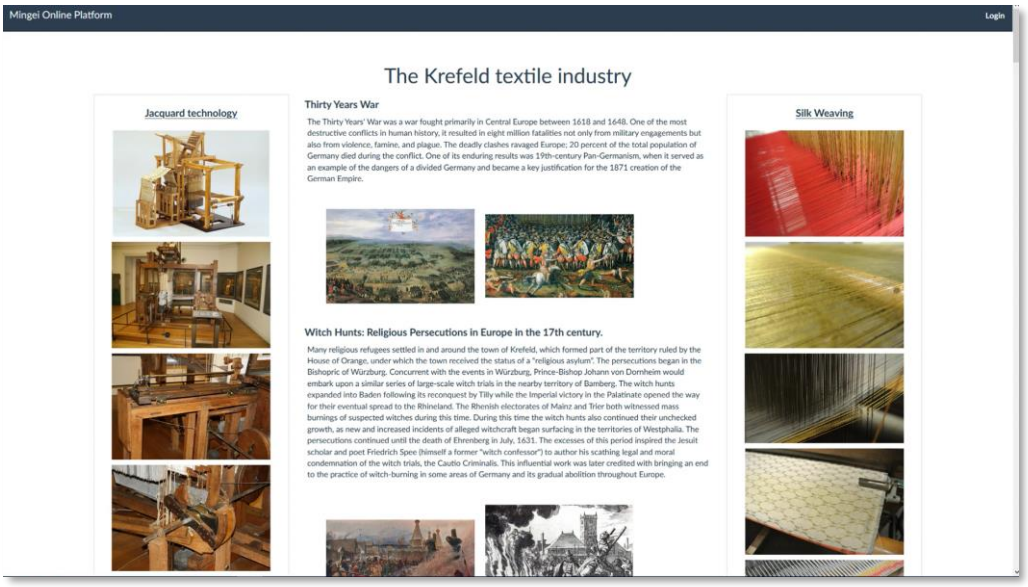


Figure 32.Craft orientation page (images from [184]).

8.2.2 Chronological presentations

The MOP component for time-line presentations were shown in previous example, and Figure 24.

8.2.3 Vocabularies

Visual dictionaries on the terms of craft objects and processes is an introductory tool for acquainting and obtaining background knowledge on a craft. Such a dictionary can evolve into a valuable reference resource that associates, form terms with colloquial and craft jargon, crisp definitions of these terms in formal representation (SKOS), with translations and corresponding explanatory digital assets (i.e., photographic documentation, 3D digitization, video, old depictions). In Figure 33 indicative samples from the Silk pilot dictionary are shown.

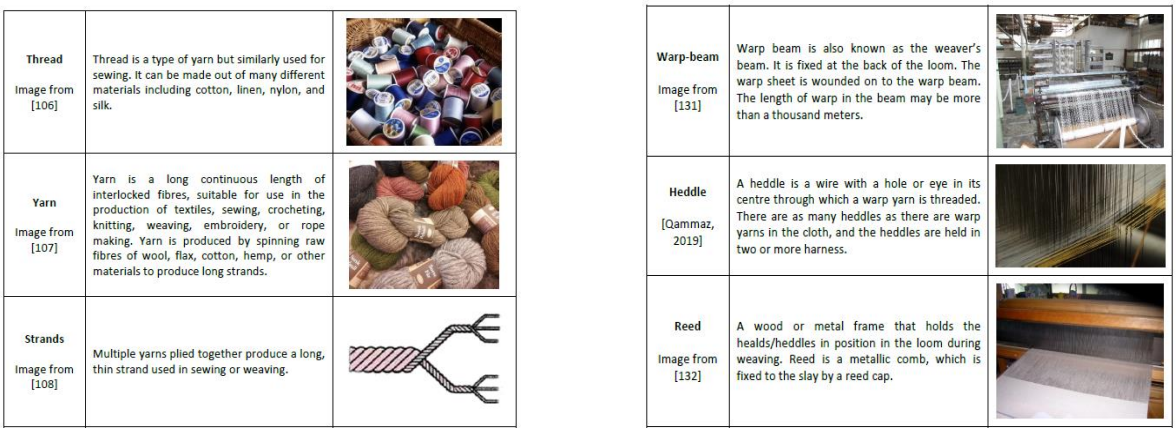


Figure 33. Elements from the dictionary of the Silk pilot (image from Mingei-2.2).

More sophisticated output channels are planned for the project pilots such a *multimedia book*, an *interactive surface*, and a *virtual human* in the role of a *teacher, companion, or guide*.

8.2.4 Virtual exhibits in real places

The **Virtual Museum** modality of Mingei (see Figure 34) presents collections of digital assets in a physical space through interactive projections. The modality is designed having in mind that (a) several museums have a large collection of artefacts in their storage, but not room to display them (b) to represent past period exhibitions, in order to virtually re-visit them, after they have ended. The modality enables interactive inspection of artefacts through gestures, and access to accompanying verbal and visual assets relevant to the exhibit, which are retrieved from the Mingei knowledge base.

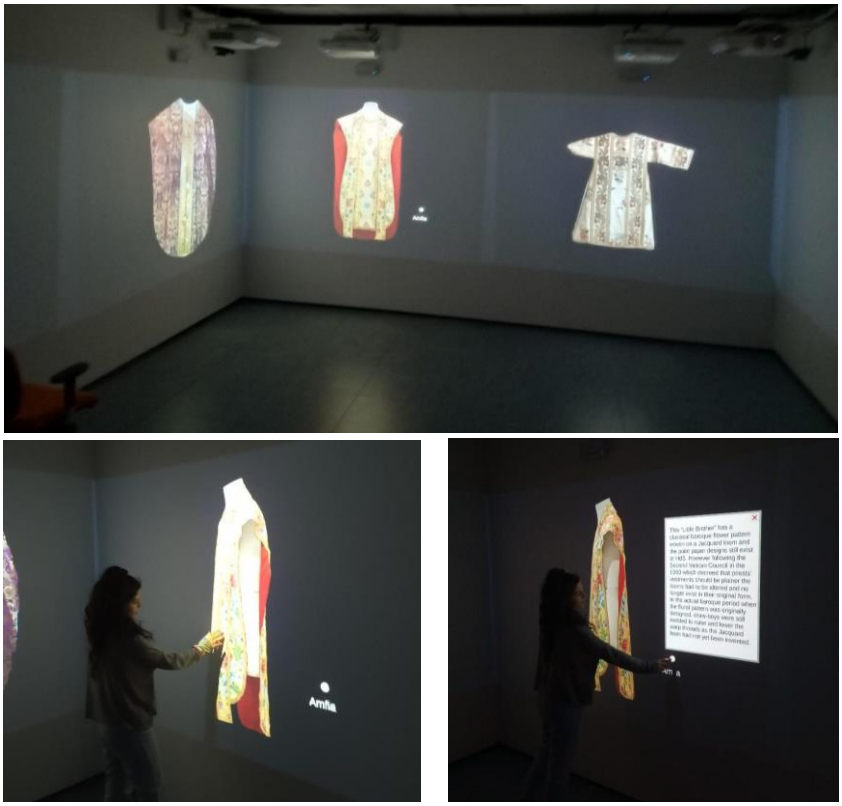


Figure 34. The Virtual Museum presentation modality (images from [184]).

8.2.5 Mobile clients

A generic access client for mobile devices that provides access to the Mingei knowledge base has been developed. The application provides access to a related to the craft information in the form of textual narrations, events, videos, images, 3D reconstructions, that are associated with the location. The prototype was enriched with an interactive map of a region with marked Points of Interest (POI). The content presented in the selected POI is drawn from the Mingei repository and is authored via the MOP. Indicative screens from the AR mobile prototype of Silk are shown in Figure 35 and Figure 36.

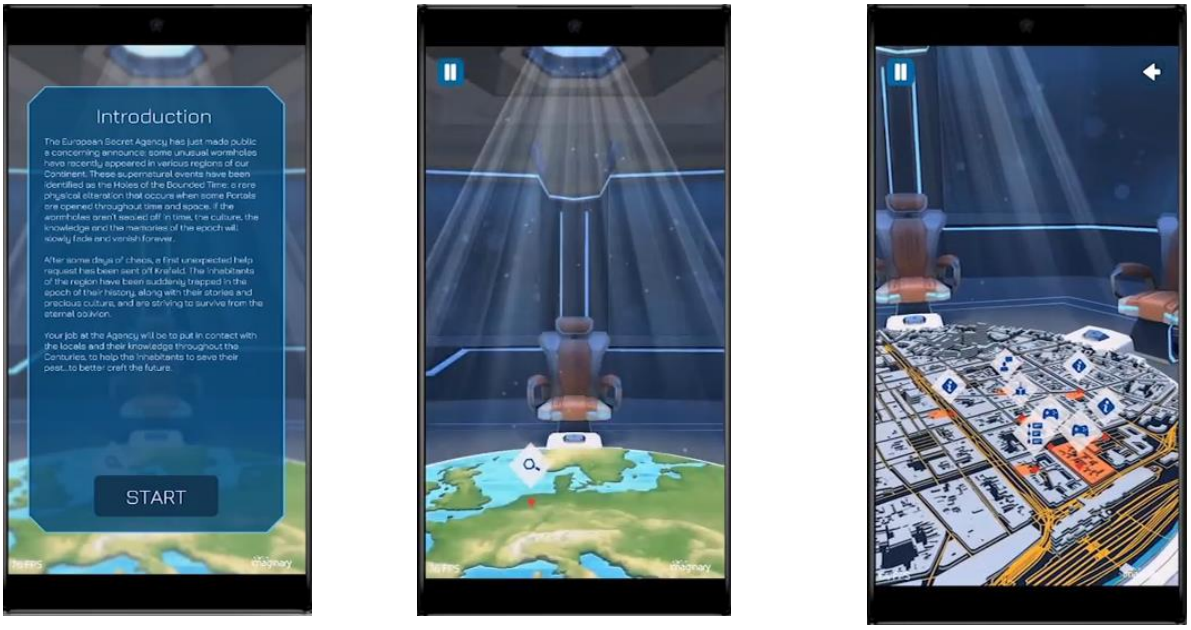


Figure 35: Mobile application prototype for the Silk pilot, showing map and verbal information at POIs (images from [186]).

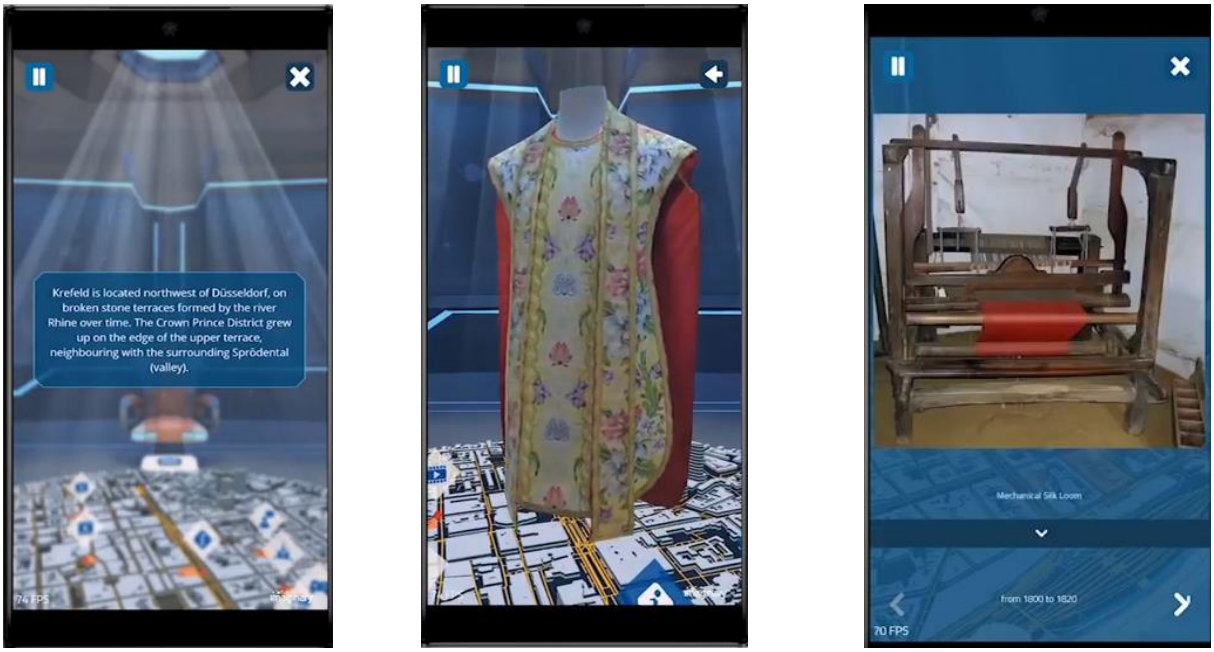


Figure 36: Mobile application prototype for the Silk pilot, showing assets from the Mingei repository (images from [186]).

8.2 Place-oriented presentation modalities

The presentation of environments is facilitated by spatial presentation modalities. The geographical organisation of narratives in Step 4, can be directly utilised in presentation modalities oriented to the presentation of geographical and spatial information.

All spatial representations are enriched with locations of interest that are associate to knowledge elements in the Mingei ontology and occurred as predetermined locations on the map. These

locations and associated digital assets are retrieved directly from the knowledge base, or other repositories. This way, spatial presentations can be enriched with any type of digital asset in the knowledge base, such as 3D reconstructions, historical information, video data, etc.

8.2.1 Map-oriented presentations

For large scale representations, a basic map-oriented presentation modality was shown in Figure 23. At the same scale but relevant to the local environment and its resources 3D geophysical maps are proposed. Two corresponding modalities were implemented. The first is an immersive projection room that overviews a 3D environments, interactively navigating from bird-eye viewpoints. The second is a lightweight presentation of a 3D geophysical for mobile platforms. In Figure 37 these modalities are shown.

Figure 37. Immersive and VR presentation of geophysical context (images from [184]).

8.2.2 Virtual environments

The most typical way of inspecting or navigating through 3D environments is through a 3D VR viewer, whether in the computer screen or through an immersive visualisation system (i.e. wide-projection, VR headset).

The environments are composed with the tool presented in Step-4, in Section 4.3.3. Furthermore, this editor was extended in the context of Mingei, with the capability of planning virtual walkthroughs. In particular, a component that produces video output for a predetermined walkthrough of the virtual camera. The tool contains a few common trajectories that can be parameterised, such circling through an object of interest, rotating an object for inspection, looking around, etc. We use this extension to systematically create videos of 3D digital assets, for demonstration purposes. The primary video can then be enhanced with narration, subtitles, music etc. In addition, the tool provides additional rendering modes (i.e., textureless, wireframe, etc.), to provide detailed illustration of the geometrical structure where needed.

The tool is demonstrated in the two examples containing hyperlinked videos. The first regards the craft of Dry Stone Walling (ICH, UNESCO inscription 14.COM 10.b.2). In the example (see Figure 38), traditional settlements for moving husbandry (ICH, UNESCO inscription 13.COM 10.b.10), which were built by Dry Stone Walling are presented, via a guided virtual walkthrough. The scene is composed by multiple scans, in order to support viewing both the inside and the outside of the structures. The second example regards the architecture of Mastic villages at Chios. The overview shows how the architecture served fortification of the village, for protection against invaders and pirates (more details are provided in Mingei-D2.2).

Figure 38. Virtual walkthrough of husbandry settlements at Psiloritis UNESCO Global GeoPark. Video: **https://youtu.be/FHCJU7mkbOw (images from [184])**

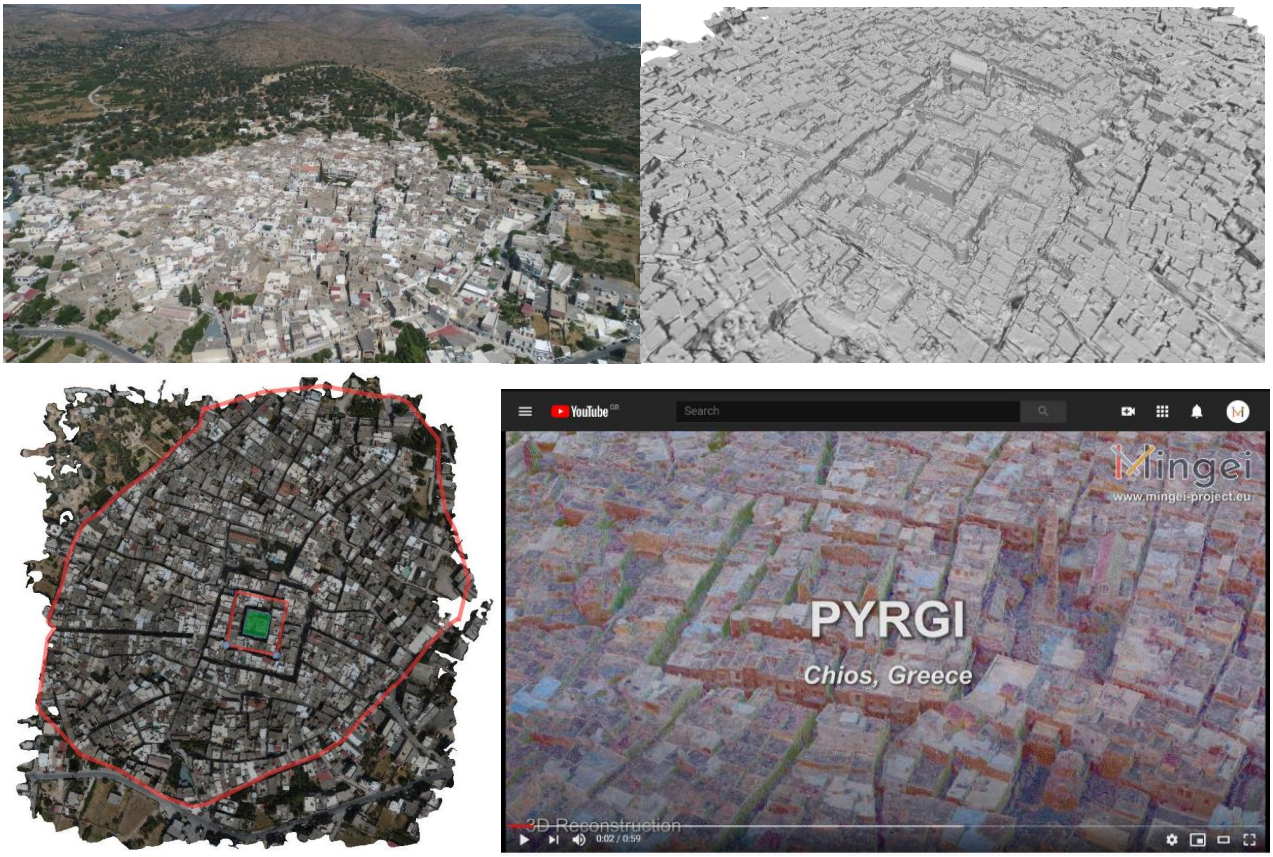


Figure 39. Annotated 3D reconstruction and virtual walkthrough. Video: https://youtu.be/9xNlrGSBfIE (images from [184]).

8.2.3 Virtual exploration

A VR application has been developed (see Figure 40) that enables virtual exploration of the natural environment from a terrestrial viewpoint. The terrain of the game was generated by importing the geophysical map into unity3D. Then flora and fauna were imported together with 3D reconstructions of villages. The concept of the game is to explore the island in different eras and acquire knowledge about the cultivation and trade of mastic in each one, through a mission-oriented approach. Digitised rural environments are also important to the realism of such application.

Figure 40. A VR application for the presentation of mastic trade and the exploration of the natural environment of Chios (images from [184]).

The game is enriched by re-using the digital representations of garments, machines, and original tree structures that were acquired from the Mastic Museum at Chios (see Figure 41 and Figure 42). The images are hyperlinked to online videos that present the reconstructions on the YouTube channel of Mingei.

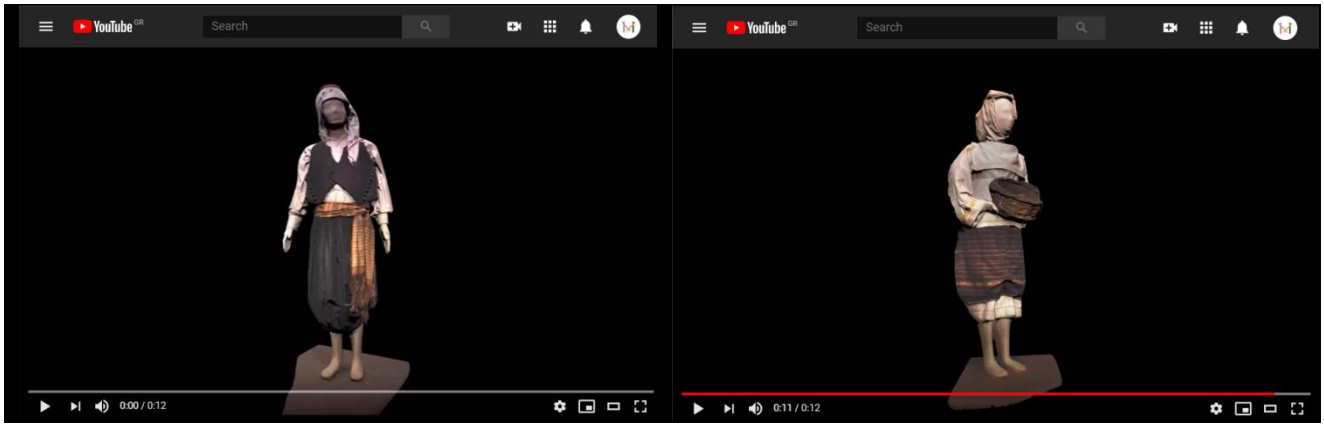


Figure 41 Videos showing reconstructions of traditional garments, in the Mingei YouTube channel [Evdemon, Zabulis, 2019].

Figure 42. Videos showing reconstructions of mastic trees, in the Mingei YouTube channel [Evdemon, Zabulis, 2019].

8.3 Training modalities

First-person acquaintance applications introducing **basics skills** are implemented, which will allow the manipulation of **virtual** and **real objects** and **tools.**

8.3.1 2D presentation of actions

Two-dimensional visualisation of actions is particularly useful for conveying motion and instructions on printed matter and physical surfaces, opening a wide avenue on applications that involve physical objects and surfaces (i.e., mixed reality).

Our approach is to use useful concepts from the world of art, in the world of motion visualization. Our goal is to utilise the insight that such visualisations provide to efficiently create meaningful visualisations of human motion, on 2D media. The reason we choose art for this purpose is that artists have for long studied the perceptual appeal of motion visualisation method over centuries of experimentation as the History of Art conveys. The advent of brain imaging through fMRI is lately revealing the neurological basis of this appeal[10]. Painters, illustrators, and directors use **motion lines**, **contrast**, as well as, **superimposition** and **juxtaposition** of visual frames, to facilitate the mental recreation of the depicted motion by the observer. Abstractions, such as motion lines, provide insight in understanding the motion. Our technical contribution is the MotiVo computer-aided authoring system, for the visualization of human motion.

MotiVo [45] is an authoring system that simplifies the process of motion visualisation by offering a number of visualisation tools as integrated components. Using those tools, motion is visualised by parameters, such as the blending of key poses of an activity, the visualisation of motion trajectories, the application of image filters to visualisations and their combinations. The MotiVo system is presented in Mingei-D5.5.

Motion lines comprise one of many topics that have been studied, both by the history of art and neurosciences, due to (a) their efficacy in conveying information in intuitive ways for humans and (b) understanding how the human visual system works. Motion analytics are imported and appropriately superimposed upon the 2D image, to facilitate the process of trajectory annotation. In Figure 43, application of this technique shows how to perform a fine periodic motion, for the rolling of sensitive golden thread.

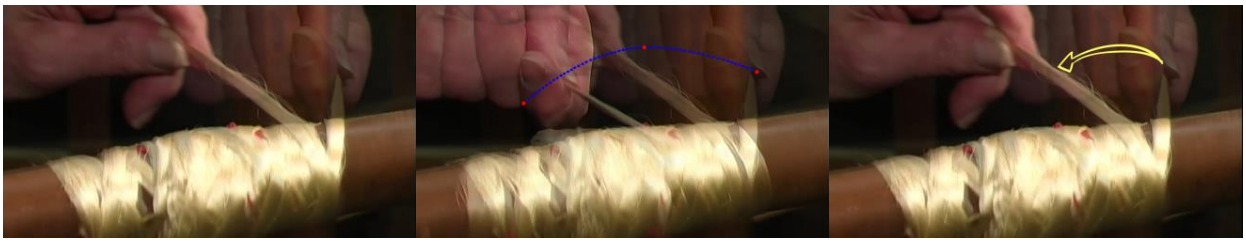


Figure 43. Authoring of gesture visualisations using MotiVo (images from [184]).

Juxtaposed illustrations in deliberate sequences have been used in illustrated instructions and comics [135] , to convey motion and order of events (i.e., see Figure 44). Visualizing processes as a sequence of juxtaposed key pose depictions of events, provides a clear overview of the narrated process. The principle is that the depiction capitalises on the “visual interpolation” or “filling-in” perceptual process. Annotations provide visual clues of motion in individual frames. Typically, characters are simplified, to better convey the motion rather than non-relevant details. Abstraction in visual descriptions was advocated by Le Corbusier, by reducing complex photographs into increasingly simplified drawings, made with a few lines [136] .

[10] J. Lehrer, (2007), Proust Was a Neuroscientist.

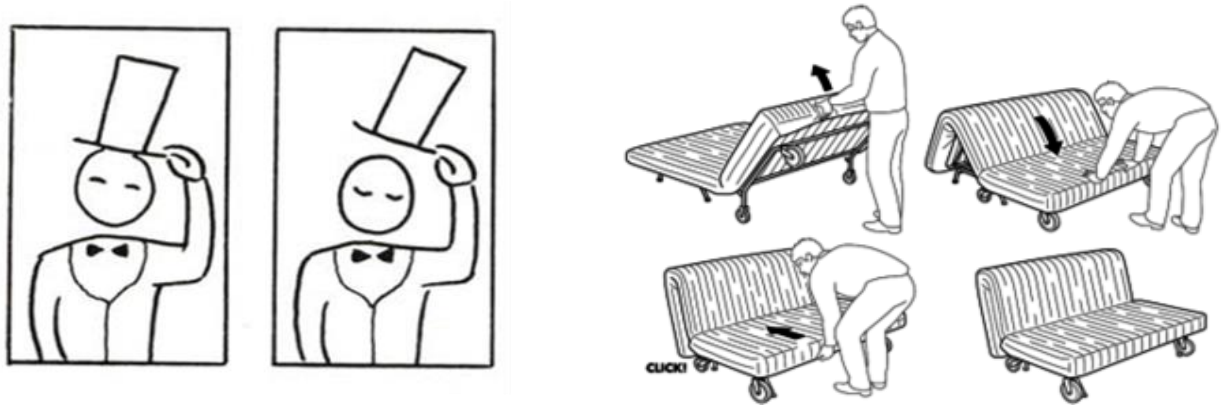


Figure 44. Juxtaposed images leading to visual interpolation (images from [135]).

An example of producing such an illustration is shown in Figure 45, which presents a carafe glassmaking process in the form of a graphical story, enriched with verbal content and visual annotations.

Figure 45. Authoring of illustrated instructions with MotiVo (images from [189]).

8.3.5 3D presentation of actions

Virtual Humans can be used to present craft processes, as well as to demonstrate tool and machine usage. An avatar may use different tools throughout an execution of a Motion Vocabulary Item (MVI), or interchange between tools. A MVI is used in the context of this research work to

represent an instance of a specific motion segment. MVIs can be combined and interleaved to represent entire procedures and are considered building blocks of a Motion Vocabulary (MV). The MV in turn can be used to create “sentences” that encode different actions and procedures. As a result, the MV can be used to encode a wider variation of actions and combinations of actions than the initial MoCap data used for its implementation. The Virtual Human uses instructions and motion-driven narratives to explain the task to the user, which is to exercise (see Figure 46).

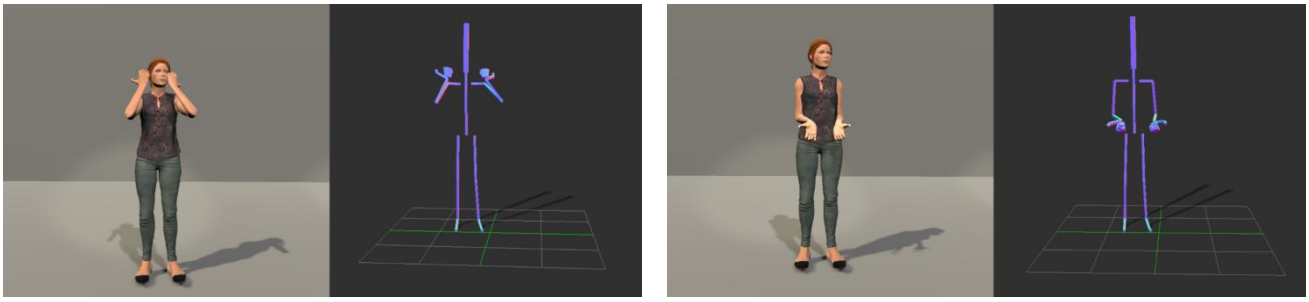


Figure 46. An avatar animated from motion capture data (images from [185]).

In this context, MoViz provides access to motion-driven narratives that entail the use of modelled machines interfaces. In the example of Figure 47, the represented gestures and induced machine motions are accessed to demonstration the use of the machine in a particular task; in this case weaving on the loom.

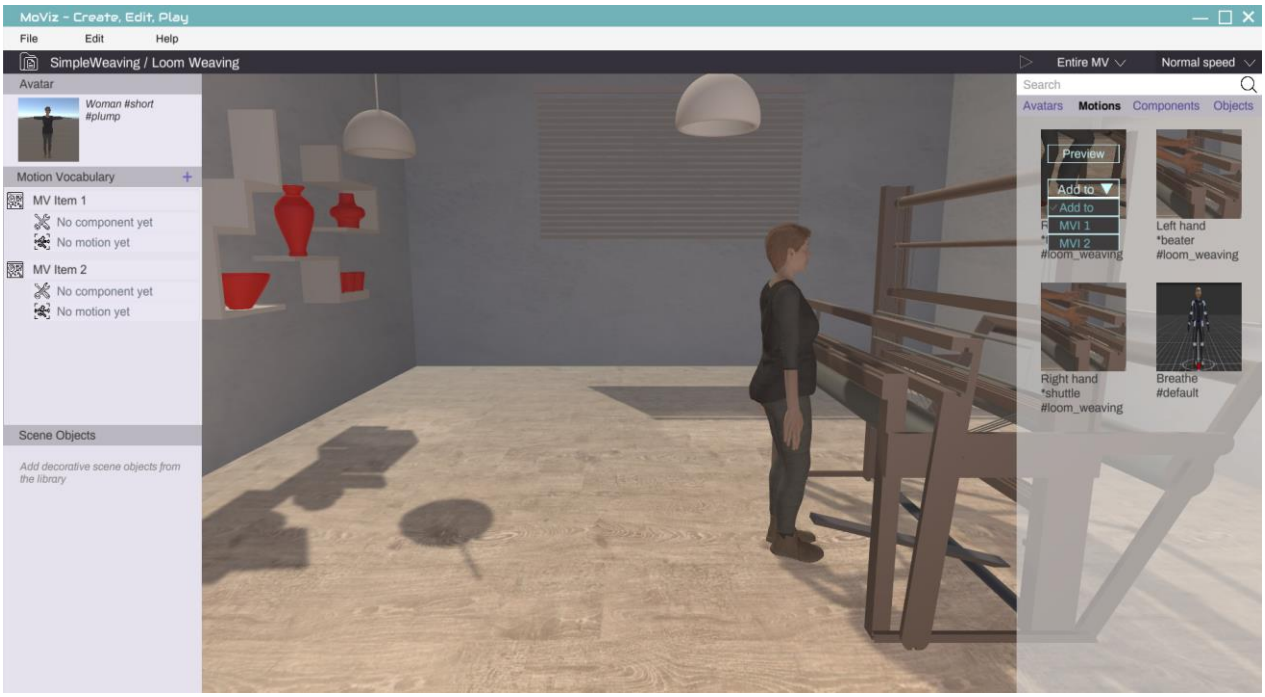


Figure 47: MoViz two MVIs are shown on the left. On the right, the menu for adding animations as MVIs is shown (image from: Mingei-D4.2).

Pertinent uses of the 3D authoring environment is to include **demonstrations of skills and processes**, powered by **intuitive visualisations** of practitioner **actions** and **techniques**. These are enhanced with iconic abstractions of tool usage gestures, such as in Figure 48.

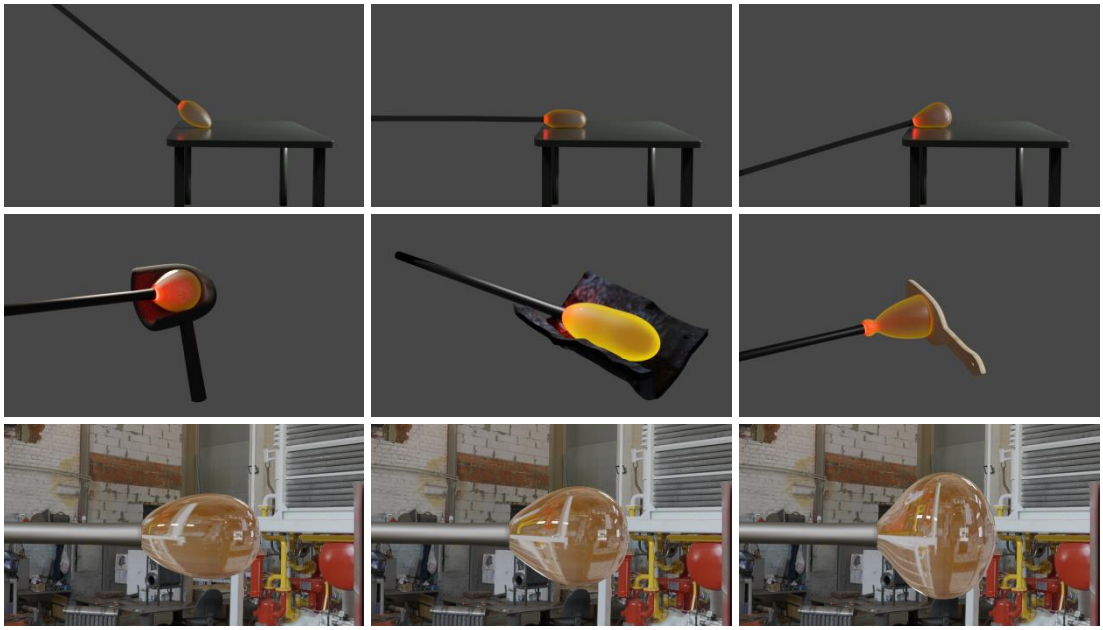


Figure 48. Computer-aided, VR presentation of glass making processes from [46]. Top: marvering. Middle: shaping. Bottom: illustration of the glass deformation during glass blowing.

8.3.3 Interactive presentation of actions

Craft gestures that include tool handling are visualised and trained in a training context. As such, a first person interactive presentation modality is selected. To create training scenarios, the ovidVR SDK by ORamaVR is utilised [44], using VR controllers enable the grasping and handling of tools.

In Figure 49, the example provides training of hammering a nail in a wooden surface. The structure of the training scenario is broken down into smaller sub-tasks. The user is asked to pick up the tool. Performing this action equips the tool in the virtual hand and the tool then follows the movement of the VR controller. Afterwards, a training animation activates which indicates how the tool is to be used, in this case how the hammer should be moved to hammer the nail down. The user is then asked to duplicate the indicated motion using the VR controller. Once the nail reaches the maximum depth, the training scenario is completed.

Figure 49. VR training tutorial (images from [184]). Video: https://youtu.be/wpYxf-ZBFII

Training in this case regards the handling of tools for cultivating and harvesting a mastic tree (see Figure 50). The game guides the player through the process with instructional content. The player in each step has then to select the appropriate virtual tool and follow the instructions on how to use it to complete the given task. In the example, the recommended motion to create an incision to a mastic tree, in order to collect its resin, is simulated as well as cleaning and preparing the soil under the tree for harvesting.

Figure 50. VR training for mastic cultivation (images from [184]). Video: https://youtu.be/796IngzoqIQ

8.3.4 Interactive presentation of processes

Serious games can be exploited for understanding and learning craft processes that span over time. In these cases, VR is not a priority, as it is the purpose and planning of the process that is communicated, rather the specifics of handling of a particular tool.

In Figure 51, a mobile application provides training on the cultivation of mastic trees, over a period of months, visiting the trees periodically to make the appropriate incisions per time of the year. Of relevance is not only the incision technique but also the density, number, and locations of incisions, per time of year. In winter, a small number of incisions of the base of the trunk is used to slowly "wake" the tree and produce resin. Besides training on utilitarian processes, traditional factors are accounted. Density of incisions, relates an emic emotion of mastic cultivators, because it is associated with the intention of maximising production on the cost of the tree's well-being[11].

[11] Overharvesting is well known to damage the tree and eventually reduces the production of the sucking year.

Figure 51. A mobile application that introduces the tasks of mastic cultivation (images from [186]). Video: https://youtu.be/JjOcxmrQ744

The same approach is used in the understanding of intangible processes. In , a game explains the connection between the point paper design and the production of textile motifs[12]. The game is designed to provide a better understanding of the artistic dimension of textile design and manufacturing. During the co-creation meetings and talks with stakeholders an interesting issue was raised. The work of the various craftsmen to first create a design, to transform this to point paper and ultimately to punch the cards which control the Jacquard unit whilst weaving is frequently overlooked or barely even recognised by the visitors to the museum. The first craftsman draws a picture or motif in pencil, the point paper designer transfers this to the point paper using watercolours. This point paper design is then used to punch cards for the Jacquard loom. To highlight this aspect, the game enables the user to draw his/her own pattern, punch a corresponding card, produce the fabric, and see how it would look as a garment, in this case a silk scarf (see Figure 52).

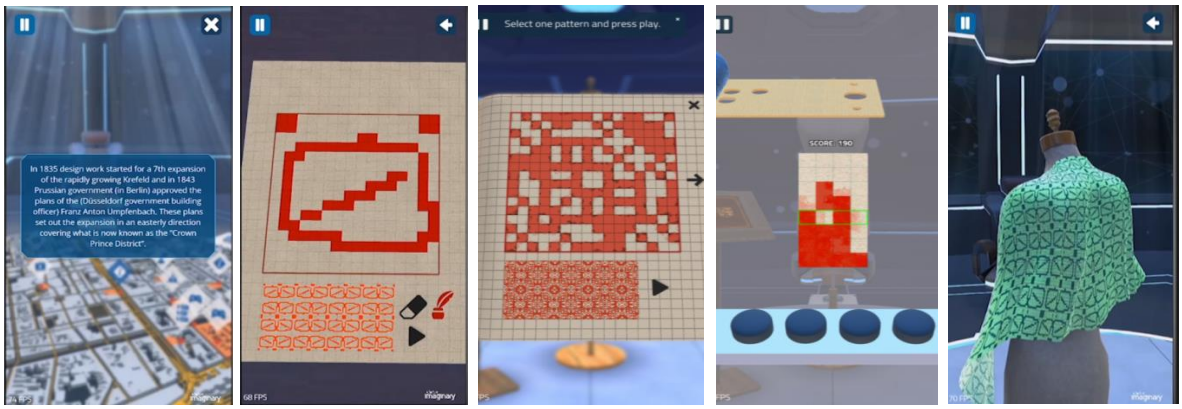


Figure 52. A mobile application that introduces the pipeline from pattern design, its encoding in Jacquard punch cards, and its virtual fabrication in a worn textile. (images from [186]). Video: https://youtu.be/ooZb2uwcxYw

The work of the craftsmen to first create a design, to transform this to point paper and ultimately to punch the cards which control the Jacquard unit whilst weaving is frequently overlooked or barely even recognised by the visitors to the museum. The first craftsman draws a picture or motif in pencil, the point paper designer transfers this to the point paper using watercolours. This point paper design is then used to punch cards for the Jacquard loom. To highlight this feature, a new game has been designed, in which the user will be able to draw his/her own pattern and then punch a corresponding card in order to produce the final fabric and see the final textile production.

[12] A demonstration of the game can be found here: https://youtu.be/-0ep8g_A1u0

9. STEP 6. Making impact

Interest is central in the dynamics between stewardship and public. Heritage must be *understood*, to be *valued* and *cared* for and, thereby, *motivate preservation interest* [190] . **Awareness** of the value of HC knowledge and skills for European societies, cultures, and economies can be supported by documenting HC. Supporting the general public to access and acknowledge its CH is a first step towards its preservation. In this way, people become a permanent stakeholder in this goal. Crafts have traditionally been associated with single craftspersons as well as with part time activities or family business. Nowadays, many individual trade their craft products online. The simplification of learning and digitisation of promotional content support the operation and encourage the foundation of small enterprises. Mingei puts forward the **motivation of financial interest** in the context of CH economy due to HCs. The suggestion is that economic interest towards HCs will necessitate their preservation. As thematic tourism is such a means, **sustainability** of CH as an economic resource has to be **carefully planned**, so as not to inhibit craft expression due to **over-tourism.**

In pertinence to Objective 6 of Mingei, “Impact to the Cultural Heritage Domain” we target tree goals.

- Benefit CHIs, and CCIs
- HC training, education, and HC research
- Objective 6-C: Promoting HC tourism, raising business interest, and funding HC preservation

Mingei **pilots** explore the contributions of applications in specific use cases, which are solidly grounded on three different yet complementary case-studies: mastic-cultivation, silk-weaving and glass-making.

The glass-making pilot focuses strongly on the representation of hand and body gestures through motion-driven narratives. It entails the re-creation of lost techniques, with the help of practitioners. The pilot studies the use of a variety of tools, personal creativity, tracking technological adaptation of the HC across time, and artistic expression for glassmaking as handicraft and as industrial craft.

The silk-weaving pilot regards an industrialized craft and use of machinery. Focus is placed in the representation of machine operation and corresponding motion-driven narratives. The pilot focuses at education applications to support craft preservation.

The mastic-cultivation pilot includes indoor and outdoor narratives and presents in context the societal and economic facets of this HC, as well as its impact on legends, traditions, and heightened sense of shared identity among members of the community of this indigenous HC. Gender and intergenerational learning aspects are captured and presented, illustrating how this HC is passed on through generations. The pilot will further promote HC tourism, agro-tourism and mastic branding initiatives on the island of Chios.

9.1 Objective 6-A: Benefit CHIs, and CCIs

HC representation contributes to the **documentation** and **digital preservation** of HC assets. The **Mingei** Online Platform provides a **resource for researchers** and **the general public**. This platform will avail the opportunity to makers and communities to **promote their work and region**.

Narratives create **new content**, *stories and experiences*, for *content-owners, craft makers*, and *HC communities*. Corresponding applications will **raise interest** in broader audiences, including the general public, visitors, tourists, and prospective apprentices. Storytelling and mobile technologies and installations provide **comprehensive and captivating** HC presentations. Benefits CHIs and CCIs regard:

- **re-use of digital assets** in **new content and new presentations** on HCs, and
- **new ways** of **appreciating and experiencing HCs** important in reaching new collocated and distant audiences.

The MOP provides access through a portal view of the repository and HC representation. Co-designed WWW applications for practitioners and HC communities will provide an opportunity for virtual, promotional exhibitions promoting, certification of product quality, and collaboration with the local tourism industries. The Mingei Online Platform can be used to host virtual exhibitions authored by curators.

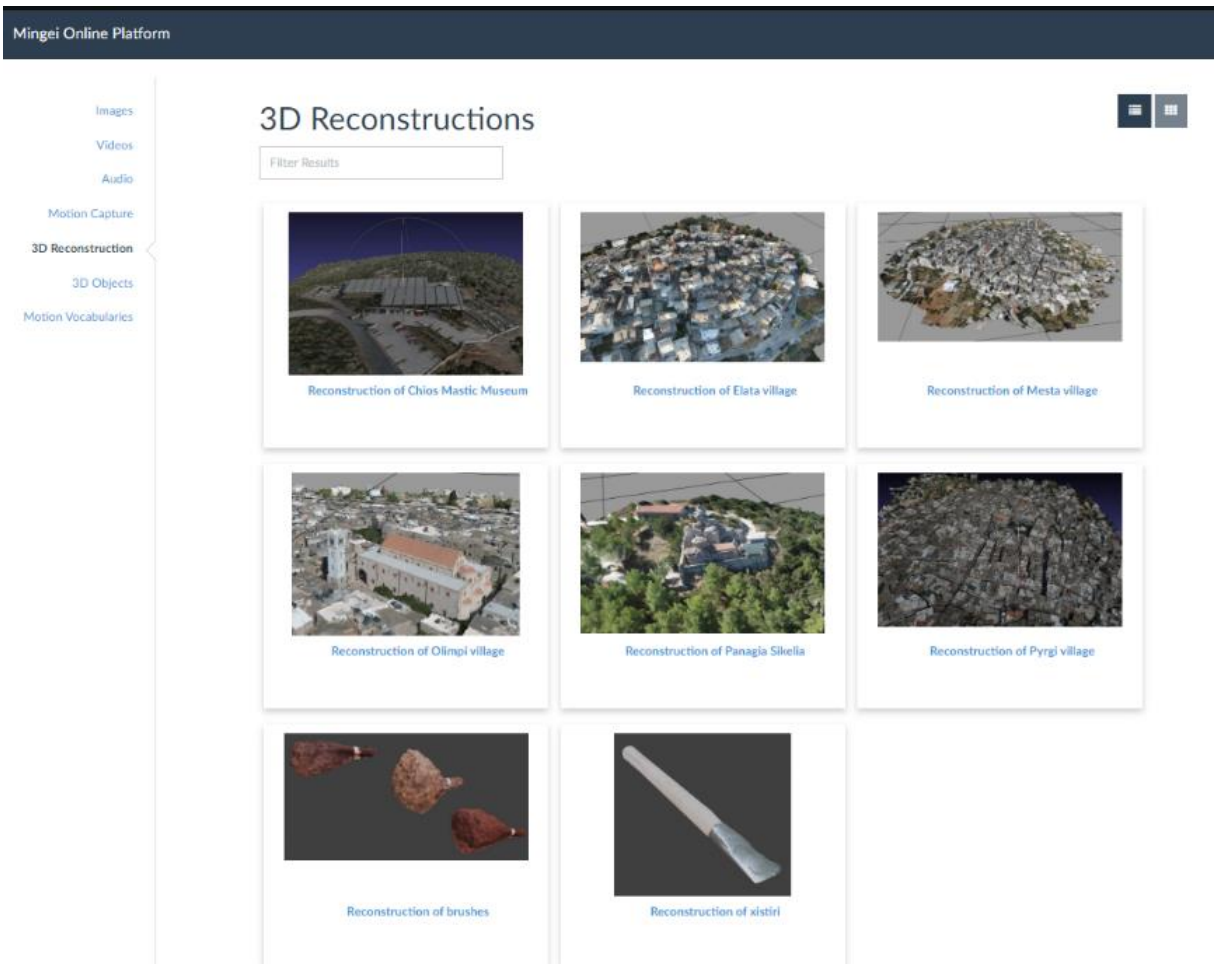


Figure 53. Screenshot from the Mingei Online Platform (images from [184]).

Nowadays, the role of CHIs is shifting towards “gathering spaces” [191] , similar to Cathedrals and Agoras of the past. As the role of CHIs is shifting towards that of Societal Institutions, potential is explored in providing public spaces for their audiences and communities*” [192]* . In this process, CHIs are seeking ways to engage users of varying in age, skills, social and economic backgrounds. We propose participative and collaborative activities that **enhance the value** and **become the reason** of a physical or virtual visit. At the same time, they offer opportunities for cultural and economic growth, which can return the investment.

Collaborative design enables users, experts and stakeholders to be involved together in a design process. In this way, creative and inspiring methods are used to come to new, insights. The aim is to create shared value with those people involved. The approach aims the **relevance** of the end product and process, **agency** and **ownership** among the people with whom design it, and a sustainable implementation of the process and end product. The diversity of knowledge brought from different domains is valuable; participants build a relationship and ideas and shared values arise in the dialogue with each other. By involving persons with relevant knowledge and expertise, **relevance** is ensured as these persons connect with an existing dialogue on a specific topic. **Ownership** emerges when participants feel that they are part of the project and they are both proud of willing to commit to.

Capacity building is the process by which individuals and organizations obtain, improve, and retain the skills, knowledge, tools, equipment and other resources needed to make and implement decisions and perform functions in an effective, efficient and sustainable manner. In this context, the Mingei protocol simplifies the process of documentation of CH due to craft, for communities and CHIs. Documentation is a central outcome of a HC digitization project.

9.2 Objective 6-B: HC training, education, and HC research

HC training is important as the ability to teach a HC enables its preservation. Off-site training is facilitated through the Mingei Online Platform. Corresponding applications show how HCs have been practiced, and include insightful annotations of digital assets, such as illustrated instructions and motion summarization. On-site training is implemented by MR installations and mobile devices where visitors are introduced to a HC through practical tasks, craft gestures, and use of tools. The educational experiences are supported by motion driven narratives and demonstrations. Real-time and gesture recognition will provide feedback to visitor actions and compares them with recorded motion driven narratives.

In Craft Centres, Maker Spaces, and FabLabs HC practitioners and LHTs are engaged in physical making of artefacts to **reconstruct lost information** on the making of artefacts, when no documentation or testimonies are available anymore. **Re-creation of techniques** on artefact making or material treatment can be captured, documented, and evaluated as potential implementation of techniques, shedding light on lost knowledge on craft processes.

Educational applications on HCs can **contribute to contemporary issues of craft education [**193] . In **Mingei**, a first step is taken by offering well-documented, introductory HC training experiences, to raise interest and attract potential apprentices. Mingei explores contributions that counter the

lack of instructors, geographical remoteness of apprentices, and lack of training sites, using new presentation and visualisation technologies to relay represented knowledge.

The maximisation of impact activities encourage links between informal educational organisations and formal education sector. Informal learning is defined as learning resulting from daily life activities related to work, family, or leisure. It is often referred to as experiential learning and can to a certain degree be understood as accidental learning. It is not structured in terms of learning objectives, learning time and/or learning support. Informal learning does not lead to certification. In the last years, there is a proliferation of participatory and informal learning, combined with entertainment and socialization. Supporting activities that combine formal courses and practical experiences reduces institutional barriers and increases interest for more specific craft education.

In Figure 54, shown is a promotional video for ecotourism services in which groups of tourism in which the knowledge of mastic cultivation is taught. The Mastic pilot is oriented in providing tourism and education services to foster and expand thematic tourism related to HCs.

Figure 54. Ecotourism promotional video (image from [184]). Video: https://youtu.be/okrRU4y3q04

Empower craft education, training and certification. Training and educational tools contribute in the preservation of HCs and in the long-term sustainability of associated economies. There is an urgent need to work towards appropriate accreditation systems for craft skills that recognize both high-level skills and skills that have been acquired through informal and non-formal learning engagement. Applications that accurately represent craft skills can be a step towards this direction.

9.3 Objective 6-C: Promoting HC tourism, raising business interest, and funding HC preservation

The wealth and variety of expressions and forms of ICH is steadily becoming a principal motivation for travel around the world. Many forms of cultural tourism are associated with longer duration of stay [145] . The UN-World Tourism Organization (UNWTO) recognizes that an important challenge lies in identifying, protecting and safeguarding ICH by investing on sustainable tourism development, in consultation with local communities and other stakeholders[146] . In line with the Faro Convention, Mingei demonstrates the value of HCs in "*sustainable development, cultural diversity and contemporary creativity" [148]* , meaning that profits will contribute and motivate preservation of HCs. By providing **compelling tourism experiences,** Mingei targets to increase visibility of European HCs and preserve this form of ICH as a *"shared source of remembrance, understanding, identity, cohesion and creativity" [145]* . Stakeholders will *"enjoy the benefits of tourism development"* and *"establish projects with communities"*.

9.3.1 Guided tours

Guided tours for city visitors can be created with the MOP. Krefeld is a city in North Rhine-Westphalia, Germany, with a rich industrial and cultural history tied to silk and velvet weaving from the 1600s onwards. Krefeld, also known as the "Town like Silk and Velvet", is not a mainstream touristic destination, however it has a lot to offer to visitors. In the context of the silk pilot in Mingei and through the collaboration with the Museum "Haus der Seidenkultur", a number of narratives have been formulated to support the storyline of the silk weaving craft in Krefeld. Such narratives include: Krefeld history from its origins to its transformation to town of Silk and Velvet, Jacquard weaving, History of the Haus der Seidenkultur, understanding the craft of silk Jacquard weaving, ecclesiastical fabric weaving in Krefeld, ecclesiastical textiles, etc.

In Mingei, we are examining how these narratives can be used to support a thematic tourism use-case scenario with multiple exploitation opportunities. One of the examined methods is to utilise the silk weaving narratives to create customisable city tours. The vision is to provide a way for the stakeholder to create city tours customised to various target audiences, i.e. families, individual visitors, Rhine cruise visitors, etc. Using their mobile devices, the visitors will have access to a selection of rich CH digital content from the Mingei platform associated with the specific points of interest included in each tour, formulated in user-friendly multimodal presentations and experiences. The material can be used in the context of existing guided tours, of creating new tours, or even as a means of advertising to attract new visitors. In this example, a city walk for Krefeld has been created. In each location of interest a video and when required a 3D reconstruction is associated with the accompanying online digital content. Figure 55 shows an export of our modelled GIS information in the format of Google Maps[13]. In Figure 55, the 3D reconstruction of a weaver's house is shown along with the video narration. In the particular case, the 3D structure of the building is of interest to the craft and therefore its 3D reconstruction is shown. As explained in the accompanying video, the reason is its windows and the indoor light that they avail. Weaving is a craft that requires light and prior to electricity windows made it possible to work longer hours. For this reason, weaver's homes tended to have multiple windows on more than one face of the house.

[13] The Krefeld Silk City Tour Map can be found at the following link. The link to the associated videos are in the comments of each location: https://drive.google.com/open?id=1BSzZ11JANAOVpqwa-eB0yaUDHDqHzlu1&usp=sharing

The route covers locations relevant to Krefeld's silk textile manufacturing history, in a recommended order. Each location is linked to a curated video narration that presents historical and cultural data about it. Building data that are relevant to the craft can be presented this way, such as the relevance of windows and weaving in a temporal context.

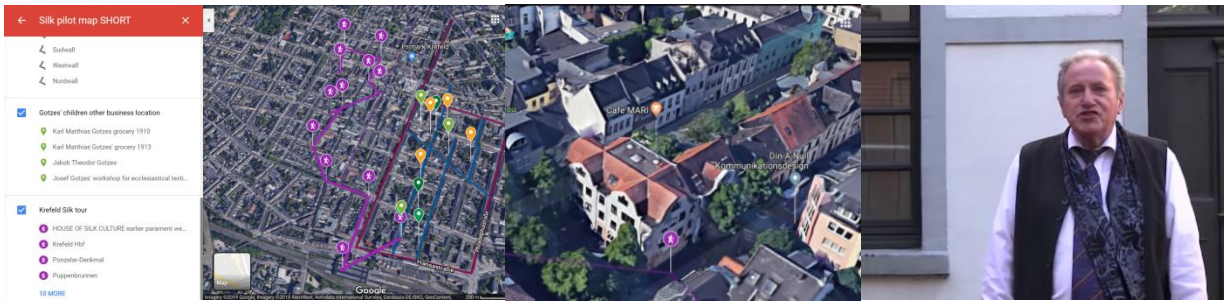


Figure 55. A weaver's house (image from [184]).

9.3.2 Craft workshops

The island of Crete in Greece is an internationally popular tourism destination. The majority of tourism concentrates on the seaside locations as the majority of the tourism sector in Crete concentrates of sun-and-sea tourism. At the same time, the mountains of Crete host traditions that cover more than a millennium. Some of the most identifying elements of Cretan culture originate from the region of Psiloritis an UNESCO Global Geopark [47]. The village of Margarites is a simple to reach, mountainous and off-centre destination at this park, at an altitude of about 300m, within the region of this park and is one of the largest pottery centres in Greece.

Pottery is one of the oldest human crafts, originating before the Neolithic period, practiced by elemental materials and processes: Earth, water, and fire. Old and new techniques coexist in the 20 some pottery workshops and showrooms of the village, where traditional and modern pottery is produced. At Margarites, pottery tradition dates from the Neolithic period and is highly-relevant to the ample reserve of clay found at its rural surroundings at the mountain of Psiloritis.

Mingei encompasses an action towards cultural tourism relevant to traditional crafts and their participatory promotion and transmission. In collaboration with local policy makers and businesses a tourism network is planned that involves participation in workshops and seminars with more than a day of duration. Of relevance to the proposed work are pottery workshops held for students and visitors. Visitors can view and participate in demonstration of traditional pottery. An initiation, educative experience into pottery was designed based on the modelling of traditional pottery in steps, showing how raw earth materials are transformed into pottery articles (see Figure 56). The process is modelled in five steps for which descriptions and educational videos are provided. The concept is showcased in a webpage[14] [48].

[14] http://www.mingei-project.eu/pottery-experience-keramion/

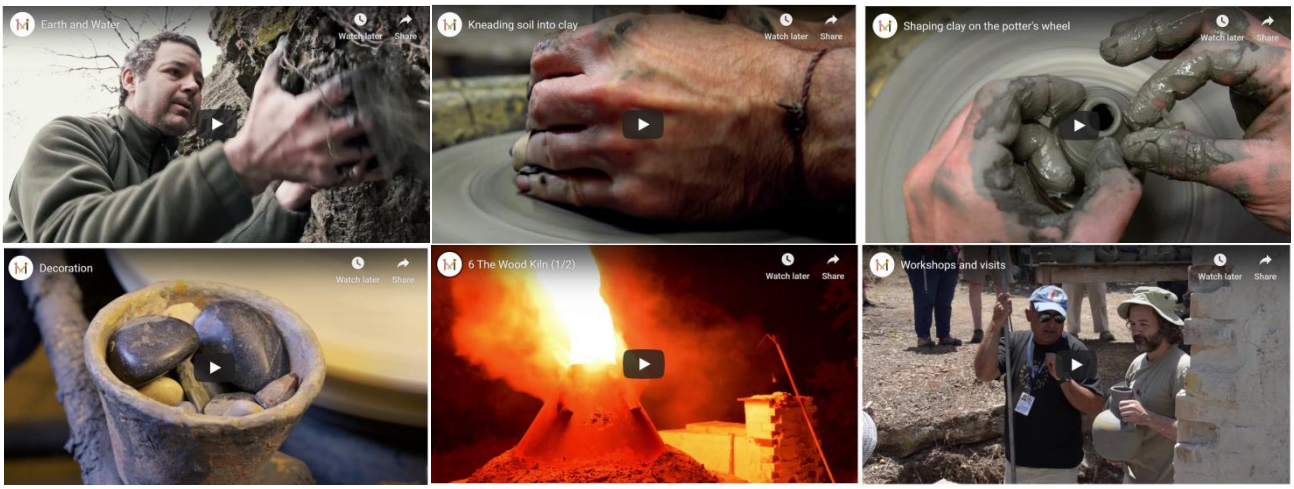


Figure 56. The basic steps of pottery making (image from [184]).

Nearby Locations of Interest are showcased to increase the value of a visit, such as the ancient city and archaeological museum of Eleutherna, as well as routes at the Psiloritis UNESCO Global Geopark, transhumance, the seasonal droving of livestock along migratory routes [34] as well as sample traditional Cretan cuisine is an expression of the Mediterranean diet [49].

9.6 Future applications

Through collaborative design we envisage an array of potential applications that can be implemented with the Mingei tools. They fall in the following case:

- preserving the cultural heritage
- providing information on craft objects and the people who make them
- providing information on the communities related to crafts
- developing and commercializing craft products
- increasing awareness of crafts and their importance
- follow-up with new expressions of traditional crafts in the modern age
- finding new ways to valorise traditional crafts in the modern age
- exchanging and distributing information at national, regional and international level
- training new craft practitioners
- collecting documentation of the inscription of HCs in CH inventories
- collecting statistical and demographic data that for documenting the status of HCs
- availing knowledge and data to the general public in CH professionals, in a format compatible with international standards on CH documentation
- catalysing cultural and economic development due to HC, by providing a multidimensional, multimodal, and machine-interpretable knowledge infrastructure that is readily available to third party applications
- providing technological components that present an compelling ways experiences related to HCs that can be used in awareness, safeguarding, and thematic tourism applications relevant to HCs

- increasing the capacity-building potential by providing a simple to use infrastructure, and good practice guides, and technical tools for self- documentation, digital curation, and promotion of own content and heritage, by relevant stakeholders and communities.

Annex 1. Textile scanner

Mingei utility. FORTH has created a prototype modality for the scanning of digitisation of textiles in ultra-high resolution.

For the scanning of textiles an experimental installation was implemented. The installation is based on a large scale custom FDM printer designed by FORTH. The specifications of the printer include printing bed size of 40cm x 50cm and maximum printing height of 50cm. The printer follows the basic Cartesian movement principles achieving movement accuracy of 0.1 microns. The printer is using open technologies for the implementation of electronic components (Arduino Mega 2560, RAMPS 1.4 Arduino hut, and DRV8825 Stepper Motor Driver. The firmware is implemented on top of Marlin. The basic FDM printing setup is presented in Figure 57.

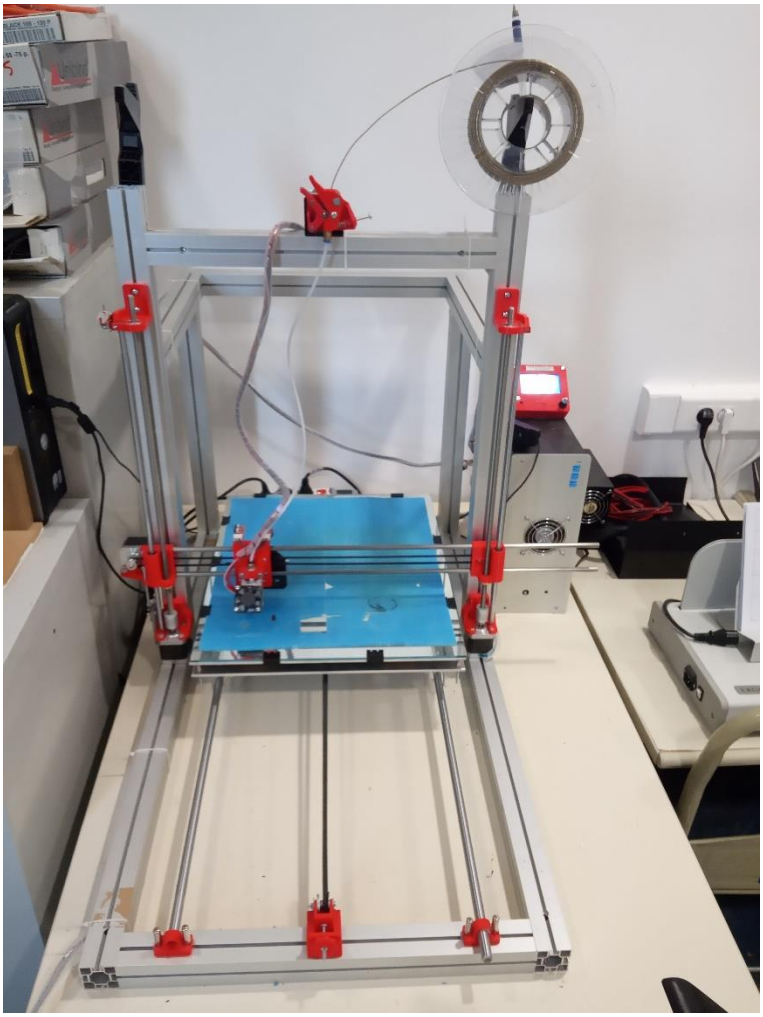


Figure 57: Large scale custom 3D printer (image from [184]).

Based on this technology we implemented an experimental setup that facilitates the XY moving capabilities of the printer for macro photography. At the same time Z moving capabilities can be used for achieving various distance photography. Based on this setup a custom sensor base was design to host the sensor (Olympus Tough TG-5) as shown in Figure 58.

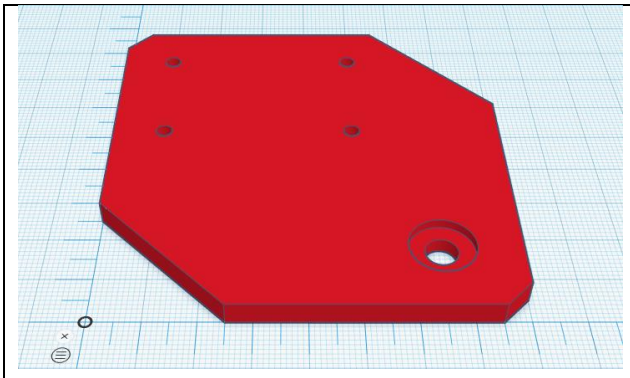
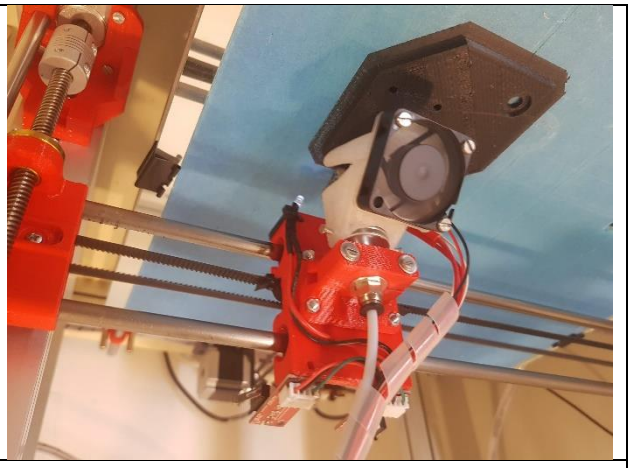
	
Base design	The printer was used to print the base (RepRap-style)

Figure 58: Sensor base and printing on the FDM printer (image from [184]).

With the sensor base printed the setup of the 3D printer was adjusted to host the sensor as shown in Figure 59.

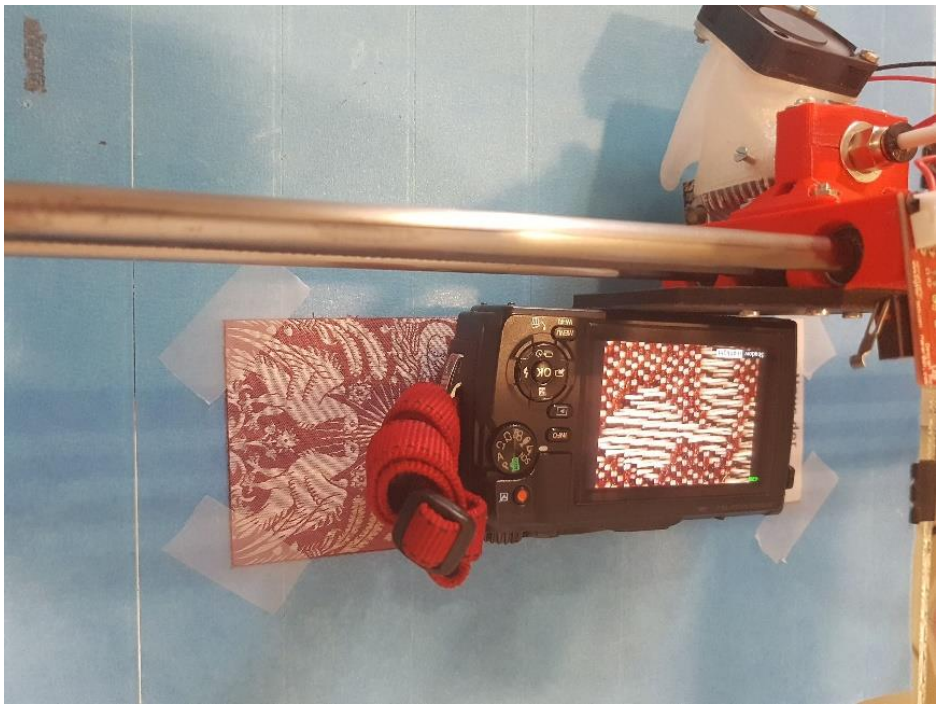


Figure 59: Base and sensor attached to the FDM printer (image from [184]).

Then the printer was programmed using GCODE instructions which is the instruction set used by Marlin firmware based 3D printers as the one in our case. The GCODE is producing instruction to the printer to move in a variable length grid pattern as shown in Figure 60.

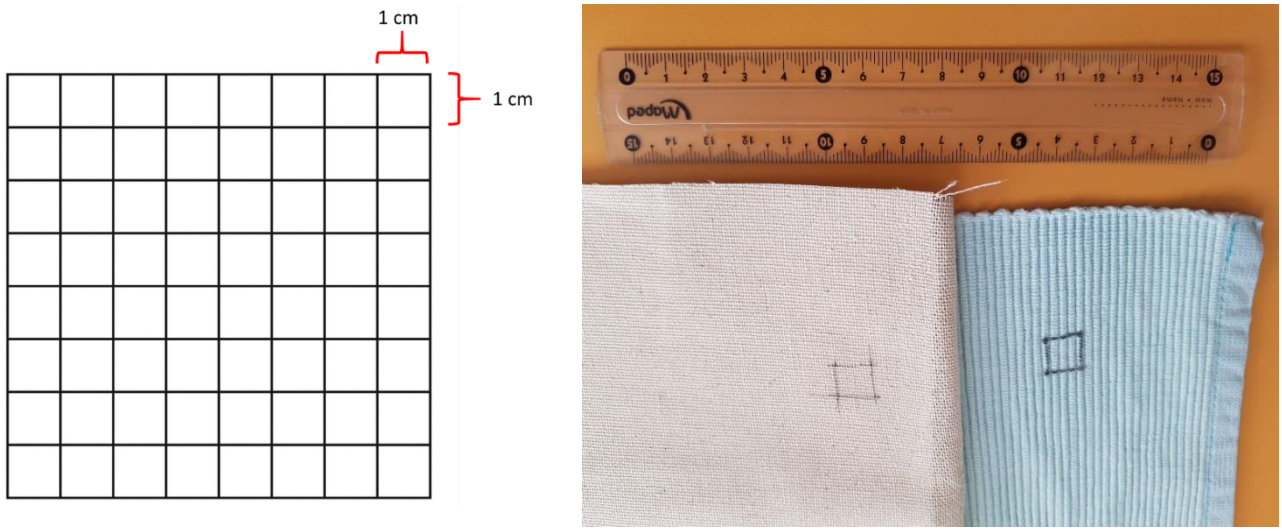


Figure 60: Grid structure and textile examples (image from [184]).

In each step of the grip a picture is taken from the sensor. The collection of pictures for each height is used to perform image registration that creates the image mosaic. For the experiments several textiles where used in order to evaluate the technology in various use cases. Some examples are shown in the following figure.

Upon completion of the validations the experimental setup was used to scan a silk textile provided by Haus der Seidenkultur. For reference the scanned textile were first scanned on a conventional 2D scanner. The result is shown in Figure 61.

Figure 61. Silk textile sample (image from [184]).

The scanning results using the proposed modality can be shown in the following figures. To demonstrate potential the quality of the digitization a preview URL is provided online [In the electronic version, click to view online demo]**.** The following figures present an example of a close caption of the textile achieved through the online viewer.

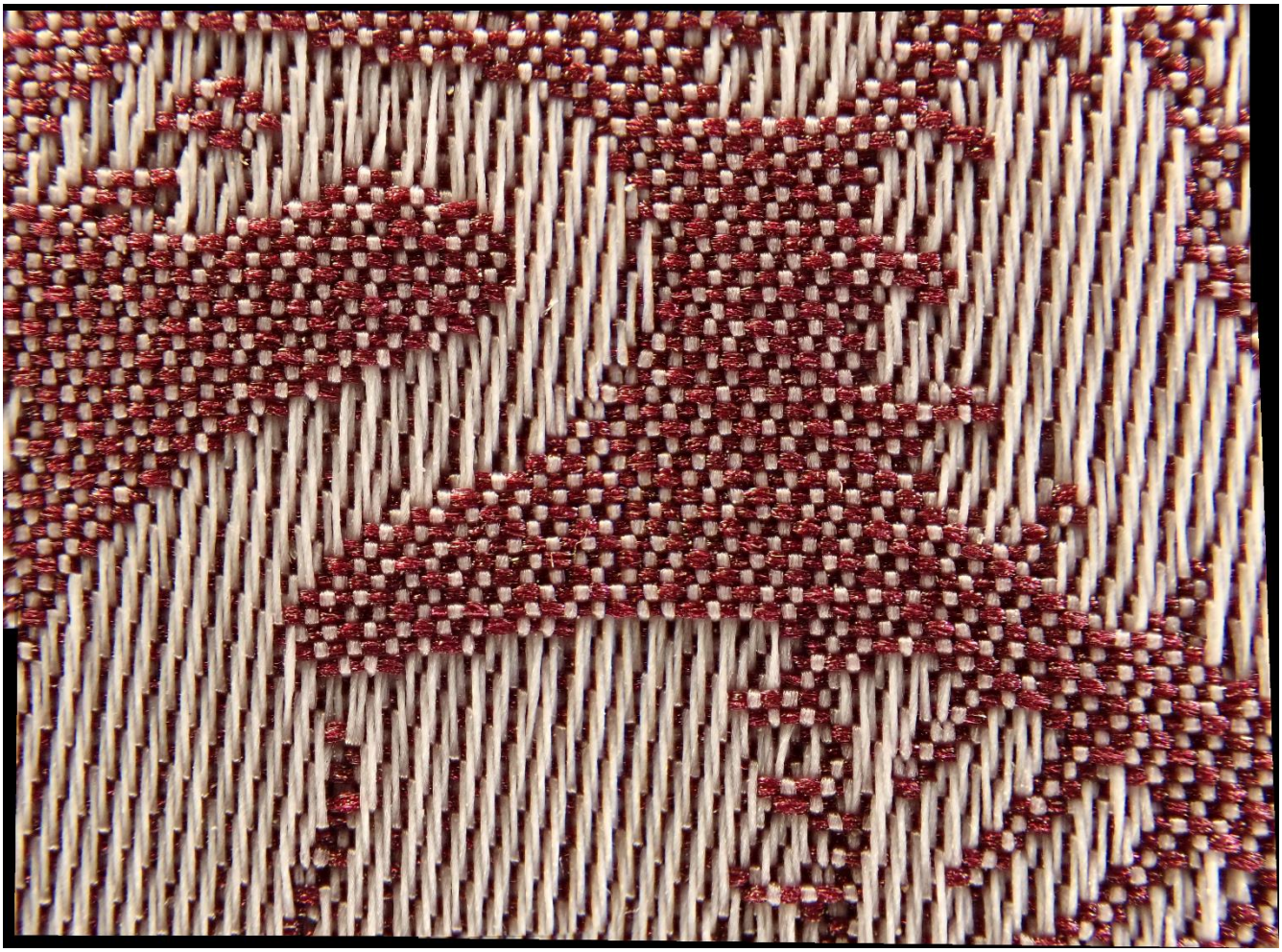


Figure 62: Textile mosaic (image from [184]).

Figure 63. Textile detail in medium magnification (image from [184]).

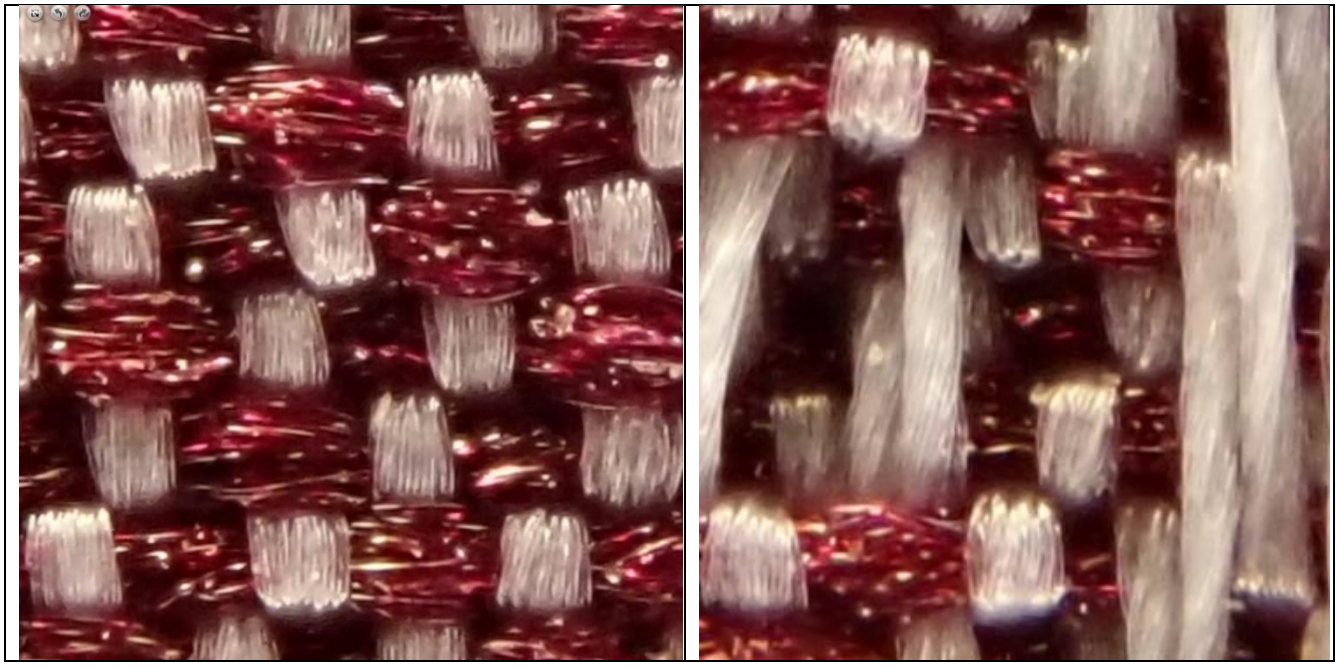


Figure 64. Textile high-magnification details **(image from [184]).**

Annex 2. Digitisation of literature resources

This Annex refers to text segments below been selected from the list of literature resources and categorised as to the type of contextual knowledge they provide.

These segments are the sources based on which some knowledge elements for the silk pilot were formed. The transcriptions of these segments are organised "lab notes", from the curation process. They are stored so that the curation process is **tractable** to its sources. Thus, the **original text** is required in the documentation of **accurate** narratives, by referencing the **sources** and the specific fragments, where information was obtained.

Due to copyright issues we do not copy these segments here, but instead provide specific references to them and a brief description of the knowledge obtained from them. We also reproduce the numeric data found in the tables of the book (i.e., regarding demographic and financial information), which are utilised in narratives on craft context.

A2.1 Geographical and temporal context

[WWW resource: *"1800 – 2017, The Development of Textile Technology"*, TextilTechnikum (Textile Technology Center), by the Monforts Quartier, Mönchengladbach].

The knowledge source provides information on textile production and distribution on the Lower Rhine region, from the start of the 19th century.

A2.2 Origins of community

- Encyclopaedia Britannica, on "Brethren" (protestant church group), providing pointers to Alexander Mack (1679–1735), the 1715 the Marienborn congregation whose members moved to Krefeld, and the 13-20 families which moved from Krefeld to Pennsylvania in 1719.
- Concordia Trust Online, on the founding of Germantown, Pennsylvania.
- Global Anabaptism Mennonite Encyclopaedia Online, on "Krefeld (Nordrhein-Westfalen, Germany)" The church history of Krefeld can be found in this resource. Its content testifies that Krefeld was a shelter for believers of religious dogmas. It furthermore confirms the influence of the von der Leyen family as a local influencer and donator of the church.

[Barbara Meyers, **Textiles and the Reformation,** Unitarian Universalist History, Part I, 2001]

Provides indication on that Catholic and Protestant churches encouraged the virtuous exercises of spinning, weaving, carding and needlework at home. Moreover the paper sheds light on gender roles, indicating that Catholic clerics and Luther disapproved of women's independence. As such, they disapproved of "spinnstube" (spinning bees) gatherings of spinners for the purpose of sociability and work without distractions, which sometimes attracted unattached men and courtship. At the same time these gatherings were encouraged by the textile industry, due to the knowledge transfer and the division of work that took places in these gatherings. The book provides depictions of the collective mentality in art illustration. The Plate 5 of the books provides depictions of the collective mentality in paintings of that time, illustrating textile work as a virtuous activity.

- *School of Caravaggio, The Virgin and Saint Anne, early 17th Century, from Fratelli Alinari Archives, Florence, Italy.*
- *Gerard Dou, Reading the Bible, c. 1660, from Musee du Louvre, Paris.*
- *Gerard Dou, Prayer of a Spinner, c. 1660, from Alte Pinakothek, Munich.*

Plate 6 of the book provides illustrations of Spinning Bees, both scandalous and proper, by presentation of material from Germanisches Nationalmuseum, Nuremberg from: Medick, Hans, "Village Spinning Bees: Sexual culture and free time among rural youth in early modern Germany", in Interest and Emotion – Essays on the study of family and kinship, edited by Hans Medick and David Warren Sabean, Cambridge University Press, 1984, pp. 317-339.

A2.3 Economic and social context

[Barbara Meyers, Textiles and the Reformation, Unitarian Universalist History, Part I, Fall 2001]

The chapter "Rise of Modern Commerce and Capitalism from Feudalism" provides information on the European feudal society decline in the 16th century. It shows that political power began to be centralized in a state government and describes that a mercantile economy arose, attempting to centrally control the economy, in the interest of strengthening the state. The chapter underscores that textiles were relevant to the solution of the two main problems the emerging mercantile state was facing:

1. Influx of foreign exchange.
2. Impoverishment of rural populations.

[Herbert Kisch, "From Domestic Manufacture to Industrial Revolution: The Case of the Rhineland Textile Districts", Oxford University Press, 1989] and [Herbert Kisch, "Prussian Mercantilism and the Rise of the Krefeld Silk Industry: Variations upon an Eighteenth-Century Theme", Transactions of the American Philosophical Society, 1968 American Philosophical Society]

Kisch posits regional differences as important for understanding Germany's industrialization and economic history. The author shows that the foundations of German industrialization were well established by the early 1800s. The author posits arguments in support of the concept of "protoindustrialization". The analysis provides the following insights:

1. Entrepreneurs became the carriers of industrial development in the Rhine textile regions, as merchants and factory owners with hundreds of dependent workers.
2. The economic success of minorities in the Rhenish case was due to the open social and political system, which provided tolerance and protection.
3. Early in the 18th century the township shifted, toward the manufacture of silk products as its principal source of employment. The linen weavers turned to silk weaving, as the new occupation offered prospects of higher earnings and regular employment.

The knowledge source provides data on Krefeld population and economic data on the development of a major house of silk textiles in Krefeld (von der Leyen).

Table 2 Krefeld Population, 1624—1798 [348]

Year	*Krefeld Town*	*Krefeld Territory*	*Total*
1624-25	ca. 400	ca. 400	ca. 800
1722	ca 2,300	633	ca. 2900
1740	3.522	1.054	4,574
1756	4.339	1.328	5.667
1763	4.756	1,326	6.082
1777	5,265	1,393	7,658
1798	7,896	-	-

Table 3. Von der Leyen Assets and Debits (in Talers)

Year	*Net Worth*	*Total Balance*	*Total Indebtedness*
1733	11,100	143,000	87,000
1737	36,000	185,000	99,000
1745	185,000	307,000	122,000
1751	296,000	432,000	136,000
1756	317,000	520,000	203,000
1794	1,311,000	1,754,000	443,000

Table 4. 1794 Balance Sheet.

Assets	*Talers*
Inventories of raw materials (raw silk)	446,681
Inventories of finished goods	541,200
Cash	60,286
Debtors (probably “accounts receivable”)	638 ,086
Equipment (probably mostly looms)	23,564
All dye equipment of the black dye shop	2,084
Colour dye shop including equipment	12,000
Five factory buildings and storehouse for silk	27.160
Annex	4,637
Forest	5.188
Various communally owned buildings	23,400
	1,754,293

Table 5. Number of mechanical and handlooms in the Krefeld silk and velvet districts, 1870-1913

	1870	**1880**	**1885**	**1890**	**1895**	**1900**	**1905**	**1910**
Velvet cloth								
Handloom	14,774	17,464	15,785	6,902	1,758	846	360	141
Mechanical loom	-	-	1,149	2,907	2,420	2,076	1,619	1,664
Velvet ribbon								
Handloom	2,472	242	673	964	243	221	51	25
Mechanical loom	-	-	44	197	151	276	140	229

Silk cloth								
Handloom	6,498	15,196	11,062	14,263	10,839	5,834	2,826	2,163
Mechanical loom	-	-	1,044	2,484	4,488	7,151	7,378	8,176

[N. Pounds "An Historical Geography of Europe, 1500-1840", Cambridge University Press, 1979]

The knowledge source mentions that in 1721, the von der Leyen family established a small factory to make ribbon and velvet. They were helped by the Kind of Prussia, who granted extensive privileges to Krefeld, including exemption from military conscription for its workmen.

[UNSESCO, History of Humanity, Volume VI, The Nineteenth Century, Edited by Peter Mathias and Nikolaï Todorov, Co-edited by G. Carrera Damas, A.O. Chubariyan, Shu-li Ji and I.D. Thiam]

The knowledge source mentions that riots occurred among Krefeld silk workers in 1826.

[Marcel van der Linden, "The End of Labour History?" Cambridge University Press, 1993.]

The knowledge source mentions that pre-industrial entrepreneurs preferred cities and large industrial villages, as their finances were located at the commercial centres of industrial regions. This urbanisation had two consequences:

1. The cities profited and expanded throughout the 18th century. The capital needed to make the first industrial investments accrued in the cities.
2. The overcrowding of the crafts became a mass phenomenon. Master craftsmen were deciding not to have their sons learn the trade of their fathers.

A2.4 Gender roles

[Barbara Meyers, **Textiles and the Reformation,** Unitarian Universalist History, Part I, Fall 2001]

The knowledge source provides information on the participation of women in the textile industry indicating that

1. Early modern European women participated in the textile industry from their homes. They ran cottage industries in which they spun and did needlework. Mothers taught skills of spinning, carding, weaving, needlework, and lace-making to their daughters.
2. The need for a dowry required an independent source of funds, and spinning was one way that this money was earned.

The knowledge source underscores the relationship of women growing Independence due to textile manufacturing, indicating that:

- As women were able to earn wages by working in the textile industry, some unattached women began to pool economic resources, find mutual protection and gain a sense of identity.
- Many women chose spinning as a way to earn a wage was because sometimes, spinning was the only possible employment open to women.
- Women worked for lower wages than men.

During this period, some women gained deeper self-awareness, self-identity, and independence.

Table 6. Textile wages in the union districts of Krefeld, Dusseldorf, and Hannover.

	Weekly wages in marks		
Job category	**Krefeld**	**Dusseldorf**	**Hannover**
Spinner, general			
Male	26.63	25.68	25.80
Female assistant	14.43	16.32	14.58
Spinner, cotton			
Male/female	26.74	28.56	26.61
Spinner, linen			
Male/female			
Spinner, worsted	28.39	28.33	26.37
Male/female			
Weavers, general	23.91	28.80	24.13
Male	18.53	17.61	15.90
Female			
Weavers, cotton	22.14	21.66	22.33
Male	14.95	18.31	15.11
Female			
Weavers, silk and velvet			
Male	24.10	22.90	24.70
Female	19.60	16.60	15.30
Weavers, woolens			
Male	23.51	25.82	25.37
Female	17.54	-	-

A6.5 Guilds & Craft Education

[Kathleen Canning, "Languages of Labor and Gender: Female Factory Work in Germany, 1850-1914" University of Michigan Press, 1996.]

The book informs that

- During 1883, local guilds consolidated their forces to form the Niederrheinischer Weberbund (Weavers' Union of the Lower Rhine).
- Hand weaving parents passed their skills on to their children informally; most learned to spool or creel at age five or six and began to assist at the looms at twelve or thirteen.

[Hochschule Niederrhein, University of Applied Sciences, "Textile and Clothing Technology. Textile Innovation for 110 years".] (Online resource, Accessed 28/5/2019)

The knowledge sources provides information on the education of industrial textile manufacturing in the *Rhine* area from the mid-19th century until recent times.

References

[1] D. Pye, “The Nature and Art of Workmanship”, Cambridge: Cambridge University Press, 1968.
[2] B. Metcalf, “Replacing the Myth of Modernism”, American Craft, February/March, 1993.
[3] S. Visser, et al, “Contextmapping: Experiences from practice”. CoDesign: International Journal of CoCreation in Design and Arts, 1(2), 2005, 119-149.
[4] European Commission, "Ethics in Social Science and Humanities", October 2018.
[5] J. Galliker, “Integrating the Evidence: Historic Silk Production in Context”, 2014, Textile Society of America 2014, Biennial Symposium Proceedings: New Directions: Examining the Past, Creating the Future, Los Angeles, California, September 10–14, 2014.
[6] J. Galliker, “Application of Computer Vision to Analysis of Historic Silk Textiles”, In: Drawing the Threads Together: Textiles and Footwear of the 1st Millennium A.D. from Egypt: Proceedings of the 7th Conference of the Research Group 'Textiles from the Nile Valley,' Antwerp, 7-9 October 2011, 150-163. Tielt, Belgium: Lannoo.
[7] J. Galliker, Automatic Binding Point and Surface Helix Angle Measurement in Historic Weft-faced Compound Weave Figured Silks, ICMLA Proceedings of the 12th International Conference on Machine Learning and Applications, vol 2, 529-534, December 04 - 07, 2013.
[8] P. Mishraad, et al, "Close range hyperspectral imaging of plants: A review", Biosystems Engineering, Volume 164, December 2017, Pages 49-67.
[9] W. Su, D. Sun, "Multispectral Imaging for Plant Food Quality Analysis and Visualization", Comprehensive Reviews in Food Science and Food Safety, January 2018.
[10] J. Dyer, D. Tamburini, E. O’Connell, A. Harrison, "A multispectral imaging approach integrated into the study of Late Antique textiles from Egypt" PLoS One. 2018; 13(10):e0204699.
[11] P. Herzog, B. Hill, "Multispectral Imaging and Its Applications in Textile Industry and Related Fields". PICS 2003: The PICS Conference, An International Technical Conference on The Science and Systems of Digital Photography, including the Fifth International Symposium on Multispectral Color Science, May 13, 2003, Rochester, NY, USA. IS&T, The Society for Imaging Science and Technology 2003, ISBN 0-89208-245-3, 258-263.
[12] C. Meola, G. Carlomagno, "Infrared thermography to evaluate impact damage in glass/epoxy with manufacturing defects", International Journal of Impact Engineering, Elsevier, Volume 67, May 2014, Pages 1-11.
[13] ETH-Bibliothek, “Best Practices Digitization” (Version 1.1, 2016).
[14] K. Brosseau, M. Choquette, L. Renaud, “Digitization Standards for the Canadian Museum of Civilization Corporation”, Version 1.1, March 2006.
[15] CARLI Digital Collections Users’ Group, “Guidelines for the creation of digital collections, Consortium of Academic and Research Libraries at the University of Illinois”.
[16] 3D-ICONS, “Guidelines & Case Studies”, 2014. 3D-ICONS is a project funded under the European Commission’s ICT Policy Support Programme, project no. 297194.
[17] L. Donkin, “Crafts and Conservation”, Synthesis Report for ICCROM, 2001.
[18] The Textile Museum, Washington, DC, USA, "An Introduction to Textile Terms". Archived July 23, 2006.
[19] Rita Royd Limited, Trading as Selby Soft Furnishings, “What Is Jacquard? - The History of Jacquard Looms & Weaving”, [URL], 2011.
[20] E. Posselt, (1887), “The Jacquard machine analyzed and explained: with an appendix on the preparation of Jacquard cards”, Philadelphia: Pennsylvania museum and school of industrial art.

[21] S. Korsakov, "Apercu d`un procede nouveau d`investigation au moyen de machines a comparer les idees", St. Petersbourg, 1832.
[22] Tessitura Luigi Bevilacqua, “The Production of Italian Jacquard Fabrics at Tessitura Bevilacqua”, Venezia, Italy [URL].
[23] European Commission, “Report on Digitisation, Online Accessibility and Digital Preservation of Cultural Material”, 2011/711/EU 2011-2013 and 2013-2015.
[24] Boston Consulting Group, “Digitizing Europe”, Survey Commissioned by Google, May 2016.
[25] Europeana, Survey Report on Digitisation in European Cultural Heritage Institutions, ENUMERATE EU project, Deliverable 1.2, 2015
[26] European Commission, Cultural heritage research. Survey and outcomes of projects within the Environment Theme From 5th to 7th FP, 2012.
[27] Minerva Project Editorial Board (Minerva Project 2003-11), last revision 2005-09-12, www.minervaeurope.org/structure/nrg/documents/charterparma.htm
[28] E. Bachmann, X. Yun, and C. Peterson, “An investigation of the effects of magnetic variations on inertial/magnetic orientation sensors,” pp. 1115-1122 Vol.2, 2004.
[29] C. Brigante, N. Abbate, A. Basile, A. Faulisi, and S. Sessa, “Towards Miniaturization of a MEMS-Based Wearable Motion Capture System,” IEEE Trans. Ind. Electron., vol. 58, no. 8, pp. 3234–3241, Aug. 2011.
[30] S. Madgwick, A. Harrison, and R. Vaidyanathan, “Estimation of IMU and MARG orientation using a gradient descent algorithm,” in 2011 IEEE International Conference on Rehabilitation Robotics, 2011, pp. 1–7.
[31] R. Horaud, M. Hansard, G. Evangelidis και C. Ménier, “An overview of depth cameras and range scanners based on time-of-flight technologies”, 27(7):1005-1020, 2016.
[32] Texas Instruments, “Introduction to Time-of-Flight Long Range Proximity and Distance Sensor System Design”, User’s Guide, SBAU305A–March 2018–Revised June 2018.
[33] “Understanding Optical Time-of-Flight (ToF) Technology”, Texas Instruments, September 2018.
[34] S. Zhang, “High-speed 3D shape measurement with structured light methods: A review” vol 106, pp. 119-131, 2018.
[35] S. Zhang και P. Huang, “High-resolution, real-time three-dimensional shape measurement”, 45(12):123601, 2006.
[36] L. Zhang, N. Snavely, B. Curless και S. Seitz, “Spacetime faces: High-resolution capture for modeling and animation”, Springer, 2008, pp. 248-276.
[37] D. Tu, P. Jin και X. Zhang, “Geometrical Model of Laser Triangulation System Based on Synchronized Scanners”, 2019.
[38] J. Schmit, K. Creath και J. C. Wyant, “Surface profilers, multiple wavelength, and white light interferometry”, vol 667755, 2007.
[39] E. Mikhail, J. Bethel και J. McGlone, “Introduction to modern photogrammetry”. 2001.
[40] K. Liu, Y. Wang, D. Lau, Q. Hao, L. Hassebrook, “Dual-frequency pattern scheme for high-speed 3-D shape measurement”, 18(5):5229-5244, 2010.
[41] J. Hyun, G. Chiu και S. Zhang, “High-speed and high-accuracy 3D surface measurement using a mechanical projector”, 26(2):1474-1487, Jan 2018.
[42] S. Heist, A. Mann, P. Kühmstedt, P. Schreiber και G. Notni, “Array projection of aperiodic sinusoidal fringes for high-speed three-dimensional shape measurement” 53(11): 112208, 2014.
[43] A. Grunnet-Jepsen, J. Sweetser, P. Winer, A. Takagi και J. Woodfill, “Projectors for Intel Real Sense Depth Cameras D4xx”, 2019.

[44] B. DeWitt και P. Wolf, Elements of Photogrammetry (with Applications in GIS), McGraw-Hill Higher Education, 2000.
[45] M. Daneshmand, A. Helmi, E. Avots, F. Noroozi, F. Alisinanoglu, H. S. Arslan, J. Gorbova, R. E. Haamer, C. Ozcinar και G. Anbarjafari, "3D scanning: a comprehensive survey", 2018.
[46] J. F. Andersen, J. Busck και H. Heiselberg, "Submillimeter 3-D laser radar for space shuttle tile inspection", 2013.
[47] S. Altman, W. Xiao και B. Grayson, "Evaluation of low-cost terrestrial photogrammetry for 3D reconstruction of complex buildings", vol 4, 2017.
[48] A. Miles, S. Bechhofer, "SKOS Simple Knowledge Organization System", W3C Recommendation. 18 August 2009.
[49] W. Lee, W. Bailer, T. Bürger, P. Champin, J. Evain, V. Malaisé, T. Michel, F. Sasaki, J. Söderberg, F. Stegmaier, J. Strassner, "Ontology for Media Resources 1.0", W3C Recommendation 09 February 2012.
[50] CCSDS Secretariat, "Reference Model for an Open Archival Information System (OAIS)", June 2012.
[51] V. Bartalesi, C. Meghini, and D. Metilli. A conceptualisation of narratives and its expression in the CRM. International Journal of Metadata, Semantics and Ontologies, 12(1):35– 46, 2017.
[52] D. Davidson, (2001), "Essays on actions and events", Philosophical essays, vol. 1, Oxford University Press.
[53] Z. Cao, T. Simon, S. Wei, and Y. Sheikh, "Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields," in CVPR, 2017.
[54] S. Wei, V. Ramakrishna, T. Kanade, and Y. Sheikh, "Convolutional Pose Machines," CVPR, 2016.
[55] T. Lin, M. Maire, S. Belongie, J. Hays, P. Perona, D. Ramanan, P. Dollar, and C. L. Zitnick, "Microsoft COCO: Common Objects in Context," in ECCV, 2014.
[56] C. Ionescu, D. Papava, V. Olaru, and C. Sminchisescu, "Human3.6M: Large Scale Datasets and Predictive Methods for 3D Human Sensing in Natural Environments," IEEE Trans. on PAMI, 2014.
[57] D. Mehta, S. Sridhar, O. Sotnychenko, H. Rhodin, M. Shafiei, H.-P. Seidel, W. Xu, D. Casas, and C. Theobalt, "VNect: Real-time 3D Human Pose Estimation with a Single RGB Camera," TOG, 2017.
[58] D. Tome, C. Russell, and L. Agapito, "Lifting from the Deep: Convolutional 3D Pose Estimation from a Single Image," in CVPR, 2017.
[59] J. Martinez, M. J. Black, and J. Romero, "On Human Motion Prediction Using Recurrent Neural Networks," CVPR, 2017.
[60] D. Drover, R. MV, C.-H. Chen, A. Agrawal, A. Tyagi, and C. P. Huynh, "Can 3D Pose be Learned from 2D Projections Alone?", ECCV Workshops, 2018.
[61] X. Zhou, S. Leonardos, X. Hu, and K. Daniilidis, "3D shape estimation from 2D landmarks: A convex relaxation approach," CVPR, 2015.
[62] G. Pavlakos, X. Zhou, K. G. Derpanis, and K. Daniilidis, "Coarse-to-Fine Volumetric Prediction for SingleImage 3D Human Pose," CVPR, 2017.
[63] A. Kanazawa, M. J. Black, D. W. Jacobs, and J. Malik, "End-to-end Recovery of Human Shape and Pose," CoRR, 2017.
[64] Y. Huang, F. Bogo, C. Lassner, A. Kanazawa, P. Gehler, I. Akhter, and M. Black, "Towards Accurate Marker-less Human Shape and Pose Estimation over Time," 2017.
[65] M. Omran, C. Lassner, G. Pons-Moll, P. V. Gehler, and B. Schiele, "Neural Body Fitting: Unifying Deep Learning and Model-Based Human Pose and Shape Estimation," 2018.

[66] F. Bogo, A. Kanazawa, C. Lassner, P. Gehler, J. Romero, and M. J. Black, “Keep it SMPL: Automatic estimation of 3D human pose and shape from a single image,” in ECCV, vol. 9909 LNCS, 2016.
[67] R. Guler, N. Neverova, and I. Kokkinos, “DensePose: Dense Human Pose Estimation in The Wild,” in CVPR, 2018.
[68] J. Shotton, A. Fitzgibbon, M. Cook, T. Sharp, M. Finocchio, R. Moore, A. Kipman, and A. Blake, “Real-time human pose recognition in parts from single depth images,” in CVPR, IEEE, 2011.
[69] D. Michel, A. Qammaz, and A. A. Argyros, “Markerless 3D Human Pose Estimation and Tracking based on RGBD Cameras,” in PETRA, 2017.
[70] D. Michel and A. Argyros, “Apparatuses, methods and systems for recovering a 3-dimensional skeletal model of the human body”, United States Patent No 20160086350, Filed: 22/09/2015, Published: 24/03/2016.
[71] M. Marın Jimenez, F. Romero-Ramirez, R. Munoz Salinas, and R. Medina-Carnicer, “3D human pose estimation from depth maps using a deep combination of poses,” Journal of Visual Communication and Image Representation, 2018.
[72] G. Moon, J. Chang, and K. Lee, “V2V-PoseNet: Voxel-to-Voxel Prediction Network for Accurate 3D Hand and Human Pose Estimation from a Single Depth Map,” in CVPR, 2017.
[73] A. Haque, B. Peng, Z. Luo, A. Alahi, S. Yeung, and L. Fei-Fei, “Towards viewpoint invariant 3D human pose estimation,” in ECCV, vol. 9905 LNCS, 2016.
[74] C. Zimmermann, T. Welschehold, C. Dornhege, W. Burgard, and T. Brox, “3D Human Pose Estimation in RGBD Images for Robotic Task Learning,” in ICRA, 2018.
[75] X. Zhou, M. Zhu, S. Leonardos, K. Derpanis, and K. Daniilidis, “Sparseness Meets Deepness: 3D Human Pose Estimation from Monocular Video,” CVPR, 2016.
[76] X. Zhou, X. Sun, W. Zhang, S. Liang, and Y. Wei, “Deep Kinematic Pose Regression,” in ECCV Workshops, sep 2016.
[77] A. Qammaz, D. Michel, and A. Argyros, “A Hybrid Method for 3D Pose Estimation of Personalized Human Body Models,” in WACV, IEEE, mar 2018.
[78] T. Wang, X. He, and N. Barnes, “Learning Structured Hough Voting for Joint Object Detection and Occlusion Reasoning,” in CVPR, IEEE, jun 2013.
[79] G. Ghiasi, Y. Yang, D. Ramanan, and C. Fowlkes, “Parsing Occluded People,” in CVPR, 2014.
[80] U. Bonde, V. Badrinarayanan, and R. Cipolla, “Robust instance recognition in presence of occlusion and clutter,” in ECCV, vol. 8690 LNCS, 2014.
[81] UNESCO, “Text of the Convention for the Safeguarding of the Intangible Cultural Heritage”, 2003.
[82] MINERVA, Ministerial Network for Valorising activities in digitisation, “D6.2. Good Practice Handbook”, November 2003.
[83] M. Wachowiak, V. Karas, "3D Scanning and Replication for Museum and Cultural Heritage Applications", Journal of the American Institute for Conservation, 48:141–15, 2009.
[84] J. Waycott, A. Morgans, S. Pedell, E. Ozanne, F. Vetere, L. Kulik, H. Davis, "Ethics in Evaluating a Sociotechnical Intervention With Socially Isolated Older Adults", Qualitative Health Research, Vol 25, Issue 11, 2015.
[85] S. Lindsay, D. Jackson, G. Schofield, P. Olivier, “Engaging Older People using Participatory Design” In: Participatory Design with Older People, CHI 2012, May 5–10, 2012, Austin, Texas, USA.

[86] A. Dickinson, J. Arnott, S. Prior, “Methods for human - computer interaction research with older people”, Journal Behaviour & Information Technology, Issue: Designing Computer Systems for and with Older, Volume 26, 2007.
[87] T. Barrance, “Learn about film”, https://learnaboutfilm.com
[88] P. Panteleris, I. Oikonomidis and A.A. Argyros, "Using a single RGB frame for real time 3D hand pose estimation in the wild", In IEEE Winter Conference on Applications of Computer Vision (WACV 2018), also available at Arxiv., IEEE, pp. 436-445, lake Tahoe, NV, USA, March 2018.
[89] A. Qammaz, and A.A. Argyros, "MocapNET: Ensemble of SNN Encoders for 3D Human Pose Estimation in RGB Images", In British Machine Vision Conference (BMVC 2016), BMVA, Cardiff, UK, September 2019.
[90] T. Lussetyowati, "Preservation and Conservation through Cultural Heritage Tourism. Case Study: Musi Riverside Palembang", Procedia - Social and Behavioral Sciences 184 (2015) 401 – 406, 5th Arte Polis International Conference and Workshop – “Reflections on Creativity: Public Engagement and The Making of Place”, Arte-Polis 5, 8-9 August 2014, Bandung, Indonesia.
[91] P. Reséndiz, "Digital preservation of sound recordings", Investigación Bibliotecológica: Archivonomía, Bibliotecología e Información, Volume 30, Issue 68, Supplement, January–April 2016, Pages 173-195
[92] IFLA/UNESCO, "Survey on Digitisation and Preservation", Emerald Group Publishing Limited 1999.
[93] K. Bradley, Risks associated with the use of recordable CDs and DVDs as reliable storage media in archival collections: strategies and alternatives", 2006.
[94] UNESCO, National Library of Australia, "Guidelines for the preservation of digital heritage", CI.2003/WS/3, 2003.
[95] K. Bradley, J. Lei, C. Blackall, "Memory of the World: towards an open source repository and preservation system", Conference:Meeting of the International Advisory Committee of the Memory of the World Programme, Pretoria, South Africa, 2007.
[96] UNESCO, “Digitization and online accessibility of cultural content and digital preservation”, Latvia, 2016.
[97] M. Tacchetti. "User Guide for ELAN Linguistic Annotator", version 5.0.0, 2018, http://tla.mpi.nl/tools/tla-tools/elan/
[98] Barbara Meyers, “Textiles and the Reformation”, Unitarian Universalist History, Part I, Fall 2001.
[99] TextilTechnikum, “The Development of Textile Technology”, Monforts Quartier, Mönchengladbach. https://artsandculture.google.com/partner/textiltechnikum
[100] I. Ihrke, K. Kutulakos, H. Lensch, M. Magnor, W. Heidrich, "Transparent and specular object reconstruction", Computer Graphics Forum, 29(8):2400–2426 (2010).
[101] T. Kennedy, Safeguarding traditional craftsmanship: a project demonstrating the revitalisation of intangible heritage in Murad Khane, Kabul, Int. Journal of Intangible Heritage, vol 5, 2010.
[102] D. Tranter, Safeguarding Australian heritage trade skills, Int. Journal of Intangible Heritage, vol 5, 2010.
[103] G. Barra, Chinese Craft Project, Politecnico Di Milano, MSC Thesis, 2012.
[104] European Commission: “The Economy of Culture in Europe”, 2006.
[105] H. Jennings, Towards a Definition of Heritage Craft, Creative & Cultural Skills, 2012.
[106] UNESCO, Intangible Cultural Heritage Domains, 2003.

[107] S. Markowitz, "The Distinction between Art and Craft", The Journal of Aesthetic Education, Vol. 28, No. 1 (Spring, 1994), pp. 55-70.
[108] R. Mur-Artal, J. D. Tardós. ORB-SLAM2: an Open-Source SLAM System for Monocular, Stereo and RGB-D Cameras. IEEE Transactions on Robotics, 2017.
[109] O. Kähler, V. Prisacariu, J. Valentin, D. Murray. Hierarchical Voxel Block Hashing for Efficient Integration of Depth Images. IEEE Robotics and Automation Letters, 2016.
[110] S. Golodetz, T. Cavallari, N. A. Lord, V. A. Prisacariu, D. W. Murray, P. H. S. Torr. Collaborative Large-Scale Dense 3D Reconstruction with Online Inter-Agent Pose Optimisation. IEEE Transactions on Visualization and Computer Graphics, 2018.
[111] T. Malzbender, D. Gelb, H. Wolters, "Polynomial texture maps", Annual conference on Computer graphics and interactive techniques, SIGGRAPH 2001, Pages 519-528, ACM New York, NY, USA, 2001.
[112] D. Dennett, "Quining Qualia", A. Marcel and E. Bisiach, eds, Consciousness in Modern Science, Oxford University Press 1988. Reprinted in W. Lycan, ed., Mind and Cognition: A Reader, MIT Press, 1990, A. Goldman, ed. Readings in Philosophy and Cognitive Science, MIT Press, 1993.
[113] J. Etienne-Nugue, "Crafts: methodological guide to the collection of data", CLT/ACR/90, 1990.
[114] C. Joy, "The Politics of Heritage Management in Mali: From UNESCO to Djenné", Taylor & Francis, 2012, ISBN 9781611320947.
[115] C. Costin, "Craft and Social Identity", Archaeological Papers of the American Anthropological Association, 8(1):3-16, 2008 doi:10.1525/ap3a.1998.8.1.3.
[116] Ouagadougou, “Conference on African crafts - The Current Situation and Future prospects”, February 1988.
[117] World Crafts Council, “International Conference on the Role of Crafts in the Development process”, Djakarta, August 1985.
[118] E. Pye (ed.), “Artisans in Economic Development - (Inde, Nepal, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand)”, International Development Research Centre, Ottawa, 1988.
[119] S. Kathuria, V. Miralao, R. Joseph, “Artisan industries in Asia: four case studies”, International Development Research Centre, Ottawa, 1988.
[120] Hispano-American Crafts Community, “Tenerife seminar”, October 1988.
[121] M. Nosch, C. Gillis (ed), "Ancient Textiles: Production, Crafts and Society", Oxbow Books, 2007.
[122] A Hecht, "Art of the Loom: Weaving, Spinning And Dyeing Across the World", Diane Pub Co., 2001, ISBN-10: 0756782821.
[123] H. Durrant-Whyte, T. Bailey, "Simultaneous localization and mapping: part I". IEEE Robotics & Automation Magazine. 13 (2): 99–110, 2006. doi:10.1109/mra.2006.1638022.
[124] Banks, M. (2001) Visual Methods in Social Research. London: SAGE Publications.
[125] Ketelle, D. (2010) The Ground They Walk On: Photography and Narrative Inquiry. The Qualitative Report, 15(3). Pp. 535-568 (accessed June 28, 2019).
[126] Gottesman, S. (2016) 10 Pioneering Textile Artists, from Sheila Hicks to Nick Cave (accessed July 28, 2019).
[127] Leroi-Gourhan, A. (1993) Gesture and Speech, Cambridge: MIT Press.
[128] R. Mur-Artal, J. D. Tardós. ORB-SLAM2: an Open-Source SLAM System for Monocular, Stereo and RGB-D Cameras. IEEE Transactions on Robotics, 2017.
[129] O. Kähler, V. Prisacariu, J. Valentin, D. Murray. Hierarchical Voxel Block Hashing for Efficient Integration of Depth Images. IEEE Robotics and Automation Letters, 2016.

[130] S. Golodetz, T. Cavallari, N. A. Lord, V. A. Prisacariu, D. W. Murray, P. H. S. Torr. Collaborative Large-Scale Dense 3D Reconstruction with Online Inter-Agent Pose Optimisation. IEEE Transactions on Visualization and Computer Graphics, 2018.
[131] Guarino, N., "Formal Ontology and Information Systems", Proceedings of FOIS 1998, Trento, Italy, 6-8 June 1998. Amsterdam, IOS Press, pp. 3-15.
[132] Welty, C., Fikes R., "A Reusable Ontology for Fluents in OWL", Proceedings of the Fourth International Conference, FOIS 2006, Baltimore, Maryland, USA, November 9-11, 2006.
[133] Bartalesi, V., Meghini, C., and Metilli, D., "Steps Towards a Formal Ontology of Narratives", 7th Workshop on Computational Models of Narrative (CMN 2016).
[134] S. Zeki, "Inner Vision: An Exploration of Art and the Brain", Oxford University Press, 2000.
[135] S. McCloud, "Understanding Comics", 1993, ISBN 0-87816-244-5.
[136] Arana, L. M. L. (2015, November). La Ligne Claire de Le Corbusier. Time, Space, and Sequential Narratives. In LC2015-Le Corbusier, 50 years later.
[137] J. Hoskins, "Agency, Biography and Objects", In: Handbook of Material Culture, SAGE, 2005.
[138] K. Vonnegut, "A Man Without a Country", Seven Stories Press, 2005, ISBN 1-58322-713-X.
[139] Jockers, M.. (2014): "A novel method for detecting plot". [Access date 25. August 2016
[140] A. Reagan, L. Mitchell, D. Kiley, C. Danforth, P. Dodds, "The emotional arcs of stories are dominated by six basic shapes", EPJ Data Science volume 5, Article number: 31 (2016).
[141] C. Booker, "Seven Basic Plots", 2004, ISBN-13: 978-0826480378.
[142] V. Propp Morphology of the Folktale, University of Texas Press, 1968.
[143] UNESCO, "Operational Directives for the Implementation of the Convention for the Safeguarding of the Intangible Cultural Heritage", 7.GA (2018).
[144] Harrigan, Pat; Wardrip-Fruin, Noah (2007). Second Person: Roleplaying and Story in Playable Media. MIT University Press. ISBN 9780262514187.
[145] Fairweather, P., Culture Vultures or the Boorish Masses – Who are Cultural Visitors in Australia? Canberra: Tourism Research Australia, Cultural Tourism Conference, February 2008.
[146] UNWTO, Study on Tourism and Intangible Cultural Heritage, 2012, ISBN 978-92-844-1479-6
[147] O. Acker, F. Gröne, L. Kropiunigg, T. Lefort, The digital future of creative Europe: The impact of digitization and the Internet on the creative industries in Europe, Stategy&, 2015.
[148] European Council, "Framework Convention on the Value of Cultural Heritage for Society", CETS No.199, Faro, 27/10/2005.
[149] Austrian, G., "Herman Hollerith: Forgotten Giant of Information Processing", Columbia University Press (1982).
[150] Paterson, R., and Karjala, D. (2003/4). Looking Beyond Intellectual Property in Resolving Protection of the Intangible Cultural Heritage of Indigenous Peoples. Cardozo Journal of International and Comparative Law, 11, 633–670.
[151] Bortolotto, C., From Objects To Processes: UNESCO's 'Intangible Cultural Heritage', Journal of Museum Ethnography, No. 19, Papers from the Annual Conference of the Museum Ethnographers Group Held at Birmingham Museum & Art Gallery, 18–19 May 2006 (March 2007), pp. 21-33.
[152] Ziegler, K., (2007) Cultural Heritage and Human Rights. Oxford Legal Studies Research Paper No. 26/2007. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1002620
[153] Bortolotto, (2006) C. From the 'Monumental' To The 'Living' Heritage: A Shift In Perspective, World Heritage. p 4-7, Global Challenges, Local Solutions.
[154] Pearce, C. (2000), The Making of Cultural Heritage, in Values and Heritage Conservation, Getty Conservation Institute.

[155] Bonn, M., Kendall, L., McDonough, J. (2017) Libraries and Archives and the Preservation of Intangible Cultural Heritage: Defining a Research Agenda. Illinois: School of Information Sciences.
[156] Bortolotto, C. (2010) Globalising intangible cultural heritage? Between international arenas and local appropriations. In: Labadi, S. & Long, C. (eds.) Heritage and Globalisation. London: Routledge. Pp. 97 – 114.
[157] Bortolotto, C. (2017) Placing intangible cultural heritage, owning a tradition, affirming sovereignty: the role of spatiality in the practice of the 2003 Convention. In: Stefano, M.L. & Davis, P. (eds.) The Routledge Companion to Intangible Cultural Heritage. London: Routledge. Pp. 46 – 59.
[158] Kuutma, K. (2009) Who Owns Our Songs? Ethnologia Europaea 39:2. doi: https://doi.org/10.16995/ee.1052
[159] Kuutma, K. (2013) Concepts and Contingencies in Heritage Politics. In: Arizpe, L. & Amescua, C. (eds.) Anthropological Perspectives on Intangible Cultural Heritage. Pp. 1 – 15.
[160] Lenzerini, F. (2011) Intangible Cultural Heritage: The Living Culture of Peoples. The European Journal of International Law 22:1. Pp. 101 – 120.
[161] Lowenthal, D. (2015) The Past is a Foreign Country. Cambridge: Cambridge University Press.
[162] Machuca, J.A. (2013) Challenges for Anthropological Research on Intangible Cultural Heritage. In: Arizpe, L. & Amescua, C. (eds.) Anthropological Perspectives on Intangible Cultural Heritage. New York: Springer. Pp. 57 – 69.
[163] Hamilakis, Y. and Yalouri, E., (1996), Antiquities as symbolic capital in modern Greek society, Antiquity, Volume 70, Issue 267, March 1996 , pp. 117-129.
[164] Shiva, Vandana (1999). Biopiracy: The Plunder of Nature and Knowledge. Cambridge, MA: South End Press.
[165] Slattery, Erin K. (Spring 2006). "Preserving the United States' Intangible Cultural Heritage: An Evaluation of the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage as a Means to Overcome the Problems Posed by Intellectual Property Law". DePaul Journal of Art, Technology & Intellectual Property Law 16(2), pp. 201- 260.
[166] Torsen, Molly (2008). "Intellectual Property and Traditional Cultural Expressions: A Synopsis of Current Issues." Intercultural Human Rights Law Review 3, 199-214.
[167] Wendland, Wend (May 2004). "Intangible Heritage and Intellectual Property: challenges and future prospects." Museum International 56(1-2), pp. 97-107.
[168] Ziff, Bruce and Rao, Pratima V. (1997). Borrowed Power: Essays on Cultural Appropriation. New Brunswick, NJ: Rutgers University Press.
[169] Nicholas, G., and Bannister, K. (2004) Copyrighting the Past? Emerging Intellectual Property Rights Issues in Archaeology. Current Anthropology, 45, 327–350.
[170] WIPO, (2001) Basic Notions of Copyright and Related Rights, International Bureau of World Intellectual Property Organization.
[171] Shyllon, F., (2015), Cultural Heritage and Intellectual Property: Convergence, Divergence, and Interface, In A Companion to Heritage Studies, https://doi.org/10.1002/9781118486634.ch4
[172] Reddy, Sita (May 2006). "Making Heritage Legible: Who Owns Traditional Medical Knowledge?" International Journal of Cultural Property 13(2): pp. 161-188.
[173] Posey, Darrell (Aug. 1990). "Intellectual Property Rights: And Just Compensation for Indigenous Knowledge." Anthropology Today 6(4): pp. 13-16.
[174] Greaves, Tom (1994). Intellectual Property Rights for Indigenous Peoples: A Sourcebook. Oklahoma, OK: Society for Applied Anthropology.

[175] Santilli, J. (2006) Cultural Heritage and Collective Intellectual Property Rights. Indigenous Knowledge (IK) Notes ; no 95. Washington, D.C. : World Bank Group. Available at: http://documents.worldbank.org/curated/en/854671468006636661/Cultural-heritage-and-collective-intellectual-property-rights
[176] Scovazzi, T., (2019) The UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage. General Remarks In The Legal Protection of the Intangible Cultural Heritage, https://doi.org/10.1007/978-3-319-72983-1_1
[177] WIPO, "Guide to the Copyright and Related Rights Treaties Administered by WIPO and glossary of copyright and related rights terms", p.305, World Intellectual Property Organization, Publication No. 891.
[178] United Nattions. (1994), United Nations Declaration on the Rights of Indigenous Peoples, Resolution adopted by the General Assembly on 13 September 2007 61/295.
[179] Telesetsky A (2008) Traditional knowledge: protecting communal rights through a sui generis system. In: Nafziger JAR, Scovazzi T (eds) Le patrimoine culturel de l'humanité – The cultural heritage of mankind. Nijhoff, Leiden, p 310.
[180] Kristen A. Carpenter, Sonia K. Katyal & Angela R. Riley, In Defense of Property, 118 Yale Law Journal (2009). Available at: https://digitalcommons.law.yale.edu/ylj/vol118/iss6/1
[181] Brown, M. (2005), Heritage Trouble: Recent Work on the Protection of Intangible Cultural Property. International Journal of Cultural Property 12: 41.
[182] Cominelli, Francesca, (2011), Sustaining Commons: Sustaining Our Future, In the Thirteenth Biennial Conference of the International Association for the Study of the Commons, Conference Paper [3953], http://hdl.handle.net/10535/7212
[183] Russo, A.P., Segre, G., 2009. Destination models and property regimes: an exploration. Annals of Tourism Research 36, 587-606.
[184] Zabulis, X, (2020), Mingei protocol illustrations [Unpublished work].
[185] Stefanidi, E, (2020), MoViz illustrations [Unpublished work].
[186] Nitti, V, (2020), Mingei mobile games screenshots [Unpublished work].
[187] Kaplanidi, D. (2020) Mastic cultivation schema [Unpublished work].
[188] Doa, S. (2020) Mingei Online Platform screenshots [Unpublished work].
[189] Rigaki E. (2020) MotiVo screenshots [Unpublished work].
[190] Thurley, Into the Future. Our Strategy for 2005–2010, Conservation Bulletin 49:26–27, 2005.
[191] Farago, (2015), Why Museums are the new Cathedrals, BBC Culture, 2015.
[192] ARUP, (2013), Museums in the Digital Age.
[193] Cobb+Co Museum and Southern Queensland Institute Of Tafe, (2008), Heritage Is In Our Hands - A Review Of Heritage Trade Training.