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The Mingei collection of knowledge

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Executive summary

Mingei's collection of knowledge aims to contribute to the preservation and conservation of the contexts in which a craft has been developed in Europe. We define the collection of knowledge, the process of gathering and analysing information regarding a topic; in this case, the contexts (cultural, political, economic, etc.) in which a craft can develop. Historical and scientific sources, as well as newly conducted research, can provide information in order to reveal and map the craft contexts. Therefore, we suggest that Mingei's collection of knowledge is a tool for researchers and public or private institutions with guidelines on how to conduct coherent research on crafts and craft making. These guidelines include: (1) the definition of theoretical background in order to define the scope and aim of the research, (2) the selection of suitable methods to acquire the desired knowledge, and (3) a table of data types concerning tangible and intangible aspects of crafts and craft making, which can facilitate the user to perform an inventorization of the collected knowledge. More specifically, this tool aims to help professionals and scholars in the CH domain, HC practitioners, craft communities and friends, as well as authorities and political bodies. The collection of knowledge strives to adhere to international standards of CH documentation. Nevertheless, adherence to these standards may require expertise in technology or the humanities.

Having in mind the cultural significance of every craft and the meaning it has to the craft community, the need of preserving these facts, the related HC tourism, and applicable educational needs, the Mingei collection of knowledge aspires to grasp the tangible and intangible dimensions of crafts and their multiple contexts. As mentioned before, the Mingei collection of knowledge is primarily a tool. Therefore, the document aims first to explain the methodology (digital and/or not) proposed by Mingei in order to formulate a research protocol, while, second, to present examples of applying this protocol in capturing craft instances. This is achieved through Mingei's pilots on silk weaving, mastic cultivation, and glass blowing.

Although the knowledge for these craft instances was collected during the first nine months of the project, we acknowledge that knowledge collection is a never-ending process. For this reason, at this phase, we provide the knowledge, which is mandatory for a comprehensive presentation of each pilot craft instance. We, nevertheless, plan to provide a system that will gracefully incorporate new knowledge obtained through further research, within the context of Mingei and in the future.

The remaining summary is divided into four sections referring to the methods and methodology, and the knowledge collection of each pilot as it is formulated so far.

Section 1: Methods & Methodology:

- The (digital) assets to be collected are digitizations of text, images, 3D reconstructions, motion capture, audio-visual material, and so on.
- To begin with the knowledge collection, we acknowledge that secondary research should take place in order to gather primary, secondary, and tertiary sources related to the research topic. We propose that archival research can help find primary sources such as raw data, personal letters, documentation footage, photographs, and so on, as well as secondary sources such as

reports, articles, books, films.

- The preliminary search of assets will lead to the digitisation of the content acquired and the production of new content. New content will be produced according to the needs of the researcher. First and more easily, literature can be scanned (2D). Mingei further proposes the digitization of human motion of the craft practitioners when they are working. This information helps reflect on special techniques and handwork of the craft; that is, skill and knowledge (intangible aspect).
- By digitizing the human motion, first, a repository of human motions is created in order to preserve the movement, and second, the opportunity arises to use this digital movement for the production of avatars performing craft making (either for presentational or educational purposes).
- Acquisition of contextual information regarding the craft and its community plays an important role too in knowledge collection. The collection of contextual information has already begun since the beginning of the research. In this part, we further suggest some methods used in the Social Sciences and the Humanities for qualitative research. These briefly are (a) participant observation which helps to get acquainted with the community and the craftspeople in person, (b) photo and video elicitation through which information is extracted by the participant with the aid of visual material, (c) narrative interviews that aim to give freedom to the participant to narrate personal stories as s/he remembers them, and (d) 'geography of workshop' [87] which takes a closer look on the workplaces where craft is happening.
- After collecting assets and contextual information, we organized everything into categories in order to accord thematics with available assets. For this task of inventorization, we initially use the data types offered by UNESCO for the documentation of the Representative List of Intangible Cultural Heritage. Nevertheless, we find that there are aspects that are missing and therefore we added more categories. To name the new categories, those are (a) gender roles, (b) design dimension referring to patterns and motifs and their historical dimension, (c) artistic dimension concerning the involvement of craft making in contemporary art-making, (d) geography of workshops, and (e) emic (inside) presentation in order to better understand the cultural significance of the craft by the craftspeople themselves. The complete table with the data types can be found in Annex A1.2.

Section 2: HdS Silk collection of knowledge

- We have identified that there is literature, images, and audio-video material provided by the museum of HdS. To enhance the assets, more photographs, as well as videos for the production of 3D models of the museum items were taken. Furthermore, motion capture took place at the premises of the museum in order to record the practitioners' movement when weaving with a Jacquard loom.
- Contextually we have so far identified the following categories and thematics that have arisen through the research for silk weaving in Krefeld:
  - A dictionary with tools, persons, and materials participating in silk weaving.
  - Description of how (silk) textile manufacturing works. More specifically, we take a look into the ecclesiastical textile, garment, and parament manufacturing in Krefeld, since it appears to be an important aspect of the textile industry in the town as the literature indicates.
  - We define through illustrations the geographical area concerned in the pilot and offer

a historical overview of the Rhine and its regions.
  - We focus on information concerning the Gotzes family which was the founder of the Gotzes Fabric, a former textile company where the museum is now based.
  - We look at inventions relevant to textile manufacturing and explain how it is connected to computer science.

Section 3: PIOP Mastic collection of knowledge

- PIOP holds the archive of the Chios Gum Mastic Growers Association who is the main stakeholder regarding mastic cultivation in Chios, along with the mastic growers themselves. Through this archive and PIOP's library, literature, audio-visual material, as well as digitised objects such as 2D scans of historical books were retrieved. For the collection of new assets audio-visual material was produced, as well as 3D scans of the museum's items, the mastic tree, and open spaces such as the Chios Mastic Museum and mastic villages. Furthermore, motion capture of the cultivators performing agricultural tasks took place. Fieldwork was also conducted at the mastic villages in order to collect more information regarding the significance and the perspective of the mastic growers with mastic and its cultivation.
- Contextually we have so far identified the following categories and thematics stemming from archival and on-site research in Chios:
  - Description of the cultivation craft and the processes performed by the growers and the Chios Gum Mastic Growers Association.
  - A dictionary of the equipment that is used in the different processes by the different actors, and the products that are produced with mastic.
  - We identify the distinctive geographical places in Chios that relate to mastic cultivation.
  - Socio-historically, we identified categories that strongly relate to the economy, history, and social organization of the island.
  - Festive events, oral traditions, and customs, gender roles in craft processes, local religious beliefs, artistic expression related to Pyrgi's (mastic village) decorative architecture, traditional clothing, as well as media representations (film, photography, press) of life in the mastic villages were discovered. Furthermore, emic (inside) presentations were collected through both archival research and on-site fieldwork.

Section 4: CNAM Glass collection of knowledge

- We were able to find literature, audio-visual material and digitised objects (historical books) through the museum's archive. We further proceeded with 3D scanning of objects and the glass workshop in order to create 3D reconstructions. Furthermore, motion capture was used to record the movement of the craftspeople. Fieldwork at the glass workshop of Cerfav revealed more details on glass blowing and the production of Bontemps' carafe.
- Contextually we so far identified the following categories and thematics:
  - The description on what is glass, and which is the process of glassmaking.
  - A dictionary refers to tools, equipment, materials, and persons needed.
  - A historical timeline with main events concerning glassblowing and its development.
  - We look more specifically into George Bontemps who was the most famous glassmaker in France, Choisy-le-Roi (a glass factory during Bontemps' life), and the

Conservatoire des arts et métiers (CNAM).

Keywords

Knowledge Collection, Mingei Collection of Knowledge, Tangible Heritage, Intangible Heritage, Heritage Craft, Documentation, Preservation, Conservation, Methods, Methodology, Guidelines, Contextual Information, Archive, Library, Digitisation, Human Motion, Mingei Pilots, CNAM, PIOP, Haus der Seidenkultur, Silk, Glass, Mastic.

Notes

1. The content of all URLs provided in the references was accessed and validated on the date of deliverable submission. The electronic version of this document contains hyperlinks to the WWW.
2. The deliverable contains images found on the Internet. These are verified to be copyright-free or available for fair use. Each such image is referenced and the online URL is provided.
3. The deliverable contains images, i.e. as photographs and drawings, acquired and created by its authors. These are noted in the figure captions and are unpished work of the authors unless otherwise mentioned.
4. The contributors of each table in the deliberable are noted, in the table caption.
5. In Sections 3, 4, and 5, we provide directory paths to digitised files. These paths refer to the Mingei dataset.

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Key abbreviations

HC	Heritage Craft
CH	Craft Heritage
MOP	Mingei Online Platform
ICH	Intangible Cultural Heritage
HLT	Human Living Treasure
HdS	Haus der Seidenkultur
CNAM	Conservatoire National des Arts et Métiers
PIOP	Piraeus Bank Group Cultural Foundation
MoCap	Motion Capture
OCR	Optical Character Recognition
DVD	Digital Versatile Disc
IMU	Inertial measurement unit
SKOS	Simple Knowledge Organization System
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
UNESCO	United Nations Educational, Scientific and Cultural Organization
GPS	Global Positioning System
GIS	Geographic Information System
IR	Industrial Revolution
WWII	World War II

Table of Contents

List of figures

List of tables

1. Introduction

This deliverable describes Mingei's part to **collect knowledge** on HCs with the purpose to contribute to the **preservation** and **conservation** of their **context of existence** in Europe. UNESCO has identified aspects of ICH that need to be taken into account when documenting a craft. These are exemplified in a table for the documentation of Elements of the Representative List of Intangible Cultural Heritage. Mingei follows the thinking of this list but at the same time proposes new aspects that should be considered when documenting a craft such as identified gender roles, advanced geographical mappings and inside representation of the cultural significance of the craft as expressed by the craftspeople. Further aspects that Mingei's collection of knowledge can contribute to are exemplified in "2. Our approach towards knowledge collection".

The collection of knowledge is separated into two conceptual subsections of methodological approaches in "3. Methods & Methodology". The first section concerns the management and collection of existing information on a craft through archives and bibliographic research and methods for the acquisition of new content. The new content includes the digitisation of the already existing content that was found in the preliminary, archival, and bibliographic research and the production of new material for the database concerning the craft. The second section relates to the acquisition of contextual information on a craft regarding historical, societal, economic, traditional practices, etc. that might concern a craft in a particular area.

This structure aims to provide to researchers and public or private institutions researching ICH a tool with descriptive guidelines to document a HC. More specifically Mingei's collection of knowledge offers:

- A **theoretical background** of researching and representing CH through the assumptions that have been identified so far.
- **Methods** for qualitative research, production of audiovisual material and digitisations.
- Tangible and intangible **aspects** that a craft might include.

Mingei's collection of knowledge then consists a methodological structure that is yet to form a model of scientific process. The concept of the guideline's structure is better outlined and understood through the presentation of its application on Mingei's pilots on Silk, Glass and Mastic in "4. HdS Silk collection of knowledge", "5. CNAM Glass collection of knowledge" and "6. PIOP Mastic collection of knowledge", accordingly. It is important to note that the pilots are on a different progress stage, with Silk being more advanced as its research and process started sooner.

In the rest of this introduction, we provide working definitions of concepts and state the assumptions adopted by the Mingei collection of knowledge.

1.1 What is collection of knowledge?

Collection of knowledge is the process of gathering information regarding a topic. This information can concern historical, cultural, or scientific facts that are intertwined with the topic of research. The organization and analysis of this information (or data, in other words) lead to a certain knowledge of the researched topic [88] . Aim of the Mingei collection of knowledge is to follow Sack's proposition on 'knowledge mining' and go through a semantic annotation of all the collected information in order to create a database regarding the topic of research. This database can then help researchers, individuals and public or private institutions to retrieve information on the topic according to their interest. It is important to mention though that collections of knowledge can differ regarding their content (even when it is about the same topic) because of the vast information that might exist, or their design depending on the institution that created it [1].

After collection, in WP3, we will represent the collected knowledge “formally”. In this way, in WP3, we will be able to establish links between the pieces of the collected information. To achieve our goal, we need to bridge the gap between the collected knowledge, *as provided by heritage partners*, and collected knowledge, encoded *as required by a formal representation*. From one side, the more organised the collected knowledge from heritage partners is, the simpler the encoding of knowledge in a formal representation becomes. From the other side of the gap, we focus on providing ways to contribute knowledge in meaningful and simple ways, for heritage partners. The ways are the basis of design for an intuitive interface towards the knowledge collection task.

Examples are provided in Figure 1 and Figure 2. The purpose of these examples is to illustrate how we envision the establishment of these “links”, or otherwise semantic relationships, in the Mingei Online Platform. In Figure 1, we see the form for entering biographical information; besides conventional entries, the possibility of relating a person to events is provided. In Figure 2, after selecting one of the events that will appear in a list, the system will prompt to present the interface for inserting events, such as the ones described in this deliverable. It is demonstrated that semantic links can be established with ease between persons, events, items, and places. With this goal in mind, cultural and technical patterns collaborated towards an organised collection of knowledge, which will facilitate its meaningful organisation in WP3.

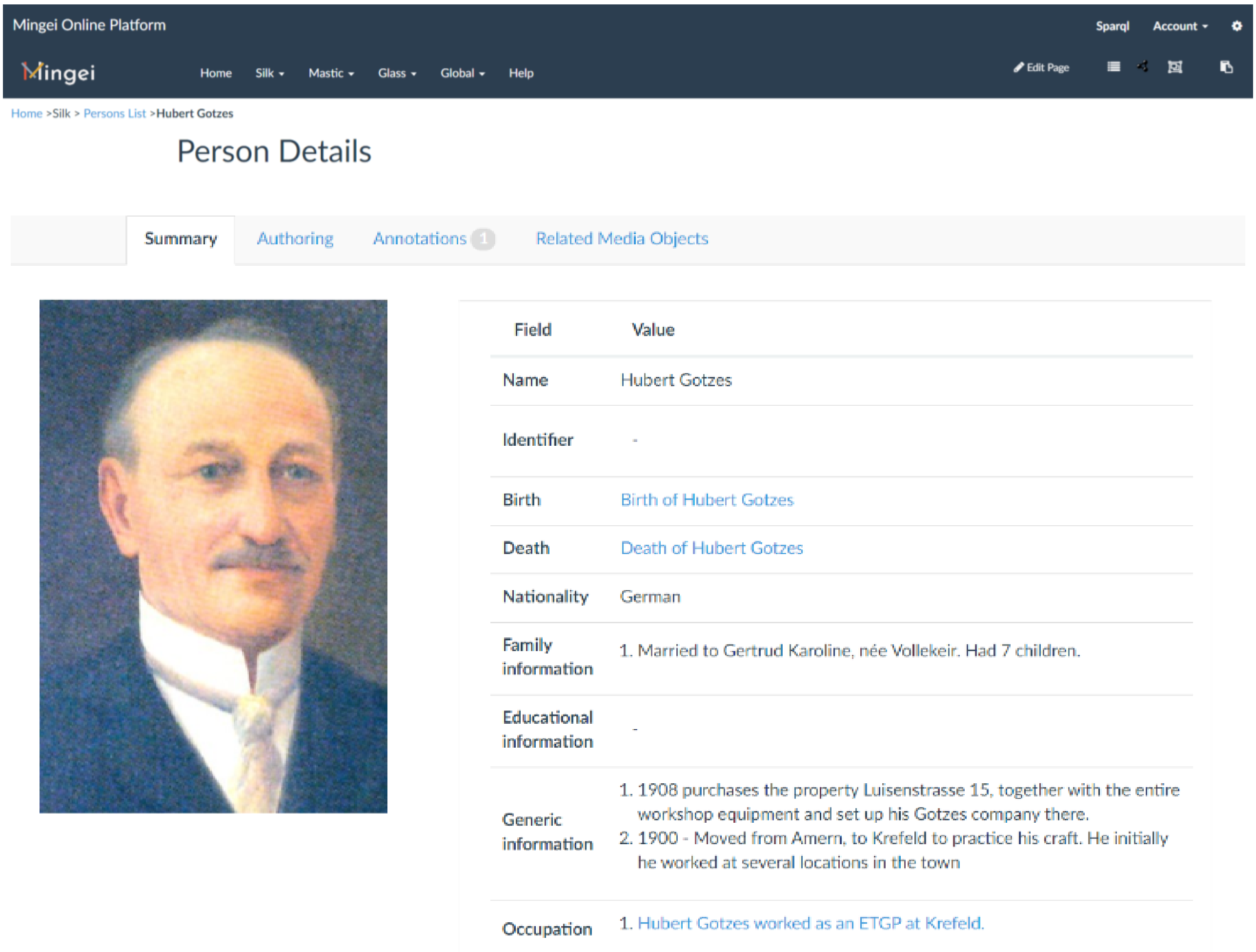


Figure 1. UI prototype for knowledge representation of biographical information (image from [170]).

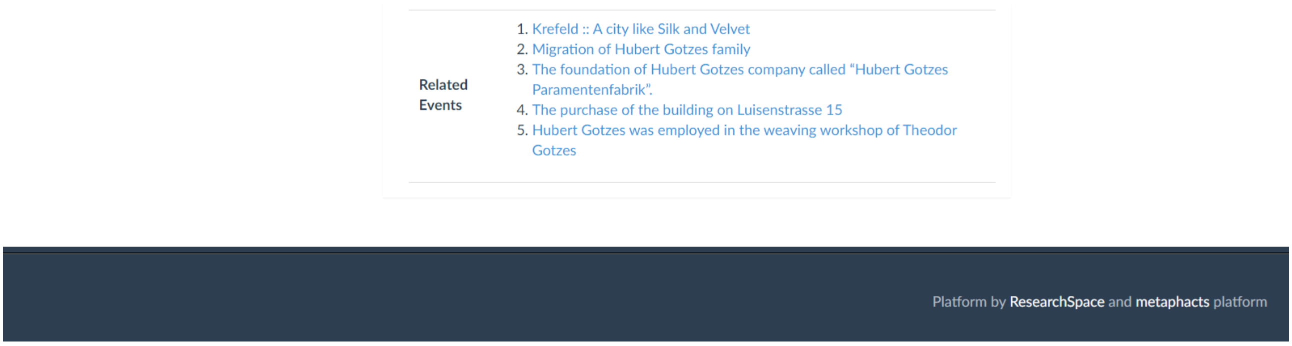


Figure 2. UI prototype for knowledge representation of event information (image from [170]).

1.2 Concepts & Assumptions

The concept that is crucial in the phase of collecting knowledge is **knowledge** itself and the making of knowledge [89] ; that is, the outcomes of the collection and analysis of knowledge.

Knowledge is strongly connected and dependent on history, culture and the writer. History offers facts, culture offers inside information but the writer defines the perspectives of facts and information. Simply put, it is the writer's representation of historical facts and cultural information, and what must not be forgotten is that every person has his or her cultural and educational background and thus bias is always involved in his or her actions. A very significant example is that of Orientalism when Said, in 1978 [5], exemplified how knowledge about the Orient (that is, the Muslim world) was constructed by European colonialists in order to show the power and cultural strength of the West over the 'Others'. This argument is a milestone when it comes to the production of knowledge and much debate exists until today.

Clifford [4] notes in general about the culture that *"is contested, temporal, and emergent. Representation and explanation – both by insiders and outsiders – is implicated in this emergence".* This is even more apparent nowadays that we live in a 'global village' [3] where information is exchanged and transmitted in rapid rhythms through several channels that exist in our everyday life, and thus culture can be affected and transformed in certain places. Positionality then should not be neglected when researching and writing knowledge because *"standing on shifting ground makes it clear that every view is a view from somewhere and every act of speaking a speaking from somewhere*" [2] .

A **collection of knowledge** then describes partially the need of humans to classify information. Said [5] notes on classification and Lévi-Strauss's 'science of the concrete' that,

"The point Lévi-Strauss makes is that the mind requires order, and order is achieved by discriminating and taking note of everything, placing everything of which the mind is aware in a secure, refundable place, therefore giving things some role to play in the economy of objects and identities that make up an environment. This kind of rudimentary classification has a logic to it, but the roles of the logic by which a green fern in one society is a symbol of grace and in another is considered maleficent are neither predictably rational nor universal."

Mingei's collection of knowledge aims to work as a tool in order to capture tangible and intangible aspects of HCs by having in mind the above-mentioned problematic of making knowledge. Its main **assumption** is the gathering of information concerning HCs as they were and are practiced in Europe. The information gathered through the process of knowledge collection will be annotated and stored in a digital database. Mingei's outcomes in using this collection of knowledge will be the preservation of HCs involving silk, glass and mastic (in the framework of the current research program, Mingei) in Europe but also the development of applications and digital archive for educational and developmental (touristic) purposes of the European countries involved.

1.5 Deliverable outline

The remainder of this document is organised as follows. In Section 2, the **contributions** of the Mingei collection of knowledge are identified. In Section 3, we present the **methods and methodological approach** to collect existing and new content but also to form a contextual framework of the content collected. In Sections, 4, 5, and 6, the current state of knowledge collected by the responsible stakeholders for each **pilot**. In Section 6, conclusions obtained from the collection of knowledge are provided.

Seven **annexes** provide information on **materials** for the collection of knowledge implementation, and **collections** of *literature, photography, and filmography* and *digitised objects* on the Silk, Glass, and Mastic pilots, as well as guidelines for photographic documentation, 3D digitisation, and recording of human motion.

2. Our approach towards knowledge collection

Challenges include the wide span of HCs in **tangible and intangible** dimensions, as well as, their **multiple**, temporal, societal, economic and geographical **contexts**.

In this context, Mingei aspires to serve the following two objectives:

1. To collect the knowledge for the three pilots of the project.
2. To formulate a method towards collecting knowledge for crafts.

The second goal conveys that while we are collecting knowledge for the first time, we are also formulating the Mingei protocol for the systematic performance of knowledge collection for crafts. This collection is required to contain the semantics of the represented knowledge. To allow benefit from the lessons learned during this collection, we have cascaded this collection from our three pilots. In this way, we can learn from the experience gained during the knowledge collection of the first pilot and apply this experience in the knowledge collection of the second.

Mingei proposes a method towards the collection of knowledge to facilitate the digitisation, documentation, conservation, and preservation of HCs. In the context of knowledge collection, guidelines for the identification of information that is relevant to collect are provided in this deliverable, as well as the computational tools to represent this knowledge digitally. The Mingei approach identifies tangible and intangible aspects of the craft, which span from practical craft descriptions to historical and societal facts that relate craft with European history and culture.

The information of the Mingei collection of knowledge will be used to rationalise the craft representation developed in WP3. This representation will digitally and machine interpretably avail this knowledge, as required for surveying-on or storytelling-about the represented topics. These topics will regard both tangible and intangible dimensions that are represented. The Mingei craft representation and documentation will not only cover the objects and techniques of the represented craft but furthermore, its significance in conjunction to historical and social events in the world and the lives of people in the community of craft practice.

On the outlook for the representation of this knowledge in WP3, the rationalisation of the collected knowledge to take place in that WP is required in order to

- **simplify** the task of knowledge insertion in the Mingei (or any other) knowledge model,
- **link** between threads and shreds of history,
- **facilitate** the emergence or discovery of new links that can form research hypotheses of storylines of interest to craft presentation and preservation, and
- **maintain** a well-defined knowledge base, particularly for the initial stage of the project.

Based on the aforementioned rationalisation process, the rationalisation of the collected knowledge will produce a set of text-based narratives that can sufficiently describe the acquired knowledge.

We acknowledge that knowledge collection is a never-ending process. At this phase of the Mingei project, we provide the knowledge that is mandatory for a comprehensive presentation of each pilot craft instance. At the same time, we provide a system that will gracefully incorporate new knowledge obtained through further research, within the context of Mingei and in the future.

3. Methods & Methodology

This chapter outlines the proposed methods and methodology to collect knowledge related to HC. The first part makes clear the distinction between data that already exist and data that will be collected. The second part suggests a guideline and analysis methodology for the collection and organization of contextual information. The third part deals with the collection of data for the digitisation of objects, environments, and human activities.

3.1 Existing content

When we talk about collecting existing content, we primarily speak about secondary research regarding the research topic that has been already defined. Secondary research can concern collecting (a) primary sources, (b) secondary sources, and (c) tertiary sources [90] [91] . **Primary sources** are first-hand information that has been gathered by a researcher through fieldwork, interviews, and other methods of interacting with research participants. These can be records, raw data of surveys, observations, interviews, documentation footage (photographs, films, video, audio recordings), letters, and so on. Although these sources primarily define primary research, first-hand information exists as raw, unprocessed data, mostly, in archives. **Secondary sources** concern processed and interpreted data. They usually have the form of reports, articles, books, documentaries, and studies. **Tertiary sources** are meta-analyses of secondary sources. Meta-analysis or meta-synthesis is a method to survey already existing literature (articles and studies) on a specific topic, analyse the results of the collected literature, and form new interpretations based on the research question of the initial study [92] [93] .

Secondary research can be conducted with various mediums and at different places. It is worth mentioning here the difference between archives and libraries [91] . **Archives** are collections of unpublished material, housed in closed stacks, organized according to the principles of the original collector. **Libraries** contain published material, in open stacks, classified according to a particular system, and you may be able to take the material out on loan.

Archival research can be conducted in order to collect primary and secondary sources. Archives of institutions (public and private) can contain first-hand information on a particular topic. Furthermore, there are also archives of smaller size, usually held by individuals as their personal history. In order to access most archives, physical displacement usually has to take place, while the researcher should also be careful in handling sensitive materials such as old books, papers, and photographs. Moreover, documentation footage might need special equipment for viewing or specialised treatment for restoration from analogue media.

Many archives have nowadays an online version of their collection (or part of the collection). Especially recently many institutions offer digitization's of their collections through the Creative Commons initiative (see, for example, the Smithsonian Open Access). Moreover, there are repositories that are entirely online, such as Europeana and Google Arts & Culture, where the researcher can find visual material (digitised photographs and videos, digital representations of objects and places, audio material). The Archives Portal Europe is a general website where the researcher can search archives by indicating the country and topic, while the Historical Archives of the European Union offers a more general view on projects and institutions in Europe for archival research. Interestingly, regarding research on ICH there is a project that created a map/database of all the e-inventories related to ICH worldwide; it is called Digital ICH Observatory.

Library research can provide published material such as related literature, that can be characterized either as a secondary or tertiary source. According to the CH domain, in which Mingei is part of, we have identified the following sectors of expertise that can be useful for secondary research:

- Social research (qualitative, ethnocultural, and sociocultural inquiries, localization of techniques).
- Tourism (craft centres and villages, itineraries, sites).
- Education and Culture (art schools, training, museums).
- Economy and Planning (statistics, budgets, major projects).
- Trade and Industry (crafts often come under this heading, statistics, foreign trade).

Note that each sector may own its library in an according institute, or information can exist in a public library such as National Libraries. Although library research might need physical displacement, nowadays this procedure has become simpler and easier for the researcher. On the one hand, most libraries already have online websites that the interested person can visit, search its catalogue, check availabilities of books, order, and then visit the library to directly pick up the material. On the other hand, there exist libraries that are exclusively online, with some of them offering open access. To indicate only a couple of them, we propose UNESCO's Open Access Portal and Digital Library.

3.1.1 Verbal content

Text

The gathered literature can be digitised and stored in a repository to serve as a reference. Digitisation of literature can be realised through 2D scanning or, when available, by born-digital versions of the documents. In this context, the following are mapped and, if possible, pre-emptively collected.

- **Literature and printed matter,** such as papers, books
- **Digital documents and records** related to contextual information (i.e. population or economic records).
- **Catalogue and archive information** for digital items and physical exhibits. As it may not be directly possible to digitise the entirety of items of a CHI it is important to be able to search for further relevant items.
- **Existing artefact digitisations,** as results of earlier digitization efforts.
- **Linked repositories.** Existing digital assets sought in digitisation archives of cultural organisations or guilds, museums, as well as linked data repositories; some originating from digitisation projects (UNESCO's World Heritage Centre and Collection, Europeana, i-Treasures).

As sources of this type of knowledge include records and historical documents, relevant are efforts towards the digitisation and conversion to text in conventional and historic documents. Pertinent projects funded by the EU are IMPACT (215064) that provided tools for digitisation of historical documents into textual information, by extending state-of-the-art in OCR. Tools for the transcription of historical handwritten documents were developed in tranScriptorium (600707). The topic of handwritten character recognition is still an active research area, particularly after the recent proliferation of deep learning technologies.

<u>Audio</u>

Audio documentation can be produced if the researcher finds that it is necessary. ICH also includes audio assets such as testimonies, songs, musical performances, elements of oral tradition such as stories and legends. International digitisation projects have provided guidelines and standard for audio recordings and their digital preservation [178] [179] [180] [181] [182] . The researcher can organise trips and interviews on his or her own or, if the budget is sufficient, arrange for a sound engineer to professionally treat the recording if a high-fidelity audio recording is pursued.

Audio recordings containing **verbal content**, such as an interview or testimony can be organised in a repository, for study and references. In many cases, transcription of speech to digital text (including speaker recognition if available), is required and, in general, a convenient way to review the content of the recording.

Speech transcription into digital has increased the automation of the process. Such technologies conserve the researcher's time by automating these tedious processes. Though speech recognition technologies are far from infallible, they are a significant aid as they reduce substantially the time of manual subscription. Typically, the operator corrects transcription errors, instead of transcribing the entire audio. Several publicly available online resources exist for the conversion of audio into text, in several languages. Sophisticated services for batch transcription are available by subscription, through a wide range of providers. In addition, all major operating systems of mobile devices (i.e., smartphone, tablet), when connected to the Internet, can provide transcription capabilities that adapt to the voice of a particular speaker, to reduce transcription errors.

Audio is of importance in terms of capturing the **sounds of environments** relevant to a craft. The sound of the natural environment or the workspace adds to the ability to provide a realistic experience. Musical recordings can be of relevance in the representation of context, such as local and traditional music, as well as, songs relevant to the practice of a craft instance.

In addition, audio files are of significant importance for the transcription of notes and interviews, to be later studied by the researcher.

3.1.2 Visual content

<u>Photographs</u>

Acquisition

The most common digitisation modality is **photography**. It is relevant to the digitisation of 2D (i.e., documents, paintings) or 3D items (i.e., materials, man-made objects). In the case of 2D items, a valuable digitisation method is the **2D scanner**.

The **digitisation** and **digital preservation** of photographic documentation of records and artefacts, is a topic that has been well established in the last two decades 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. [171] [172] [173] . In the European content, apt results, in the form of good practice and strategic guidelines are provided by EU funded activities. 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 [175] comprise a valuable starting point for these matters, as well as, the foundation of online heritage repositories, such as Europeana.

Pertinent guidelines are reviewed in ANNEX A6.1.

Like many other disciplines, the CH domain has employed photographic documentation to document shape and appearance of objects and scenes. It is a rapid and informative way of visual recording:

- 2D content, such as documents, sketches, drawings, and notes, particularly handwritten items, which are would be challenging for OCR or automatic document analysis to treat. When applicable and the fragility of items permits, a 2D scanner simplifies the process and produces images devoid of perspective and lens distortion.
- Size measurements, given a benchmark (an object of known size).
- Overview of 3D scenes and objects, from multiple views.

Photographic documentation is a method utilised on many occasions in CH, from documentation of the finding of an item (i.e., in excavation), in the documentation of the stages of conservation documents, in catalogues etc. It is important to note that (a) **a 3D scan does not replace photography**; (b) **photographs** of a scene are still **very informative**, (c) **cost-efficient**, and (d) **practical** due to the miniaturisation of electronics and optics, as well as the proliferation of mobile devices.

The appearance of an object, whether a 3D artefact or document, is comprehensively captured in a photograph. Multiple photographs are used to capture multiple views of an object; for example, coins are digitised on both sides by two photographs. This is due to the actual photographic content, as well as the observer's visual perception and prior knowledge, which enables the inference of the 3D shape, material, size, and texture, even in parts of the object that are non-visible in a single photograph.

Technical photographs (i.e. photometrically and geometrically calibrated, having a reference object to measure scale) are often used to provide measurements of physical properties. 2D scanners and book scanners have facilitated the digitisation of records, documents, and printed matter. Photographic documentation is a basic and cost-efficient form of artefact digitisation and has been in-depth studied in the domain of CH. Technical digitisation guidelines can be found in ANNEX 6.

Photographs that are part of the craft representation should aim at providing an:

- illustration of the objects, showing their shape, materials, aesthetic qualities, usefulness, decorative or commercial possibilities

- illustration of craft workers in their everyday surroundings, the tools, techniques and movements used, showing the peculiarities or difficulties of the work.

A number of shots must be determined to capture these aspects from the general to the particular, from overall views to details (i.e., broad general views, whole subject, details, and close-ups).

Craft objects (i.e., tools, materials, workshops, machines) are the primary goal of photographic documentation. Objects spotted indoors should preferably be taken outside to be photographed in daylight (museum pieces that cannot be moved will require more elaborate lighting).

It preferable to show the objects in their usual **setting, use,** and in the **workshop** where they were made or used. In all cases, a photo of the entire object with a size reference is required. In addition, close-up photographs showing any decoration or identifying characteristic are significant.

A single photograph is not enough to give an exact idea of how the object is made. If time is available, photographic documentation should start with the raw material and show all the stages that turn it into the finished artefact.

An overall view of the workshop is useful to show the atmosphere, layout of the tools and materials and the relationship between the craft workers. Depending on the complicity of the scene, a few or many images may be required.

Rectification

This utility is provided for cases where 2D planar items of interest (i.e., a picture, a cloth sample, a drawing, etc.) to be reproduced from photographs, instead of a 2D scanner. Acquiring photographic reproduction of these images is not the optimal way for the digitisation of such material. There are mainly two reasons that one may wish to follow a photographic to the scanning of flat artefacts. These are:

- Fragileness of the item
- Time, when digitisation of multiple items would be overly time-consuming, such as when the photographic subject is framed

This utility takes an image as input and initially rectifies the image for lens distortion. The utility provides an additional rectification stage at which perspective distortion is compensated. A GUI allows the user to select bounding points (i.e., the four corners of a picture) corners. The actual dimensions of the image are also provided. A homography is estimated that warps the input image to a rectified output (see Figure 3).

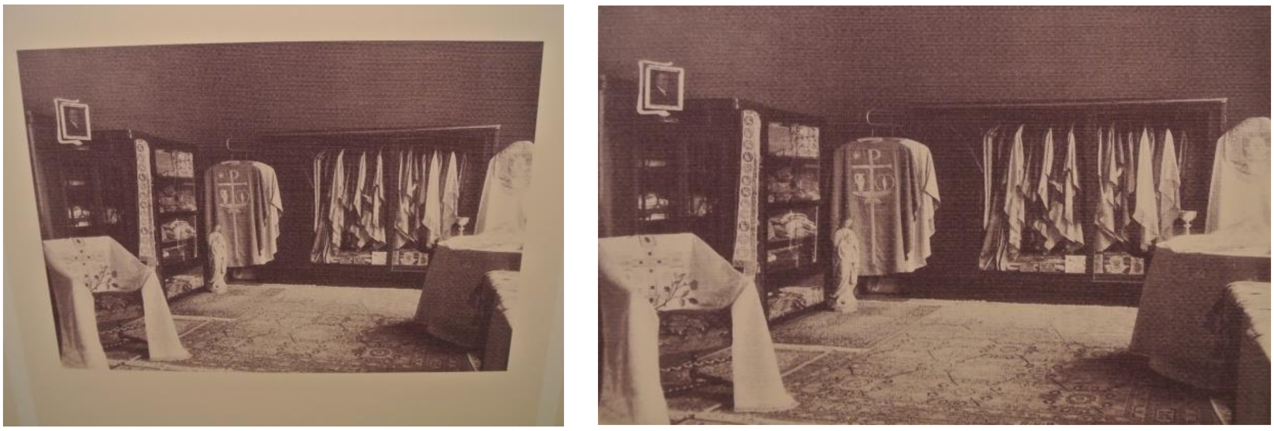


Figure 3. Perspective rectification of scanned image [Zabulis, 2019].

In some cases, pictures are behind glass. In this case, it is usual to have unwanted flare due to light reflection on a painting glass frame (see Figure 3). This effect is more pronounced when the frame is made from actual glass, rather than matte acrylic. To solve this problem, a second photograph of the same image can be acquired but from a sideways perspective, so avoiding the flare. To approximate the aspect ratio of the original image, an auxiliary frontal image can be used. This allows for the resulting image to have the correct dimensions while ensuring that flare will be minimal or absent (see Figure 4).

Figure 4. Compensation of specular reflections [Zabulis, 2019].

Using this way it is possible to acquire in a short digitisation time that a short visit to a CHI avails multiple samples, which can be studied and revisited for a more thorough digitisation (see Figure 5).

Figure 5. Extraction of catalogue samples [Zabulis, 2019].

<u>Video</u>

Recording information on video, although very much worthwhile, is difficult to carry out at the same time as making an ordinary, traditional collection of photos and written notes. It thus requires at least one more team member bigger team. A Series of short closely targeted documentary films could show a selection of characteristic objects, the way that they are made, and their use.

Although not as accurate as motion capture, the visual analysis of videos can provide a recording of human motion. In many cases, this is sufficient, such as when documenting the way that a tool is gripped, body posture or simple motions. In other cases, it may be the only available recording of a particular activity or person.

To track motion from RGB videos either from archive documentaries or new video streams two state-of-the-art methods are employed, both developed by members of the Mingei consortium. For visual tracking of human bodies, the method in [183] [184] is used, while for tracking of human hands the method in [184]. The result is the same in type as motion capture that is, 3D animation, however of significantly less accuracy and of higher sensitivity to noise.

A determining step in creating video documentation of activities is selecting the equipment, which includes one or more cameras, audio equipment, light sources, reflectors, tripod, video editing utilities, power banks, and storage media. Information in the use and selection of this equipment can be found in [185] Examples of editing software are iMovie, Final Cut, Adobe Premiere, LumaFusion DaVinci Resolve, PowerDirector, and Kinemaster.

Technical guidelines for the acquisition of videos for visual tracking can be found in ANNEX 5.2.

3.2 Contextual knowledge

An important step in understanding a topic, and in this case a craft, is to acquire contextual information. For this purpose, in the first part of this section, Mingei proposes methods to acquire contextual information. In the second part, we propose a form with specified data types that could help the researcher make a plan (a) on what kind of information is useful to gather, and (b) to organize and inventorise the collected information. The proposed form by Mingei follows the inventorisation proposed by UNESCO for the documentation of the Representative List of Intangible Cultural Heritage. Nevertheless, some additions occurred after researching the relations of tangible and intangible cultural heritage, along with Mingei's special interest in the development of according digitisations. The Mingei collection of knowledge form can be found in Annex A1.

The data types are based on the initial orientation to evaluate the importance of the craft. The main research question is summarized in the phrase "What Makes Craft Unique?" As a continuation of this question, there are the following critical questions:

- What is the cultural significance of the craft?
- What are unique aspects of the craft that need to be preserved?
- How is knowledge being transferred?
- Who are the craftspeople?
- What is the future perspective of the craft?
- Why does this craft take place in this territory?

The answers to the above questions will produce the fundamental yardstick to evaluate the adequacy of the collected material concerning the tangible and intangible aspects of the craft.

3.4.1 Collection methods

This section indicates methods to collect contextual information in order to grasp the direct impressions and information from craft practitioners that wish to collaborate in the research. It is important to mention that all the following methods require physical displacement to the area where the researched craft is practiced.

3.4.1.1 Participant Observation

Bernard [94] offers a comprehensive overview of what participant observation is about as a method. Participant observation started in the field of anthropology but, through the years, it has gained popularity in several fields that are interested in acquiring qualitative data. Participant observation is primarily a method to get close to people and communities in order to build trust and make the participants feel confident in sharing information. The data acquired during participant observation include "field notes taken about things you see and hear in natural settings; photographs of the content of people's houses; audio recordings of people telling folktales; videotapes of people making canoes, getting married, having an argument; transcriptions of taped, open-ended interviews, and so on" [94, p. 344].

There are three distinctions on how participant observation can be conducted, based on how much participating or observing the researcher wishes to do. On the one hand, the **complete participant** usually conducts research by fully participating in an activity, most of the times without differentiating his/her position as a researcher too; something that is not scientifically wise. On the other hand, the **complete observer** follows around groups or individuals and observes without interacting with them. The **participant-observer** (which is the role through which more information can be gained) can be distinguished according to the status of the researcher. First, if the researcher is an insider of the researched community, more observation and recording of some aspects of life takes usually place; thus, the researcher is an observing participant. Second, if the researcher is an outsider, it is more likely that s/he will participate more and record some aspects of life; thus, the researcher is a participant observer.

Another important aspect of participant observation as a method is the selection of the duration of research. In anthropology, it is usual to research for at least a year but this, of course, is not possible for everyone. Bernard [94, p. 352] proposes the **participatory rapid assessment (PRA)** for which the researcher has to be fully prepared before entering the field. Full preparation can include formulated, specific questions or a checklist of data types to be collected. This requires a very well-defined research topic. It is worth mentioning though that only through time, rapport can be created among people and consequently, good rapport can create trust. Thus, trust can lower the reactivity of the participants when answering questions. The levels of reactivity can define in their turn the validity of the data acquired.

Importantly, participant observation helps also in the validity of the analysis and interpretation of the collected data. As Bernard [94, p. 355] puts it:

> Participant observation gives you an intuitive understanding of what is going on in a culture and allows you to speak with confidence about the meaning of data. Participant observation lets you make strong statements about cultural facts that you have collected. It extends both the internal and the external validity of what you learn from interviewing and watching people. In short, participant observation helps you understand the *meaning* of your observations.

Observation of public scenes such as visits to markets or festivals are also relevant. to the time of day. As noted in [174] , *"it is best to wait until they are in full swing in the middle of the day, which* *is when most goods are displayed and there is a throng of craft workers, traders, and informants".* Depending on the available time, a preliminary observation period is recommended as it is possible that detailed documentation of an item or working method to be more representative than a large collection of similar objects and activities of no great interest. This time can provide a general view of a workshop, village, or rural environment market, workshop, or craft centre, and the movements of a craft worker or the objects themselves. This observation facilitates an overview of the place and activities, which is relevant to producing precise descriptions, survey reports, and record sheets. In turn, this overview allows the planning of digitization targets, significant details, or actions. Most importantly, it provided the time for social interaction, to acquaint with practitioners and the local community, which in turn facilitates their acceptability to observation and interaction.

3.4.1.3 Narrative interviews

The narrative interview is a kind of semi-structured interview. The researcher prepares some open-ended questions to guide the conversation with a participant. The aim of this kind of interview is to extract spontaneous information of the research topic, more general information that could lead to storytelling.

Interviews or discussions should preferably be conducted with the most knowledgeable or able craft worker but also with members of the local community, such as elders and former craft workers, who can provide information on objects, techniques, developments, or changes in the past. Methods of interviewing and note-taking vary little, in anthropology.

The main axis is to complete the goals of knowledge collection. On the author's hand, caution is to be taken in the recording of inaccurate information, particularly at this stage. As it is very difficult to verify, omissions are preferable to errors, as the former can be completed later on, while the later may survive for a long time.

Time of interaction with a single person can be important to avoid fatigue and reminiscences. This length of time may reasonably vary between 10 and 30 minutes. Older guidelines [174] recommended practice in rapid note-taking or stenography and a careful dating system. The proliferation and miniaturization of mobile devices with audio-visual recording capabilities has facilitated note-taking, while audio transcription of speech can relieve the researcher from the task of note-taking and allow for a more insightful interaction and communication with the interviewee. Environment sounds, such as in the workshop or countryside sounds can be of importance to the experiential presentation of the craft or setting. Moreover, a musical tradition that accompanies work or relevant festivals should be recorded for subsequent translation and transcription.

3.4.1.2 Photo and video elicitation

Photo and video elicitation is a qualitative method [7] [8] used in social sciences in order to trigger information from the participant. Visual material has a different effect on the participant's sequence of thoughts. For example, the participant might feel stuck regarding a specific topic or aspect of a topic. Depictions can trigger a person's memory and work effectively for acquiring more information. Furthermore, as a method, photo and video elicitation is closely related to the analysis of the topic depicted. That means that the participant is not only contributing to the identification of the depicted topic and its enrichment in contextual information, but also in its analysis through the conversation with the researcher [95]

In the context of this method, photographs, videos, depictions, and all other forms of visual material can be used depending on the researcher's database and the time available for the interview. Too much visual information might cause participant fatigue, though. It is better to form a semi-structured questionnaire and explain at the beginning of the interview the context of the conversation and the visual material to be shown and discussed.

3.4.1.4 Geography of workshops

'Geography of workshops' [87] is a methodology used during 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 [10] , this method helps the researcher to understand the complex interaction between the craft practitioners' gestural and sensitive actions, the active role of matter and tools, and the 'choreographic' dimension of movement in the workshop as a fundamental characteristic of 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.

3.4.2 Data types

As mentioned earlier, the Mingei collection of knowledge data types is based on a list created by UNESCO for the Representative List of Intangible Cultural Heritage. We, nevertheless, added a few more types that we consider important for the representation of a craft. In the analytical presentation of the data types below, we indicate the new types with an (*) and offer information on their conceptualization and purpose.

In general, there have been identified twenty data types adequate for the collection of knowledge regarding HC that include tangible and intangible aspects. As the types of data exemplified in the Mingei Knowledge Collection Form, they include a brief text generated by the researcher as a summary of the information concerning the type of data, while text, audio/video files, and images/3D digitisations are further requested for the database. The additional files are optional, as they may not exist in the first place.

Brief Description of the Craft: The researcher is asked to provide a short description of the craft including the processes of the craft.

Geographical Location and Range of the Craft: Here information is needed regarding the geographical area where the specific craft expands. Furthermore, it is required to define, when applicable, environmental aspects of the area that might affect the craft practice and development. The Mingei pilots offer a nice example of the differentiation of geographical expansion of a craft and environment particularity. Silk and glass-related crafts are practiced in many areas of Europe while mastic is characterized by hyper-locality since the mastic tree is cultivated only in Chios island in Greece (its cultivation is not only exclusive in Europe but the whole world). Moreover, the researcher can add to the specific data type a digital map indicating locations that are connected to the social history of the craft by pinning the location and adding a small reference of the historical fact concerned.

Selected and Representative Communities concerning the Craft: A list of individuals, groups, communities, and/or institutions can be identified here that are closely related to the craft. Their relation can be of a craft community, institution responsible for the preservation and conservation of the craft, academic, and independent researchers' affiliations, or state officials that have expertise in the craft.

Craft workers / Skilled Workers / Handicrafts Education: Some crafts have specific individuals that are highly skilled in craft making. Usually, this knowledge is transferred by internships and yearlong learning of working with the 'master'. Other crafts might be more widely known nowadays and thus many people might be practicing it or even learning it in schools and seminars. A differentiation here depends on the locality and popularity of the craft. Extensive research on the history and origin of the craft might lead to 'masters'.

*Gender Roles: It is important and interesting to note differentiations of gender roles in the process of practicing the craft. These roles might have changed through time or remained stable. Further outcomes might relate to the positions of each gender in the related community/society and their development. In an even wider scope, it relates to the general development of the position of each gender in European countries.

Equipment: Indicate specific tools, machines, and clothing (when applicable) that are used to practice the craft.

Products: Indicate products or material objects in general that are developed as an outcome of the performance or implementation of the craft.

Documents: Material gathered through the methods proposed in the previous chapters can be uploaded here. The context of this material relates to historical facts of the area where the craft is researched.

Craft Traditions: As mentioned before some crafts are practiced with techniques that might be unchanged through time. These particular techniques consist of a craft tradition that passes along through the 'masters' or skilled craftspersons.

Oral Tradition / Story Telling / Work Songs / Myths & Legends: There is an unseen world, a 'cosmology' we could say that surrounds many crafts. This is part of the oral tradition of many communities, usually small ones, where the daily interaction of people is close. Oral tradition can contain myths, songs, and stories that are told usually by elders to the younger generation, or that they are present during a feast, a celebration, or even while working.

Social Practices / Social Dimension: There is a social dimension in crafts, which exhibits the aforementioned gender roles. In addition, there is also stratification and hierarchy in the community of practice. Furthermore, there can be habits of everyday life or in close connection with the craft and the community. This can again depend on the popularity, locality, and significance of the craft.

Economic Dimension: Most of the crafts have an economic dimension since the outcome of practicing a craft is most usually products that can be consumed. The producers might sell themselves their products, or might have formed associations for the distribution of their products, or might sell them directly to companies that distribute them to markets that are local, in the same country, or even abroad. This activity might be relevant to the economic history and development of Europe depending on the significance that the craft might have or have had, and the popularity of its products.

*Design Dimension: Patterns, motifs, and shapes of a craft object can relate to historical ones that keep being reproduced until today or new ones that appear from the craftsmanship of younger, contemporary generations. An example of the historical use of patterns is that of the silk pilot when the silk weaving industry was correlated to the Art & Crafts movement of Europe. Glass making on the other hand can be also correlated with the decorative arts. Such aspects of a craft provide information on the historical development of craftsmanship and its relation to its products. Furthermore, it is important to note any creations that are determined by craft locality. These instances are unique to the craft community and they might depend on the social, religious, or environmental characteristics of the specific area.

*Artistic Dimension: There is a wide range of crafts that are associated with art. Artists themselves might get interested in learning a specific craft in order to apply it in their artworks or collaborate with craftspeople for the production of their artworks [6] . It is interesting to keep track of such information connecting craftsmanship with contemporary art tendencies.

Rituals: Some craft communities might have rituals that determine the local culture and provide a sense of community among the people. The rituals might not occur every year or in a specific calendar date. They might concern a change of status of a community member related to the craft.

Festive Events: Communities usually have festive events that are practiced on specific dates of the calendar, every year. These can be related to historical events, religion, or local practices that need to be commemorated every year.

Religious Dimension: A craft might contain religious references in their origin, or the products of a craft might be used for religious ceremonies, etc.

Learning / Education / Transmission of Knowledge: Knowledge can be transmitted locally among the community or family members. In other cases, it can happen through schools or expert institutions depending on the locality of the craft. Furthermore, there might be educational programs in museums addressed to any age. In primary and secondary schools, teachers might inform children about the craft through a specific class or special programs designed for schools.

*Geography of Workshops: It is interesting to indicate the space where the craft is practiced and according to techniques used. In some cases, laboratories or specific indoor or outdoor spaces are used. A map of this information could help learn the routes that primary materials of the craft and the craftspersons follow according to the procedure of the craft and their relations. That information could conclude the relationship of the human with the material and their intertwined movement in space.

*Emic (inside) Presentation: In order to clarify the cultural significance of a craft it is important to try to find craftspeople or families of craftspeople or people closely related to a dimension of the craft. Their testimony on what makes the craft unique and significant to them can give a better view of making assumptions about the cultural significance of the craft in general.

3.3 Collection of material knowledge

3.3.1 Digitisation of objects

Tangible heritage is perhaps the most studied component of CH, in terms of documentation methodology. Items of tangible heritage comprise physical testimonies of craft history and practice. Besides photographic documentation, the documentation of tangible heritage increasingly adopts 3D scanning and other digitisation technologies. Such digital models have a large range of uses, from the conservation and preservation of artefacts to the communication of their cultural value to the public.

The development of **technologies** for the digitisation of three-dimensional artefacts and monuments has enabled the representation and documentation of geometrical and structural information. Three-dimensional digitization (also called 3D scanning) attracts growing interest in the documentation of Tangible Cultural Heritage. This line of research has been funded by a series of EU funded projects, namely EPOCH (266660), 3D COFORM (231809), PRESIOUS (600533), STORM (700191), DIGIFACT (625637), and recently 3D ICONS (297194). It is acknowledged that **European interest progressed 3D digitisation** as a form of documentation of tangible heritage *"In 2004, […] was clear at that time that there was a paucity of North American publications on the topic of 3D scanning for the heritage [176]* . 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.

Surface scanning technologies have contributed to the digital documentation and 3D representation of CH monuments and artefacts. Besides preservation, the significance of accurate digitisation is of service to the physical **conservation** of artefacts and monuments.

In the last 15 years, the development of **surface scanning modalities** for the capture of 3D objects, building structures, or rural space, has allowed the representation and documentation of geometrical and structural information about these items. Several modalities have been developed that can be utilised for scene scanning and preservation, each of which addresses different circumstances and records different characteristics of the scanned physical object. **Contact systems** are not widespread in the CH domain, due to the potential fragility of artefacts. **Non-contact scanning modalities** are more widely employed in the CH domain, as they use light as the operating principle of the sensor. These modalities can be further classified according to the sensor type, that is, into **passive** or **active** illumination systems. Active sensors emit light whose reflection is utilised for surface detection, while passive utilise ambient light for the same purpose [9] . The 3D digitisation of objects still has several open problems, relevant to the accuracy of reconstructions and the digitisation of transparent objects (i.e. glass artefacts) [177] Currently, the most adopted and robust principles by end-user scanning modalities are:

- Time of flight
- Structured light vision
- Photogrammetry (or multiple-view stereo)

There is a range of products that employs these principles in **variations**, such as terrestrial and aerial photogrammetry. In addition, **combinations** of such principles are found in devices, such as the combination of trinocular stereo with structured light (and IMU information) in various types of handheld scanners.

Several **3D scanning modalities** have been developed in the last 20 years, which can be distinguished as to whether they require contact or not, with the scanned surfaces and objects. Contact systems are not widespread in the CH domain, due to the possible fragility of artefacts. In contrast, non-contact scanning modalities are more widely employed, as they use light as the operating principle of the sensor. They can be further classified according to the sensor type, that is, into passive or active illumination systems.

Non-contact, **3D scanning modalities**, used for the digitisation of CH, are based on either active or passive sensors. Both types of sensors fulfill artefact safety requirements, as they both operate without requiring contact with the artefact. In active illumination systems, the emitted (luminous) energy is limited to low levels, impotent of causing artefact damage. Both sensor types are non-invasive and non-destructive (see Figure 6).

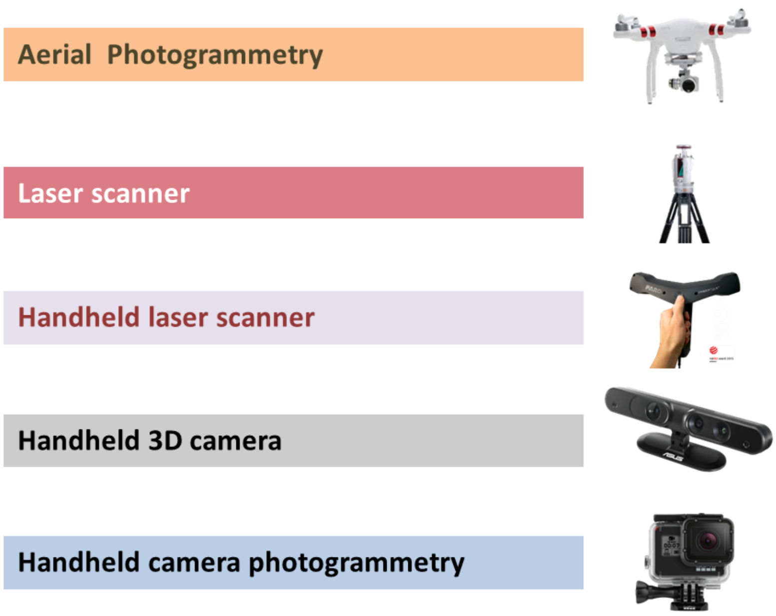


Figure 6. 3D digitisation modalities [Zabulis, 2018].

Passive sensors are typically conventional monochromatic, colour, or multispectral visual sensors (cameras). The scanning output is the computation result of a reconstruction algorithm, typically based on the correspondence mapping of multiple views. Active sensors include laser or conventional light-emitting techniques to measure 3D information, such as distance range. Some modalities integrate assisting information from an IMU or GPS unit that is operated by auxiliary software components. Passive sensors work with less information as they do not have the advantage of inserting reconstruction cues (i.e. structured illumination) into the environment. As such, they are associated with sophisticated algorithmic approaches and are sensitive to illumination artefacts. **Active** sensors typically include direct distance measurement methods and are often limited by sunlight, as it is more luminous than the active illumination source of the sensor. Occlusion is a limiting factor for both active and passive sensors and, typically, multiple scans are required to capture a 3D scene [16].

The 3D capture of objects, monuments, and environments provides new horizons in the utilisation of digitisation for the preservation of objects, virtual visits, and the design of experiential presentations. Conventional modalities fall in the aforementioned categorisation and are suitable for different types of environments, spatial scales, and indoor or outdoor conditions; in Figure 7, a taxonomy of application domains of these modalities is illustrated.

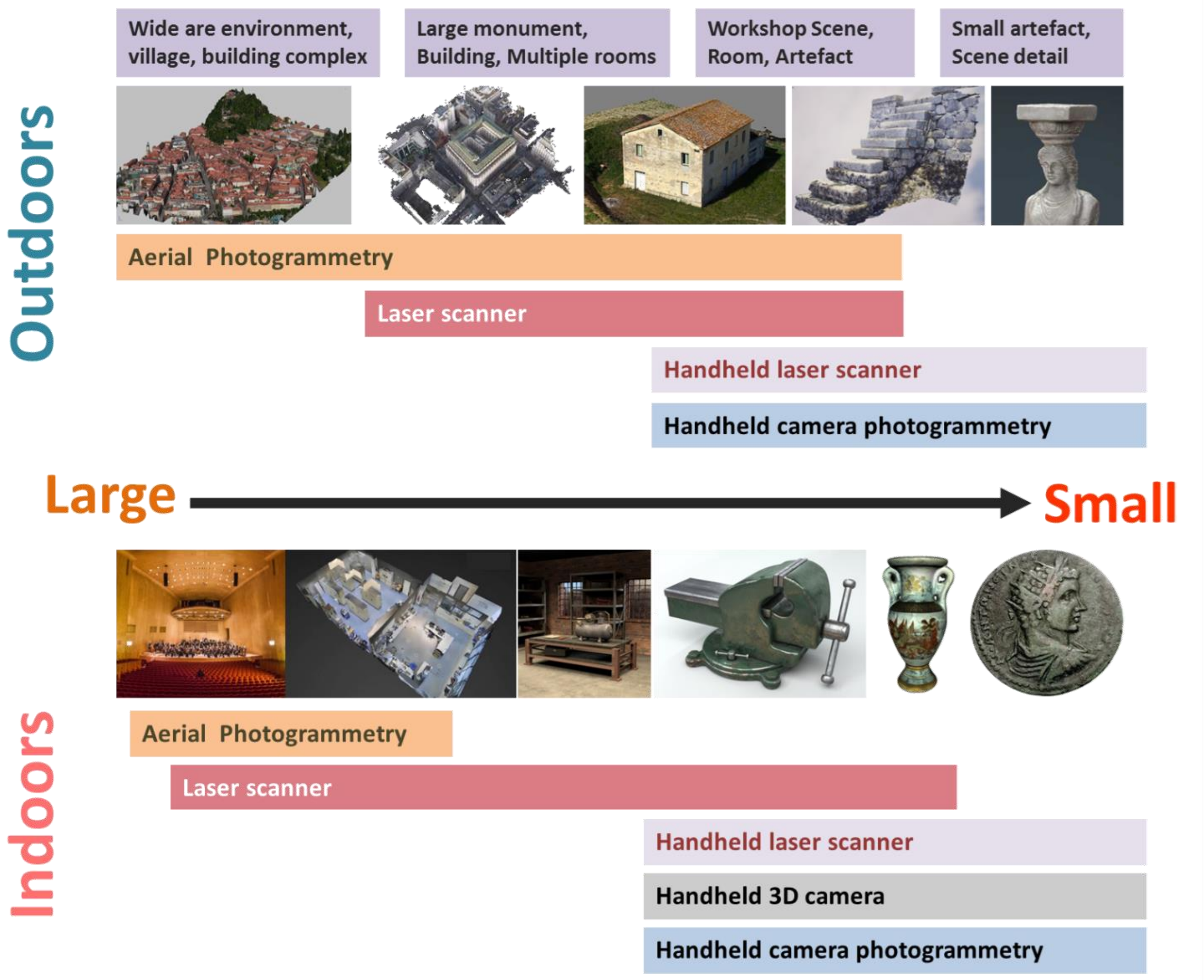


Figure 7. 3D scanning modalities and use cases in CH [Zabulis, 2018].

There are significant variations between the capabilities of different approaches. Triangulation techniques provide greater *accuracy* than time-of-¬flight but are reliable in short-range and difficult to apply in the field, due to the needs for controlled illumination. When accuracy is a requirement, close *access* to the scanned object is required. If physical access is impractical, direct distance measurement techniques (time-of-flight) provide less accurate results, particularly when the sensor is airborne and not static. Thus of temporal relevance is the *sampling rate* of the sensor (i.e., a laser scan lasts much longer than the acquisition of a digital photograph). Also of temporal relevance, is the *time duration* that is available for the digitisation, with respect to the overall time required for a scan.

The **capabilities** of the different end-user technologies vary in terms of several **criteria**:

- Resolution
- Accuracy
- Range
- Sampling rate
- Cost
- Operating conditions
- Skill requirements
- Purpose of digitisation
- Material of scanned object.
- Weight and transport

The **guidelines** are not as apt as for photographic documentation, for two reasons. The first is the recent development of some of these technologies. The second is the multiple modalities available for 3D digitisation. Modalities vary in operational capabilities and environment conditions, as well as **cost**. In some cases, the commission of the digitisation or rental of equipment may be more efficient. These guidelines are reviewed in ANNEX 6.2, per modality type.

These criteria are to be taken into account in the selection of the appropriate digitisation modality, concerning the anticipated conditions of operation, type of environment, as well as time and budget resources. A valuable resource in terms of 3D reconstruction guidelines can be found in [9] . Moreover, important resources for 3D digitisation of CH are publicly availed by the non-profit organisation “Cultural Heritage Imaging”[1], including tools, technology, and training, for several digitisation methods used in the conservations and preservation of Tangible CH.

Based on the aforementioned analysis, the applicability of digitisation modalities is presented in the following table and figure.

Table 1. Applicable sensors per type and size of the environment [Zabulis, 2018].

	Indoors	Outdoors
Building complex	N/A	Drone, Camera
Large building	N/A	Drone, Camera
Multiple rooms	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Large room	LIDAR	N/A

[1] http://culturalheritageimaging.org/

Room	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Small room	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Object, scene detail	3Dcam, 3Dscan, Camera	3Dscan, Camera

3.3.2 3D digitisation modalities

3.3.2.1 Laser scanner

The **advantage** of laser scanning for scanning environments is that it is a very efficient, accurate, and robust modality. It provides a direct point measurement on the line of sight of every radius within its view sphere at a configurable resolution and an angular breadth of approximately 270 degrees of solid angle. Another significant advantage is that each scan takes place automatically and at a reasonable temporal duration. Laser scanning has been utilized for over 20 years and significant experience can be retrieved from the literature in the form of guidelines, while a range of software products exists that facilitates the registration of partial scans post-processing of scans. It is **limited** by light-absorbent (dark) surfaces, which do not reflect enough sensor radiance for the time-of-flight measurement to succeed. Another limitation limitation is that there is no real-time feedback available; hence, a preparatory scan is typically required to find the locations that the scan should be placed.

The main **disadvantage** of laser scanning is the price of this modality: a reliable unit of medium accuracy (~2-3mm) with a scan range of about 70m is in the order of 30K Euros. In addition, a reliable unit weighs at least 7 to 8 kgr. Moreover, a laser scanner at the ground has no line of sight to the top of a building and is out of its range. Airborne laser scanning (LIDAR) exists awaits advances regarding the payload of the laser scanner and flight velocity. Another disadvantage is that occlusions give rise to the requirement of several scans to cover the surfaces of a scene; this is particularly pronounced in <u>indoor</u> environments that are usually cluttered with furniture. The acquired partial scans have to be combined, or registered, at a later stage. The registration procedure is not necessarily automatic, particularly for complex environments. To increase automation of the procedure, the placement of markers in the scene is required. This is essential if high accuracy is required. This is the case from the perspective of *scene preservation* in the Mingei project. In the <u>outdoors</u>, the operation of a laser scanner may be hindered by bright sunlight as it interferes with the radiation emitted from the scanner. Assuming proper water insulation, a laser scanner will *not* produce results as accurate as its specifications, in bad the presence of weather (rain, haze), because it has been calibrated for single-phase media (air) and not two-phase dynamic media (falling rain/haze, within the air).

In **general,** laser scanning is a very useful tool, particularly in terms of accuracy and efficiency with little effort from the operator, on the field. It is particularly useful in cluttered indoor environments where photogrammetry becomes more tedious and illumination requirements are challenging.

3.3.2.3 Photogrammetry

For digitisation of <u>outdoor</u> environments, the proliferation of Unmanned Aerial Vehicles (drones) has broadened the horizons of aerial surveillance and facilitated **aerial** photogrammetric reconstruction, providing vantage viewpoints that greatly simplify reconstruction. On the other hand, scene segments of interest may not be visible from aerial views, such as the scene locations below the eaves of buildings. Nevertheless, **terrestrial** views can be combined. This solution requires at least two scanning processes: one aerial and one or more terrestrial, depending on the complexity of the scene.

For indoor environments, photogrammetric reconstruction of wide areas (i.e. a room or a concert hall) exhibits the **disadvantage** that it becomes more tedious for several reasons. The main ones are:

- Lack of sufficient illumination.
- Lack of texture, particularly on blank walls and ceilings.
- Surfaces of high reflectance that exhibit illumination specularities when directly illuminated, such as metallic objects.
- Detailed scans require the acquisition of a large number of images occlusions and are thus time-consuming image acquisition.

In addition, photogrammetric reconstruction requires significant computational time to obtain results, because it is not based on direct measurements of spatial structure (i.e., such as the laser scanner), but is rather an algorithm that computationally infers structure from implicit measurements (images). The main **advantage** of photogrammetry lies in the (relatively) low cost of the required equipment, though high-end optics provide images of higher definition and, consequently, more accurate reconstructions and texture representations. Another advantage of photogrammetry is texture realism, as laser scanning tends to provide low-resolution texture information that looks unrealistic when used in first-person VR applications, even though the geometry may be more accurate. While a laser-only scan is probably advantageous for preserving a crime scene, it is not necessarily the best choice for VR training use case.

In **general**, photogrammetric reconstruction is less accurate than laser scanning, but it is particularly useful for photorealistic reconstructions and of practical usage in covering wide areas. Limitations of aerial photogrammetry due to occlusions can be compensated with the addition of terrestrial views.

3.3.2.3 RGB-D scanning

During the last 10 years, the proliferation of imperceptible, active illumination sensors (RGB-D cameras) has played a significant role in the development of new Computer Vision approaches and attracted new interest to older works in the domain of 3D surface reconstruction that was hindered by the limitations of binocular or multi-view stereo. One of these approaches is Simultaneous Localization and Mapping [189] , which was reinforced by the more accurate 3D point of RGB-D sensors.

In a **comparison with photogrammetry,** it falls short, particularly due to limitations of sensor hardware, as it is off-the-shelf available. The most important limitation is the range within which it is reliable: 0.5m-1.5m. This distance in combination with the relatively low definition of the RGB camera produces less realistic textures. Moreover, the sensor is mainly designed for indoor use. To operate in the outdoors, very careful illumination insulation and engineering are required. Very low levels of (sun) light are required so that they do not overcome the intensity of the active illumination component. At the same time, a controlled light source is required so that there is sufficient light for adequate texture from the RGB component of the sensor. The digitisation modality is more resistant to lack of texture, due to the use of active illumination. Nevertheless, it inherits the disadvantage of SLAM, which requires correspondences across images to retain camera tracking.

On the other hand, it exhibits the following advantages. The sensor cost is relatively low, in the order of 300 Euros. The sensor is lightweight and handheld, though it requires a laptop or tablet attached because the sensor is available as a sensor and not bundled with an image-recording module. The scanning procedure is simpler than photogrammetric image acquisition because active illumination allows for a higher degree of affinity in the trajectory of the handheld sensor. In comparison with photogrammetry, it exhibits the advantage of simpler camera manipulation in cluttered environments. It thereby could comprise a handy and cost-efficient tool, for cases where a simple scan suffices the requirements of documentation.

In the context of Mingei, a **new system** was developed for 3D reconstruction using a commodity RGBD sensor.

FORTH **implemented an RGB-D scanning modality** based on state-of-the-art RGB-D SLAM and reconstruction [186] tailored for this type of sensor.

The system is comprised of three components. The first component captures images from a handheld RGBD sensor and at the same time estimates the 6DOF pose of the sensor as the user moves it in the scene. The captured data are saved on hard disk using a custom video file format. The maximum size of the video file is 46 MB per second, assuming an image resolution of 640x480 and a frame rate of 30 frames per second. The second component uses the captured data to offline generate a coloured triangle mesh of the scene. Mesh generation can take from a few seconds to a few minutes, depending on the number of captured frames. The resulting 3D model is stored in the hard disk in ply format and uses mm as its metric unit. The two components are based on the algorithms described in [186] and [187] , respectively. The third component combines data from multiple capturing sessions and fuses them into one 3D model, provided the data have partial overlap. It is based on the algorithm described in [188] . Results are demonstrated below. The left image shows the RGB component of an RGB view. The right image shows the 3D reconstruction obtained as a mesh of triangles.

Conclusion: the scanning modality is not sufficient for high-end 3D scanning it provides a photorealistic reconstruction of room or desk-sized artefacts. Along with the cost-efficiency of the sensor, this module comprises as a solution of small-budget digitisations. It preferable use is to provide a 3D overview of an indoor room. Besides scanning a workshop are this utility will be used to scan locations within CHIs to place the Mingei systems. In this way, their installation can be virtually previewed in VR.

Figure 8. 3D reconstruction of a machine for punching cards [Zabulis, 2019].

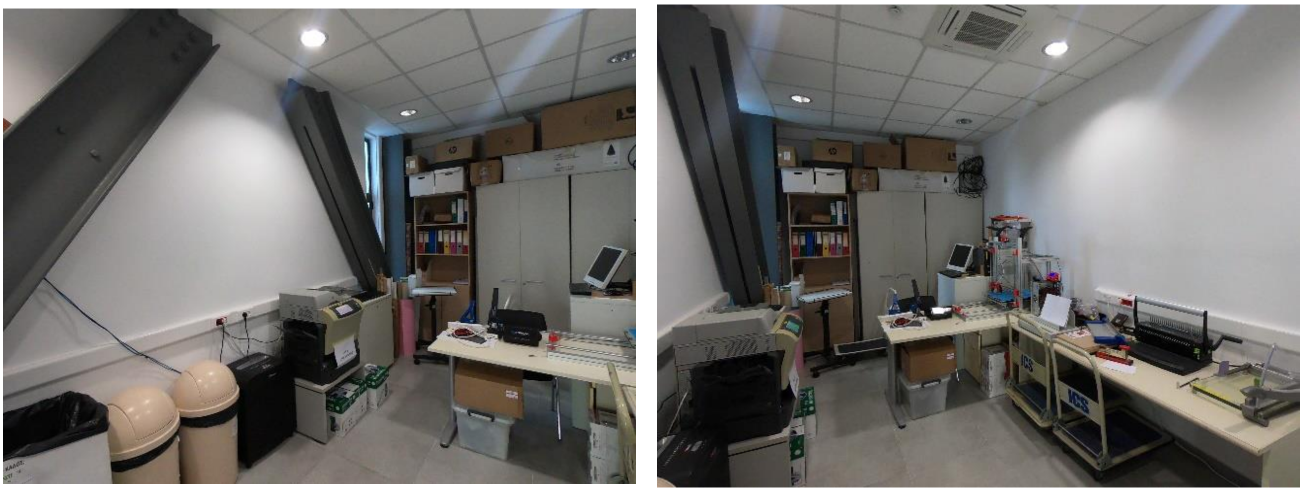


Figure 9. RGB-D scanning. Top: images of the environment. Bottom: 3D reconstruction [Zabulis, 2019].

Conclusion: the scanning modality is not sufficient for high-end 3D scanning, as it provides a fairly accurate reconstruction of room or desk-sized artefacts. In wider areas, tracking error accumulates resulting in inaccurate reconstructions. In addition, textureless areas cause similar difficulties as with photogrammetric reconstruction and call for the use of markers. Along with the cost-efficiency of the sensor, this module comprises as a solution for small-budget digitisations. Its preferable use is to provide a 3D overview of an indoor room or room region.

3.3.2.4 Hand-held optical and inertial scanning, with real-time feedback

A high-end module comes from the combination of trinocular stereo with active illumination and inertial measurements coming from a sensitive IMU. For brevity, we henceforth call this type of device handheld scanner. The modality exhibits clear advantages to RGB-D scanning in terms of affinity of manipulation and robustness. Moreover, real-time feedback on a lightweight companion device (i.e., a tablet computer) can significantly facilitate the acquisition process. The range of such devices is in the order of $8m^3$ and its accuracy can be in the order of 2mm. It is suitable for applications in which digitisation needs to be urgently scanned from various perspectives. Like any optical method, it is dependent on texture and exhibits limitations in shiny objects. The main disadvantage of pertinent devices is their high cost, which is in the order of 16-20K Euros.

3.3.3 Digitisation of actions

Crafts include a number of actions and activities, where one or multiple practitioners use handicrafts, tools, and materials to create artefacts. These activities can be digitised in terms of human motion and may be laborious or dexterous and include intangible aspects such as skill, knowledge, and design (see Figure 10). In the context of crafts, human motion is the point where the **intangible** dimensions of skill, design, and knowledge meet with the **tangible** dimensions of tools, machines, materials, and artefacts.

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. Notable examples are iTreasures

(600676), MODUL DANCE (Moving with Dance Artists across Europe 2010-2014), DANCE (645553), European Theatre Lab, and TERPSIHORE (691218).

Figure 10. Craft activities [Zabulis, 2018].

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 goal is to record of the motion of subjects in three dimensions.

Motion Capture (or MoCap) technologies **directly measure** the movement of subjects in three dimensions, based on wearable markers or sensors whose location and orientation are estimated in 3D. As such, the resulting data are not necessarily intuitive to visualize without processing. Digitisation of human motion has been achieved by several methods, which can be classified based on whether they require subjects to **wear markers or not**. Two main technologies are used.

The first is based on the **optical** detection and 3D estimation of wearable markers. This approach typically requires a careful setup environment (i.e. a motion digitisation studio or theatre) that includes multiple optical sensors that observe the worn markers from multiple views. The operating principle is the multi-view stereo triangulation of these markers. As such, camera calibration and precise illumination is required. Moreover, a complex motion may require a large number of views, in order to cope with marker occlusions. These occlusions may be self-occlusions, where markers are occluded by the body members of the subjects, or generic occlusions where markers are occluded by other objects such as, in our case, tools, and machines.

The second is based on **inertial** measurement units (IMU) that are worn. Unlike optical MoCap, inertial MoCap computes the location and orientation based on inertial changes due to subject motion. The results encapsulate human motion in 3D with detail and therefore show a complete representation of the recorded motion. Most importantly, they do not require the setup of a studio or sensors. This is important, as the installation of sensors can be difficult or impossible at the location of craft practice, such as a traditional craft workshop environment or outdoor rural space.

More information on the digitisation technologies available for capturing human motion is available in Annex 7.

4. Silk

The Haus der Seidenkultur (HdS) is a museum about Krefeld's silk industry, located in a former silk factory that specialised in producing liturgical vestments. The museum has a rich archive and collection of objects related to silk and jacquard weaving, some of its looms are still in operation thanks to a group of volunteers, who had careers in the city's silk weaving industry. HdS provides the case of a craft at risk of becoming extinct. During this pilot, partners will explore the challenges and requirements related to an industrialised craft that takes place in a (small) factory setting. Some of the expected points of attention will be the challenge of dealing with a wide variety of information, from written archival sources to fragile textiles and large looms, the use of machinery, and capturing the locality of a craft strongly associated with Krefeld, yet also practiced elsewhere in slightly different ways.

The pilot of silk relates to technical skill and historic reference. For centuries, the German city of Krefeld was known as "The city of Silk and Velvet", although today many other industries can be found there. At the Haus der Seidenkultur, a former silk factory turned into a living industrial monument, the traditional craft of Jacquard weaving is still practiced. While one might associate heritage crafts with dexterity, hand tools, and cottage industries, the silk weaving workshops of Krefeld form an opposite in some ways. The craft takes place in a more industrialised environment, making use of large, noisy machinery, as well as a unique form of technology-enabled craftsmanship.

In this section, the results of the application of the Mingei collection of knowledge to the Silk pilot are presented, up to M10 of the project.

4.1 Existing content

The existing assets of the HdS organisation that has been until now incorporated in the Mingei assets are comprised mainly of curated texts of the museum, images, and documentaries.

4.1.1 Literature

Literature including the curated text of the museum and pertinent essays from museum collaborators and personnel were provided by HdS. The original texts were in German, some published and some from the museum's records, and translated by HdS in the context of the project. In almost all cases, both the English and German texts are provided. The original text segments are in: DS.Mingei\Silk\ExistingContent\DigitalText

4.1.2 Images

Object recording on-site focused on museum exhibits that have unique historical value. More specifically, we took photos of patterns in books, paintings, manuscripts, garments and fabrics as well as close-up photos of the various parts of the looms. All of the data were collected using the J1 camera under proper lighting and can be used both as assets to re-create a virtual version of the museum as well as a standalone source of information.

The images are of two types. First, there are images of textile samples and, including textiles that are patterned with historic themes. Second, there are images that appear in HdS publications. The images were massively rectified with the tool reported in "3.1.2 Visual content" of this deliverable. The photographs collected comprise of about

- 10 portraits of members of the Gotzes company
- 25 historic photographs of Krefeld relevant to the silk textile trade
- 250 textile samples
- 20 photographs of historic loom artefacts (from CNAM)
- 30 textile manufacturing documents with instructions

All images are online in the MOP (see Figure 11) and available at: DS.Mingei\Silk\ExistingContent\Images

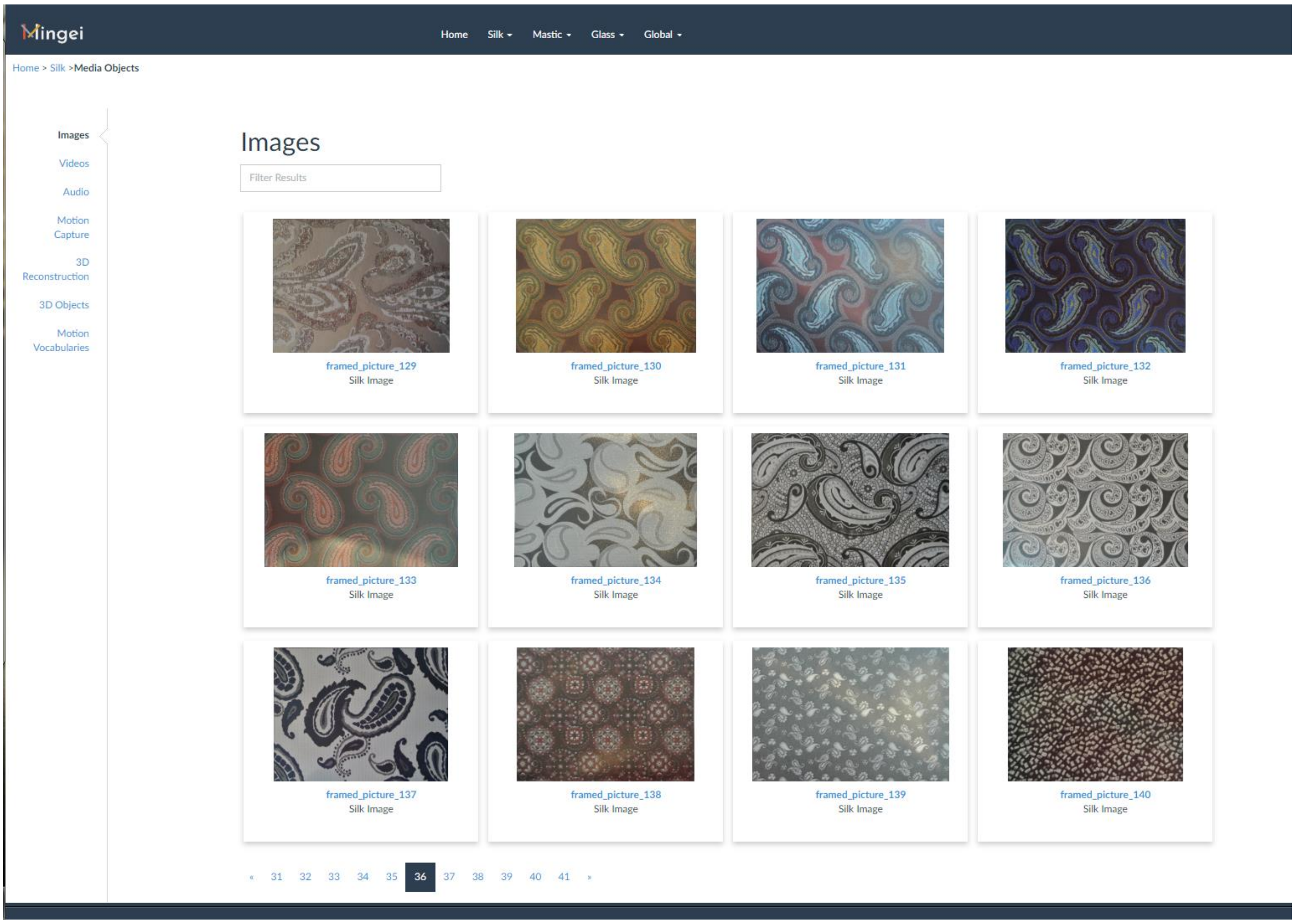


Figure 11. Screenshot of the Mingei Online Platform (images from [170]).

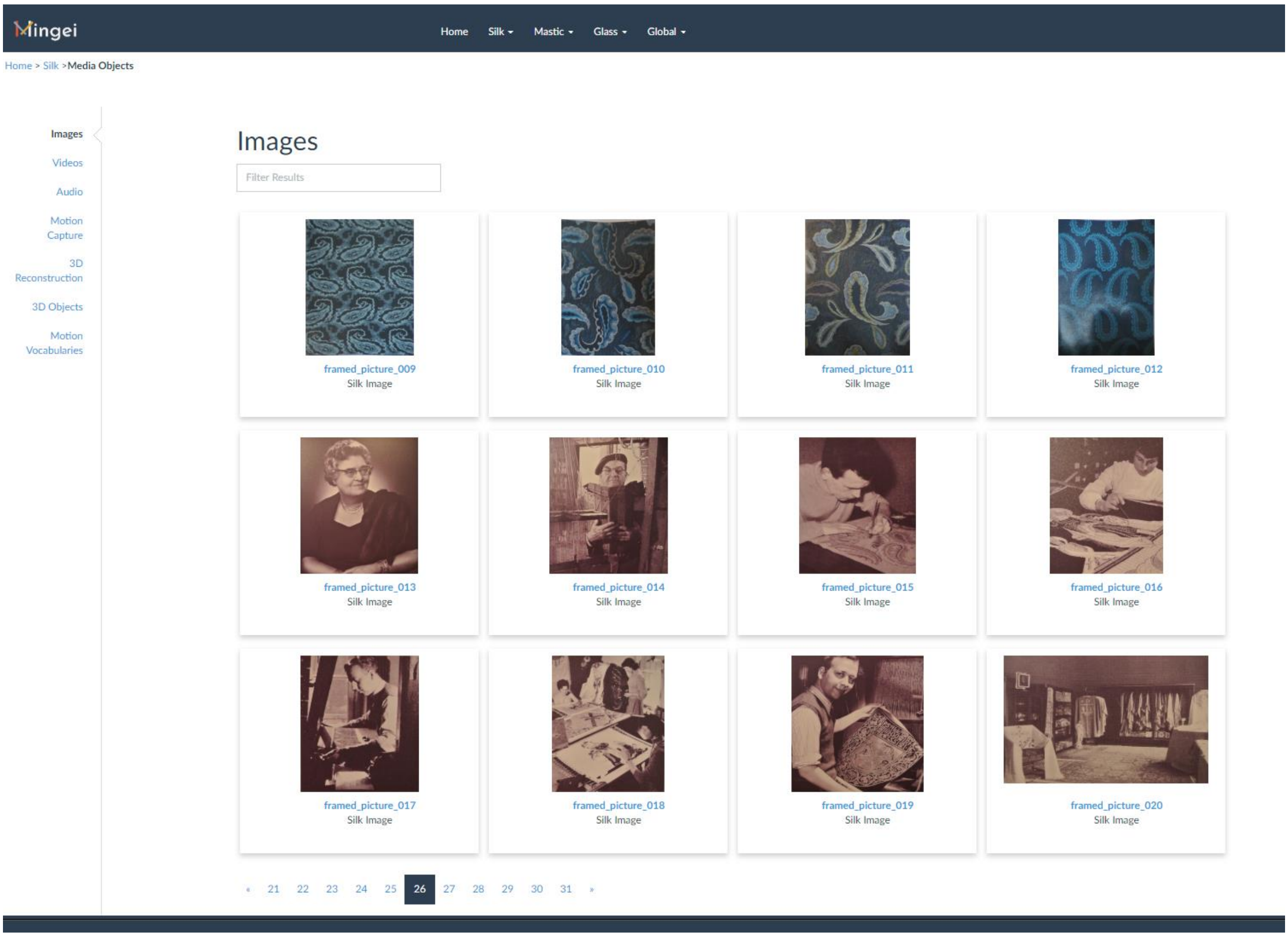


Figure 12. Screenshot of the Mingei Online Platform (images from [170]).

4.1.3 Audio and Video

The three documentaries are productions by HdS and they were converted from DVD format to MP4. The two documentaries contain demonstrations of the weaving process, performed by the community of volunteers of HdS. The third is a guided walkthrough in the city of Krefeld at places of relevance to the silk workshops of Krefeld. The documentaries were provided to the digitisation project.

Available at: DS.Mingei\Silk\ExistingContent\AudioVideo\

4.2 New content

4.2.1 Literature

Digitisation of articles, essays, and books were collected and used in the documentation of the represented craft instance. These are either (a) already found as textual files from online libraries, or (b) digitised as images, Cored, reviewed, and manually corrected for OCR errors.

Available at: DS.Mingei\Silk\ExistingContent\OnlineText

The digitisation of **documentation** can provide craft insights and illustrate complex crafting procedures. In the figure below, technical drawings for the construction of a Jacquard loom and its operation are shown.

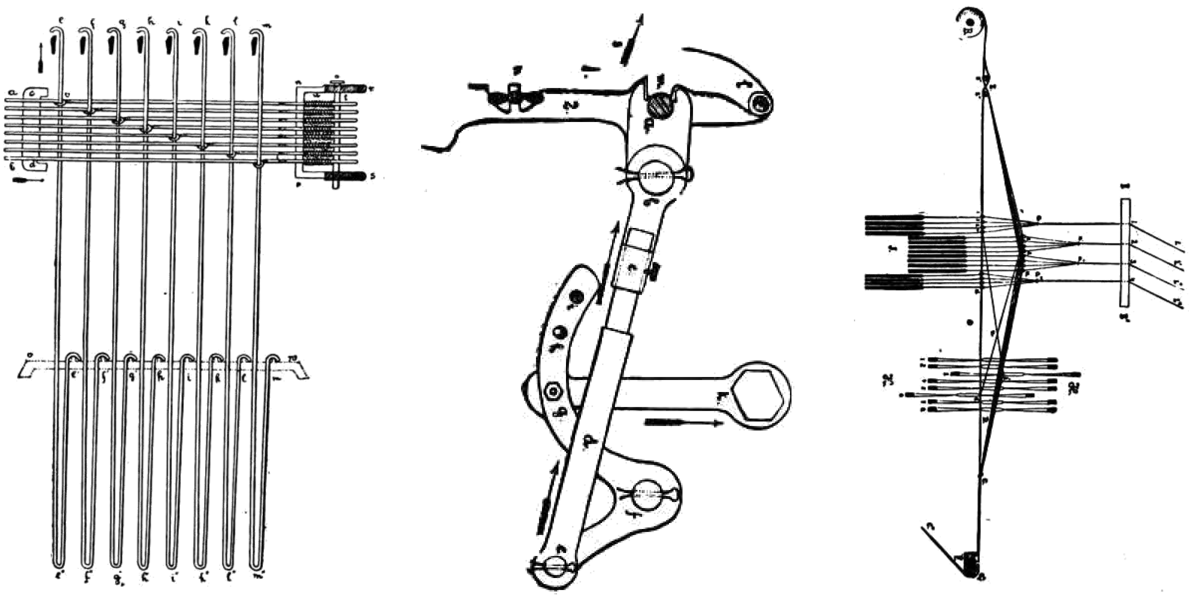


Figure 13. Technical drawings for the Jacquard attachment (images from [70]).

4.2.2 Images

Photographs of museum items were acquired by FORTH. Original and rectified images are stored. The photographs collected comprise of about

- 20 textile manufacturing documents with instructions
- 110 overview photographs of looms and HdS workshops
- 80 loom detail photographs
- 10 photographs of silk threads
- 50 photographs of plants used in the manufacturing of colour pigments
- 4 sets of photographs of detailed ecclesiastical garments (about 800 photographs).

In addition, photo sets of reputed artefacts of HdS regard ecclesiastical garments (Figure 14).

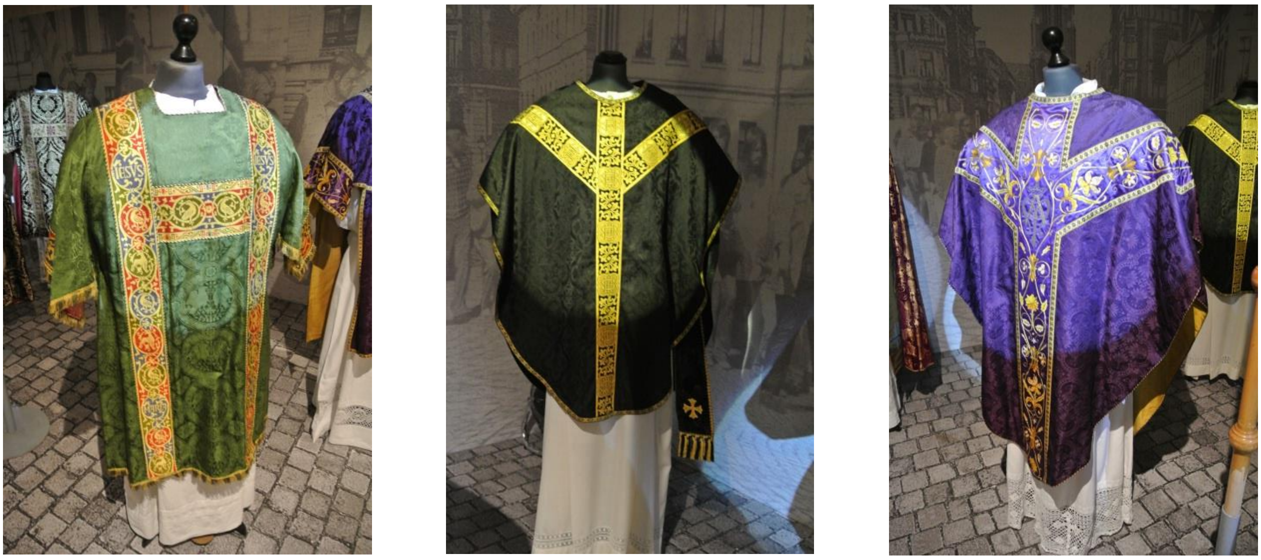


Figure 14. Ecclesiastical garments of HdS [Qammaz, 2019].

All images are available at DS.Mingei\Silk\Images as well as in the MOP. The figure below shows some of the images on the MOP (see Figure 15).

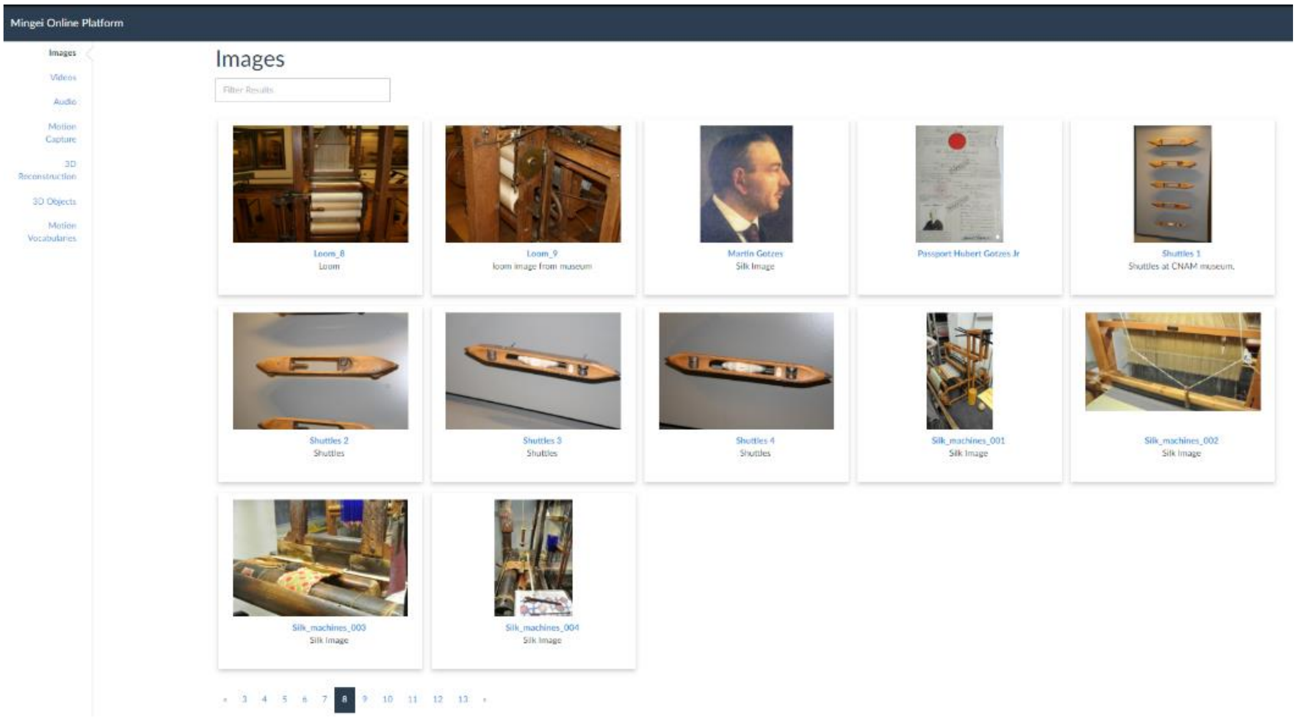


Figure 15. Screenshot of the Mingei Online Platform (images from [170]).

4.2.3 Video

Collected data are RGB and RGBD videos of (i) practitioners performing textile production tasks and (ii) static objects from multiple trajectories around the object, for their 3D reconstruction using a hand-held device. Pertinent results can be found. All videos are available on the MOP (see Figure 16) and in the directories below

- DS.Mingei\Silk\RGBVideo\MoTraRGB_2D
- DS.Mingei\Silk\RGB-DVideo\

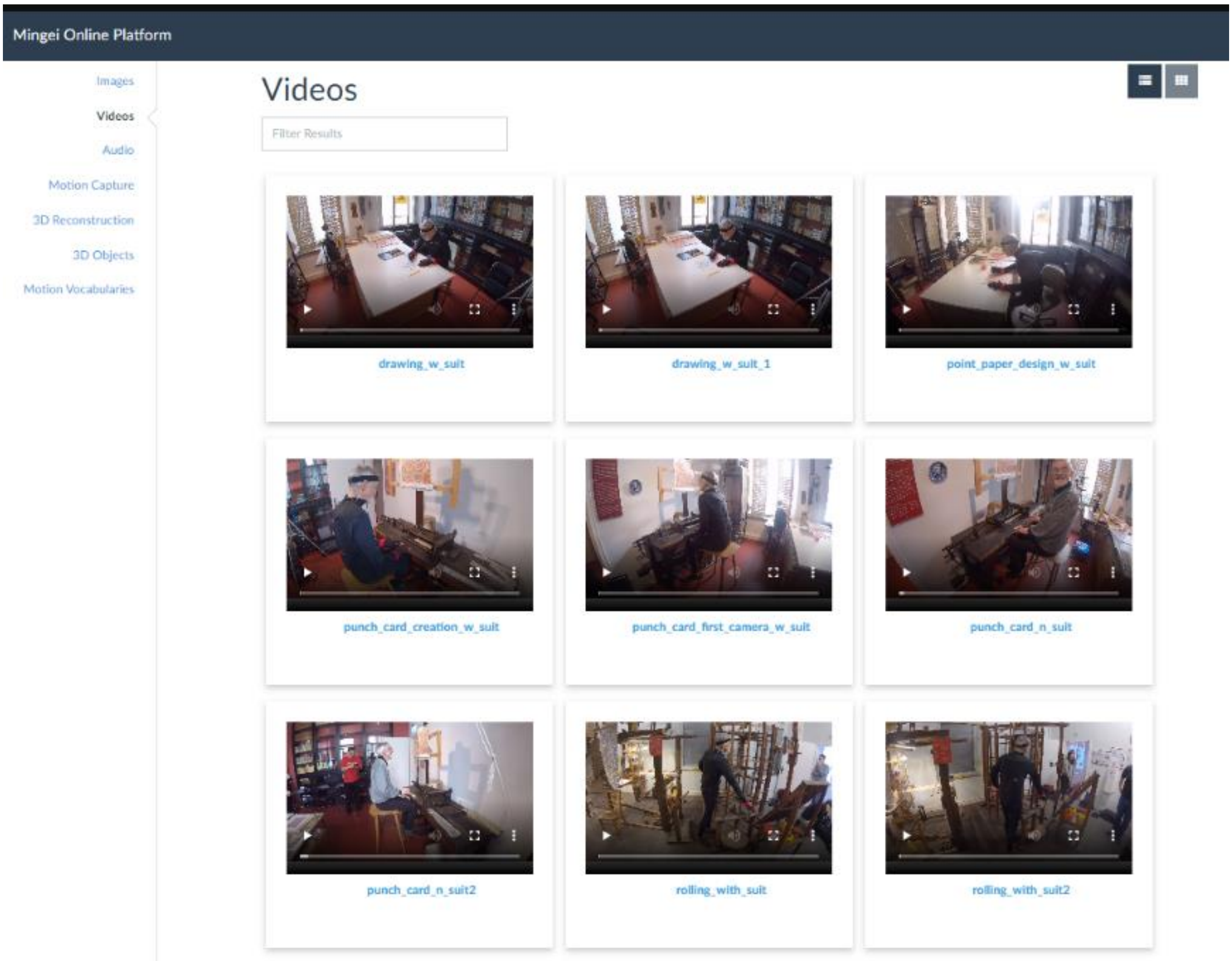


Figure 16. Screenshot of the Mingei Online Platform (images from [170]).

4.2.4 3D Reconstruction

The first digitisation regarded reputed artefacts of HdS regard ecclesiastical garments (Figure 14). In the figure below (Figure 17), the **3D digitisation of a deformable object,** an ecclesiastical garment, Germany, is shown.

Figure 17. Original images (top) of an ecclesiastical vestment made from silk and gold brocade and photogrammetric 3D reconstruction (bottom) [245] Click for an online demo.

In the figure below (Figure 18), the reconstruction of 4 more such garments is shown. The images are hyperlinked to the YouTube channel of the Mingei project. The 3D reconstructions are also available through the MOP (see Figure 19).

Figure 18. Online videos showing 3D garment reconstructions [Katzourakis, Zabulis, 2019].

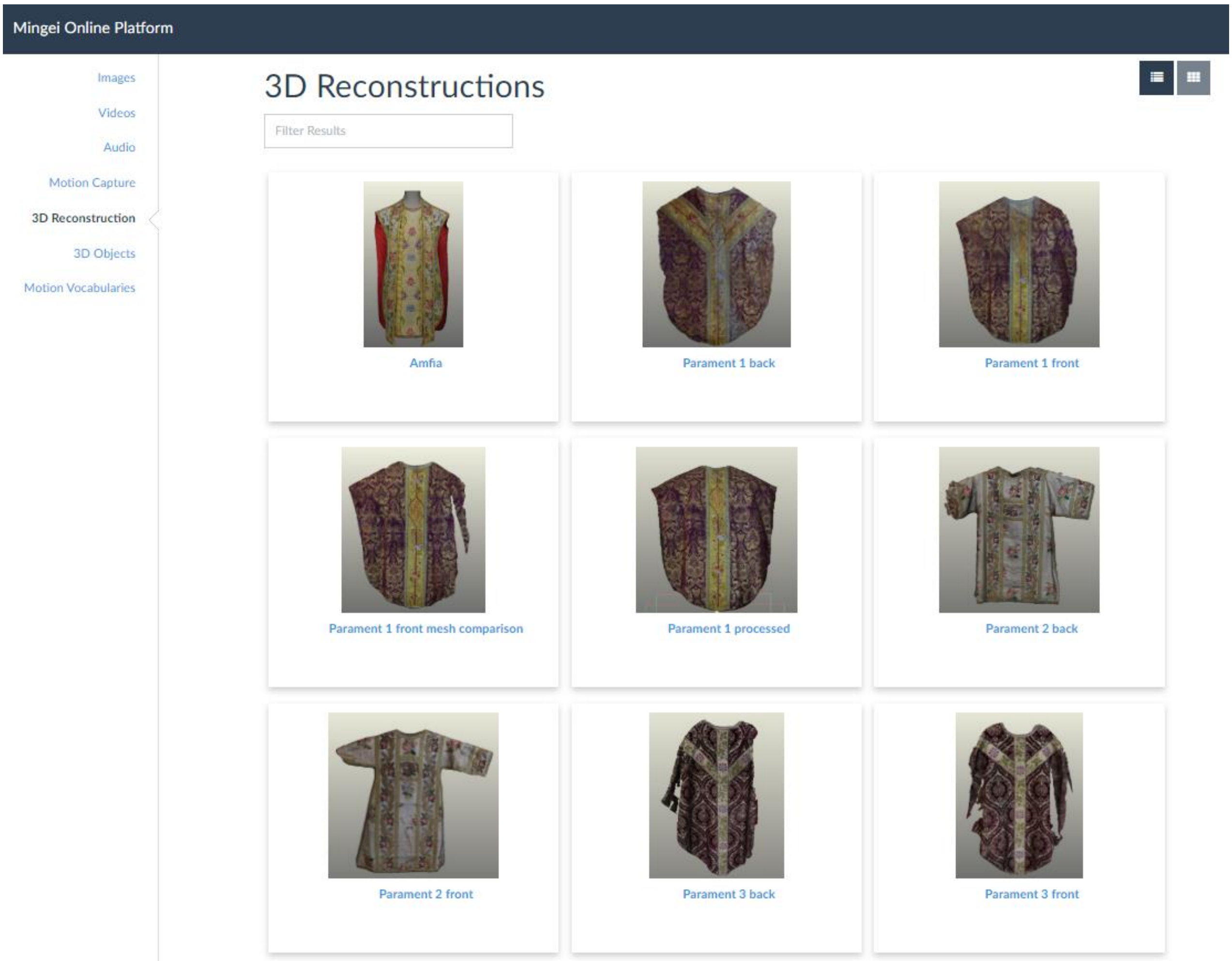


Figure 19. Screenshot of the Mingei Online Platform (images from [170]).

4.2.5 Digitisation of human motion

Motion capture was conducted with two mastic cultivators in the premises of HdS. A practitioner performed the activities for producing Jacquard-woven, silk paraments. These activities ranged from the design of the pattern, to its point-paper encoding, to the punching of Jacquard cards, and the weaving of the fabric. The procedures were performed separately.

The data are available in DS.Mingei\Silk\MoCap\OriginalMoCap

Their visualisation is the object of WP5 and is presented separately in the deliverables of this WP.

4.3 Craft and contextual knowledge

4.3.1 Textile manufacturing basic information

- The term "textile" comes from the Latin word *tepee* ("to weave").
- The process of making cloth is to first spin the raw materials into yarn, and then weave the yarn into cloth.
- Sometimes, a finishing or "fulling" process is required after the cloth is woven.
- Spinning and weaving have been done since prehistoric times. The first technology used in spinning was the spindle.
- The process of spinning was mechanized by the introduction of the spinning wheel into Europe in the 14th century.
- The spinning wheel, which had been developed and used in India long before, allowed the continuous spinning of thread. Spindles and spinning wheels were the only way to make yarn or thread until mechanical spinners were invented during the Industrial Revolution.

Fibre is a unit thread of a natural or manufactured matter that forms the basic element of fabrics and other textile structures.

Yarn is spun thread used for knitting, weaving, or sewing.

Strands are yarns braided together to produce a long, thin strand used in sewing or weaving.

A **textile** is a flexible material consisting of a network of fibres (yarn or thread). Textiles are formed by weaving, knitting, crocheting, knotting or tatting, felting, or braiding.

Fabric is a material made through weaving, knitting, spreading, crocheting, or bonding that may be used in the production of further goods (garments, etc.).

Cloth may be used synonymously with fabric, but is often a piece of fabric that has been processed.

Figure 20. From fibre to fabric [Beisswenger, Zabulis, 2019].

4.3.1.1 Processes

Textile manufacturing is the conversion of fibre into yarn and of yarn into fabric. In this section, we focus on the subset of textiles that contains weaved fabrics that are then transformed into textiles. The material used is a defining factor for the final product.

A defining factor of the structure of textiles (and thus weaved fabrics) is their weave. The three basic weaves are plain, twill, and satin. Weaves that are more complex require sophisticated tools for their manufacturing and sometimes blur the boundaries between weaving and knitting.

There are many variable processes available at the yarn-spinning and fabric-forming stages coupled with the complexities of the finishing and colouration processes to the production of a wide range of products. For example, colouring (dyeing) may take place on the yarn or the woven fabric.

The “finishing” of textiles also varies according to purpose and material. Finishing refers to the processes that are performed after dyeing the yarn or fabric to improve the look, performance, or “hand” (feel) of the finished textile or clothing, i.e. mercerisation, salvaging.

As textiles are omnipresent in the lives of people since the earliest recorded stages of humanity, the process of textile manufacturing has been studied in detail. This is even more evident in products of high consumption, such as cotton and wool, or notable worth, such as silk. The organisation and sequence of processes of fabric manufacturing and their variants according to material or type of final product are studied in the technical domains of industrial textile manufacturing. In the EU, the naming of fabrics according to the composition of fibres and weaves is legislated by the Regulation (EU) N° 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products[2]. In this subsection, we follow the abstraction provided in Figure 20, regarding the creation of fabrics.

A prior process to textile manufacturing is the collection or cultivation of fibre. Different types of fibres are used to produce yarn, i.e. cotton, wool, and silk. The type of weft also determines the texture and properties of the woven product.

A post process to textile manufacturing is the creation of woven products, such as clothes or household linen. Additional post-processing may involve additional wefts or transformations of decorative nature, i.e., the supplementary weft on brocades with gold and silver thread or the weaving of “ksombliasta” additional ornamental structures as in Anogia, Greece (see Figure 21).

[2] See the page of EU - Expert group on textile names and labelling for catalogues of textile names.

Figure 21. Traditional weaving at Anogia, Crete, Greece. Screen capture from the YouTube channel of the Mingei project [Zabulis 2019].

Although nowadays yarn and textile manufacturing are usually undertaken by individual, specialised vendors, this was not necessarily the case in the past. Cottage industries treated textile production as a seasonal agricultural process and produced textiles all the way from the cultivation/collection of threads. In cottage industries, often the entire families participated. The children or wife prepared the spools for the loom shuttles using a reeling wheel, while the husband weaved (see Figure 22). The silk weaving workshops studied by the HdS Mingei pilot follow this pattern, creating silk threads from silkworms until the production of expensive brocades, using gold thread that was imported from Japan.

Figure 22. Family participation, in textile manufacturing (image from [98]).

This organisation and documentation of textile manufacturing were industrialised during the transition from the putting-out to the factory system, in which the Industrial Revolution (IR) played the lead role. It is worth noting, that though technical and economical, IR has influenced the formation of “eras” that gave rise to artistic expression and movements. In Figure 23, from the top left and clockwise, the following are shown. 1. An illustration of London during the Industrial Revolution, showing the pollution from “smog” (Unknown). 2. Engraving of a Luddite leader, possibly Ned Ludd (Unknown). 3. Textile from the Arts and Crafts era (“Strawberry Thief”, William Morris c. 1917). 4. Weaved matting textile from the Bauhaus weaving workshop (Gertrud Arndt, c. 1930).

Figure 23. Influence of the Industrial Revolution in arts and crafts (images from [99] [100] [101] [102]).

4.3.1.2 Weaving

Weaving is a central operation in the manufacturing of textiles, fabrics, carpeting, and wicker.

> *"The structure of fabric or its weave - that is, the fastening of its elements of threads to each other - is as much a determining factor in its function as is the choice of the raw material. In fact, the interrelation of the two, the subtle play between them in supporting, impeding, or modifying each other's characteristics, is the essence of weaving."*
>
> Anni Albers (1965), On Weaving.

Depending on the fibre, fabric, carpeting, and wicker can be weft. Using these materials, one can create textiles, baskets, or matting (see Figure 23). In the case of **fabrics**, two distinct sets of **yarns** (or threads) are interlaced at right angles to form a woven product.

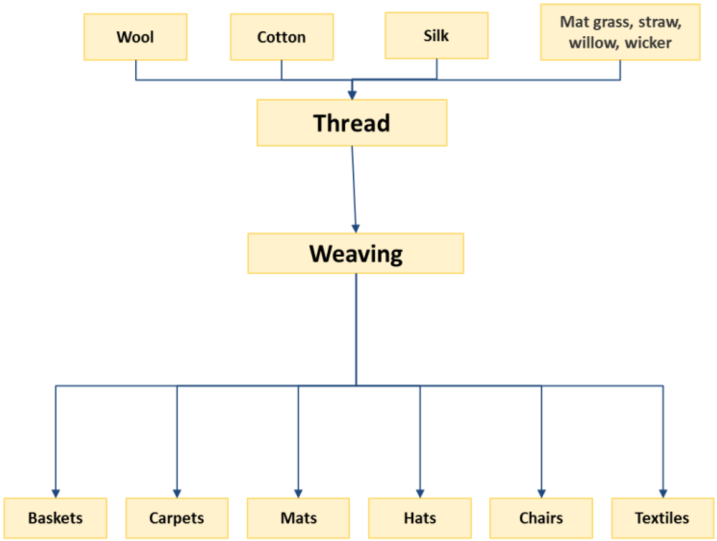


Figure 24. Thread materials and woven products [Karuzaki, 2019].

For a comprehensive treatment of weaving the reader is referred to the milestone work of Albers [66] .

There are other ways of creating textiles, such as weaving knitting and breading which, as contemporary industrial materials, are topics of industrial research, i.e., [67] , as well as, research beyond the realms of the textile industry in the quest for new materials [68] .

4.3.1.3 Weaving fabrics

Weaving is a way to fasten multiple parallel threads that are extended by tension with a perpendicular, interweaved, and much longer thread. Most types of weaving require a minimum of equipment. Machinery introduced over time aims to ease and accelerate the process of weaving. A historical and technological review of weaving fabric for textile manufacturing is provided in D1.3, Sections 7.1.1 and 7.1.2, respectively.

The yarn that comes from the spinning mill is rewound onto the warp beam of the loom before being used for weaving. In warping, the warp threads from the warping creel that have been sorted by the gathering reed are wound onto the warping drum. After warping, the spooled warp threads are wound onto a large metal roll, the warp beam of the loom.

A loom is any device that holds the warp threads at a reasonable tension and facilitates the interlacement of yarn. A shed is the area formed when some, but not all, of the warp threads are lifted. When the weft thread is passed through the shed, it is over some threads and under the rest. The basic mechanism that forms this shed is the heddle. A heddle is a hole that the warp threads pass through. When the heddle goes up, the warp thread associated with that heddle also does.

Passing a string through a heddle is a task similar to passing a string through a needle. Thus, setting up the threads through the heddles is a tedious and time-consuming task. It is thus important to perform it as scarcely as possible. Estimation of thread quantities is an important part of loom preparation. The weaver must be able to repair a broken thread so that passing the string through the heddle is avoided.

Depending on the way of creating tension for the warp threads, different kinds and types of looms have been invented, i.e. the blackstrap loom, the draw loom, or the conventional handloom where bars are attached to each thread to create tension.

Up to the invention of the heald, individual warps were lifted by fingers, to insert perpendicularly the weft. The heddle mechanised the lifting of warps. The upper heald frames are connected by a cord passing over a roller, and the lower heald frames are connected to treadles. By depressing one treadle, one heald frame is raised and the other lowered, separating the warp threads. This separation creates an opening, or the shed, that facilitates the insertion of the weft. Depending on which heddles are lifted in each warps different structures, or weaves, can be woven.

A way to introduce the weft thread was by hand. The weft is wound around a rod that is called pirn and, while it is interwoven through the warp, it is unravelled from the pirn. The idea of winding the weft yarn onto a stick that could carry it faster through the shed from side to side led to the development of shuttles.

Pressing the weft into place, firmly and evenly, across the width of the fabric is not easy to be performed by hand. This tool is required to be:

- **flat** to be entered into an open shed,
- **smooth** to glide easily along the warp threads,
- **firm** so as not to bend under pressure,
- **long** to reach across the warp and beyond to be held, and
- **bladelike and blunt** on one side to reach deeply into the angle of the opened shed.

These requirements led to the beater-in or batten, which for a sword like appearance is called the “weavers sword” [66] .

Weaving is summarized as a repetition of these three actions:

- **Shedding**: warp threads are separated by raising or lowering healds to form a clear space where the weft should pass.
- **Picking**: weft is passed across the loom. This is implemented by hand, shuttle, air-jet, or rapier.
- **Beating-up or battening**: the weft is pushed up against the fell of the cloth by the beater.

In Figure 25, the three stages of weaving are illustrated.

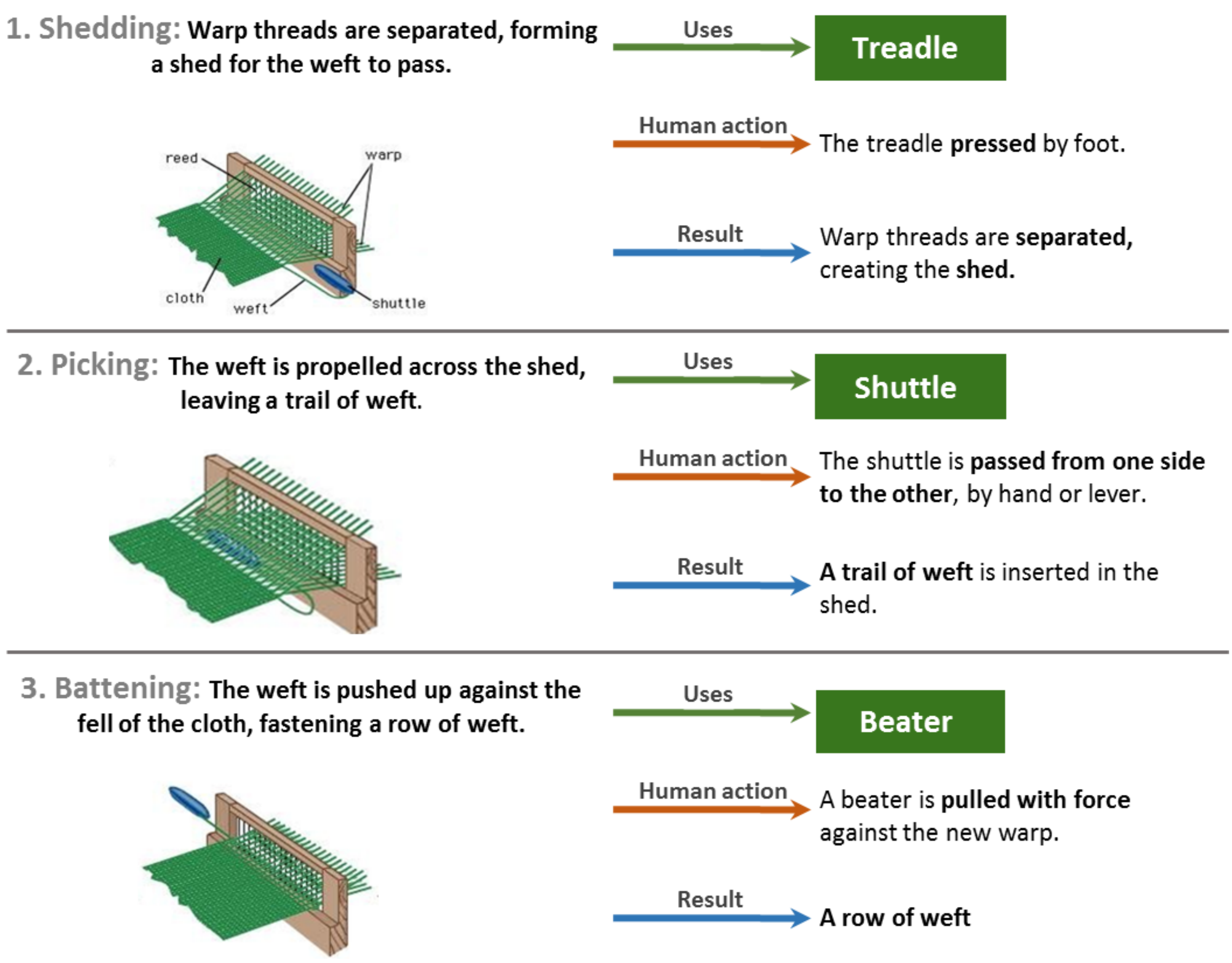


Figure 25. The three stages of weaving [Karuzaki, Zabulis, 2019].

Table 2. Significant events in loom technology [Zabulis, 2019].

The invention of the flying shuttle (1775-1778)	The flying shuttle, or "wheeled shuttle", is a loom accessory that increases productivity, and enables the weaving of wider cloths by a single person. The shuttle runs along with a "race", built into the beater, on rollers. The weaver, rather than passing the shuttle manually, pulls a cord shooting the shuttle across the race. When the weaver pulls the cord left wise, the shuttle flies left and the opposite.
The invention of the	The first mechanized loom was designed in 1784 by Edmund

power loom (1785)	Cartwright and built in 1785.

4.3.1.5 Patterned fabrics

Since antiquity, craft communities have been embedding cultural elements in weft products, for decorative or emblematic purposes. Like many craft products, patterned fabrics have a dual substance. They are usable items, yet at the same time, they include heritage that represents a region and its people. In terms of traditional textiles, one can often recognise the origin of textile from its decorative patterns or visual style.

The pattern of a woven product may contain an aesthetic, decorative, or artistic dimension. This notion was explored in the domain of textiles by the weaving workshop of the Bauhaus design school (see Figure 26).

Figure 26. Northwesterly (Anni Albers, 1957, image from [157]).

Weaving a patterned fabric is a tedious process that requires additional skill to encode specific, multi-coloured patterns. The invention of the Jacquard attachment facilitated the process, as complex patterns would be once encoded in a storage medium (punched cards) by a skillful individual and, then, automatically reproduced. This further increased the automation of the tedious patterned weaving task and resulted in the ability to manufacture highly detailed patterns. Moreover, fewer skills were required to weave textured patterns.

4.3.1.6 Jacquard patterned fabrics

The Jacquard attachment is a device fitted to a loom that simplifies the process of manufacturing textiles with complex patterns. The machine was controlled by a “chain of cards"; that is some punched cards laced together into a continuous sequence. Multiple rows of holes were punched on each card, with one complete card corresponding to one row of the design.

To create patterned fabrics using a Jacquard loom, the fabric design is first sketched and transferred to squared paper. A skilled worker translates the design into punched cards, using a machine for punching cards. Each complete card represents one row of the weft pattern. The holes created in the cards encode the selection of threads to be lifted when the shuttle passes for that particular row, for the implementation of the pattern. Technically, the holes allow the hooks to pass through which, in turn, trigger the heddles to be lifted. Cards are laced together in a chain and introduced to the loom. In Figure 27, punched designs for the Jacquard attachment are shown (top French index, bottom American index).

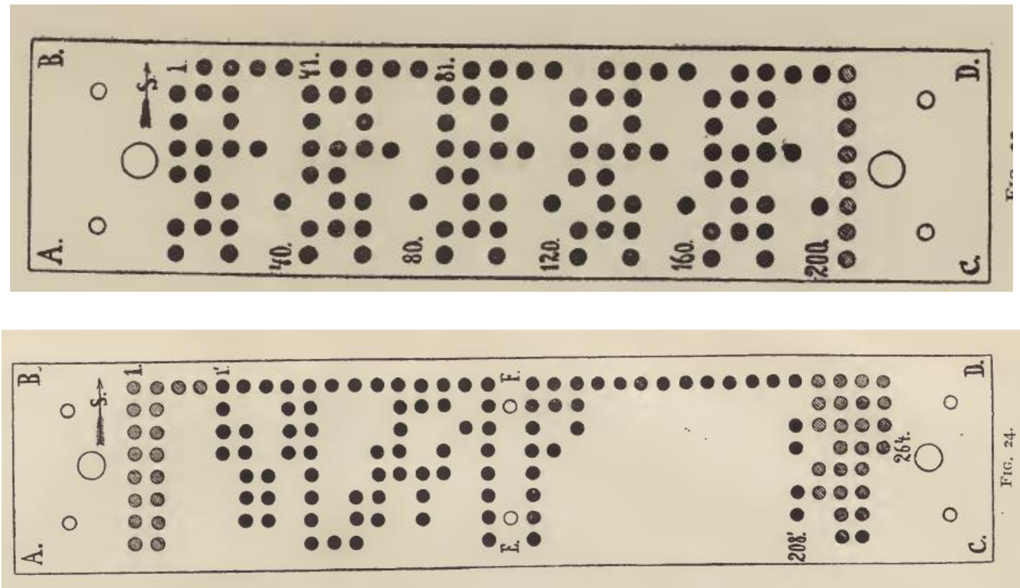


Figure 27. Punched cards for the Jacquard attachment (images from [71]).

The act of lifting some of the warp threads so that the weft passes only below those can be better understood when looking at a woven fabric, from both sides. As shown in the figure below (Figure 28), the two sides are complementary. In the figure, note that only the left column appears inverted, as the pattern has a vertical symmetry.

Figure 28. Two sides of a silk woven fabric [textile sample HdS, photographs Zabulis, 2019].

The posture of the worker operating the cutting machine reminds of the posture of the piano player (see Figure 29) and, hence, cutting machines are called piano machines. The operator sits on a stool and reads the design in front of him, placed similarly to a sheet of a music score.

Along with the technical instructions for the construction of such machines [69] , good practice guides were also provided [70] [71] . Such guides focused on the efficiency and robustness of the task performed by the worker. In [71] (see Figure 30), it is recommended that workers should not lift their gaze from the pattern and work uninterruptedly, so as not to lose count[3]. The use of "heavy squares" supports this goal and, in [71] (see Figure 31), insight is provided on the selection of the area of heavy squares according to the type of machine and type of weft.

[3] The same concept is also met at "touch typing", which is a style of typing without looking.

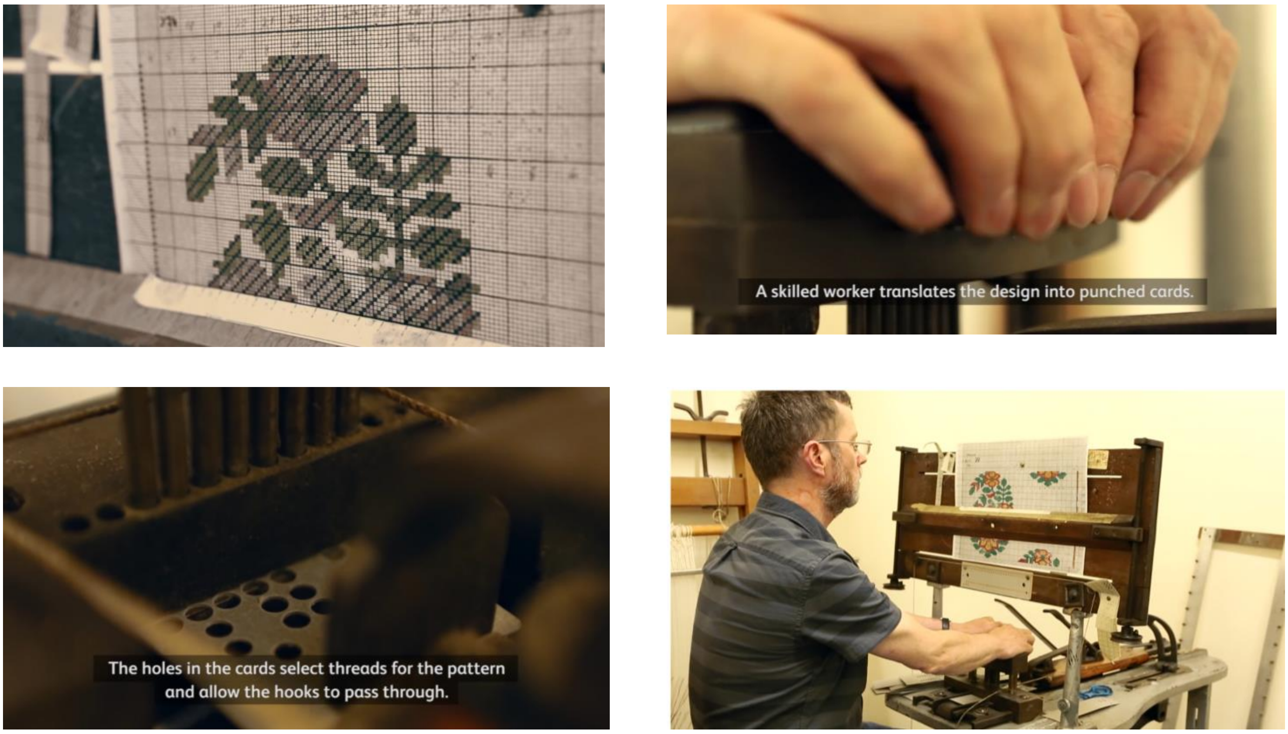


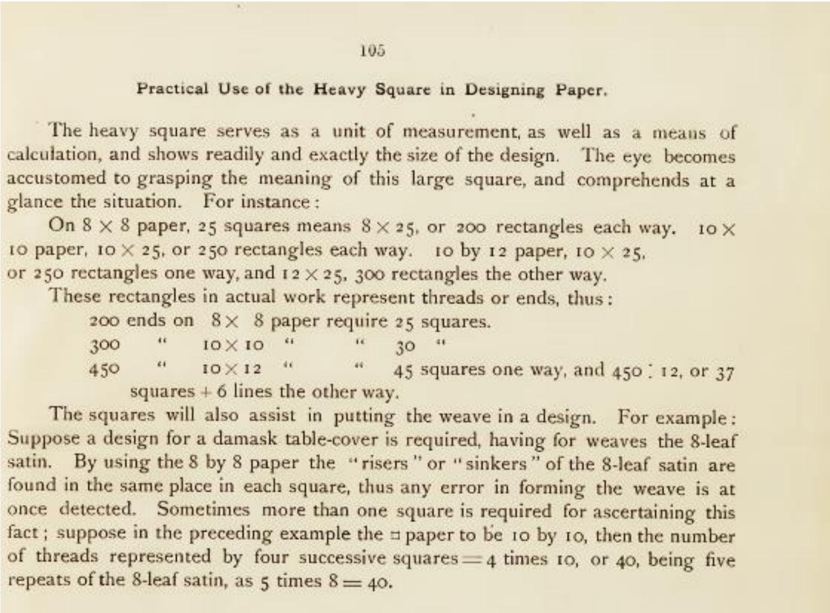
Figure 29. Punch card typing (video stills from [103]).

During the cutting operation the fingers should not be removed from the keys ; they should always be in readiness to press the required key into action, as this is the only way to become expert.

The eye of the card stamper must rest uninterruptedly on his design ; and the keys are called at will by the fingers, without the eye leaving the design, to find out where a certain key or finger is situated at the time.

Figure 30. Good-practice guide for punch card typing [Zabulis, 2019: annotated image from [71]].

Squared Designing Paper for the Different Textile Fabrics Executed on the Jacquard Machine.


105

Practical Use of the Heavy Square in Designing Paper.

The heavy square serves as a unit of measurement, as well as a means of calculation, and shows readily and exactly the size of the design. The eye becomes accustomed to grasping the meaning of this large square, and comprehends at a glance the situation. For instance:

On 8 × 8 paper, 25 squares means 8 × 25, or 200 rectangles each way. 10 × 10 paper, 10 × 25, or 250 rectangles each way. 10 by 12 paper, 10 × 25, or 250 rectangles one way, and 12 × 25, 300 rectangles the other way.

These rectangles in actual work represent threads or ends, thus:

200 ends on 8 × 8 paper require 25 squares.
300 " 10 × 10 " " 30 "
450 " 10 × 12 " " 45 squares one way, and 450 ∶ 12, or 37 squares + 6 lines the other way.

The squares will also assist in putting the weave in a design. For example: Suppose a design for a damask table-cover is required, having for weaves the 8-leaf satin. By using the 8 by 8 paper the "risers" or "sinkers" of the 8-leaf satin are found in the same place in each square, thus any error in forming the weave is at once detected. Sometimes more than one square is required for ascertaining this fact; suppose in the preceding example the ⌑ paper to be 10 by 10, then the number of threads represented by four successive squares = 4 times 10, or 40, being five repeats of the 8-leaf satin, as 5 times 8 = 40.

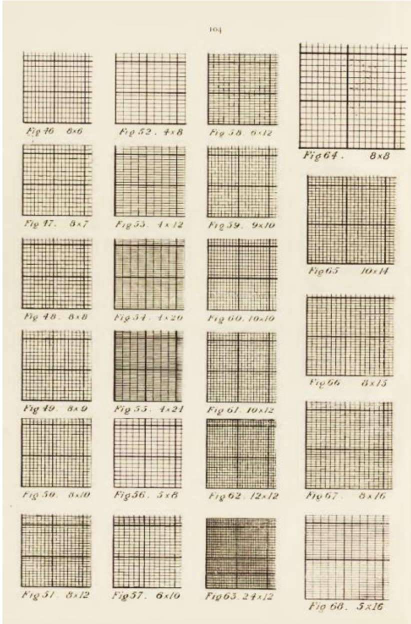
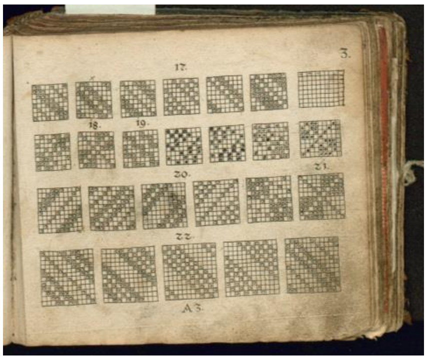


Figure 31. On the use of the "heavy square", in point paper pattern design (image from [71].

4.3.1.7 Coding of punched cards

In the distant past, pattern weaving was done without the use of notation. Skilled weavers might even not plan the pattern in advance. The loom parts, like heddles or shafts, store most of the necessary information and skilled weavers can read bindings and patterns directly from fabric. Fabric samples were probably the best and most commonly used memory or storage for patterns.

The first mention of documenting the required skill in notation is found in [76] . Interestingly, it also resembles a music score. A historical survey on early notation that helped weavers encode and transfer the knowledge of reading patterns and convert them into punched cards is provided in [73] . In 1969, a method and apparatus for producing Jacquard cards has been patented [74] . Nowadays, the process is treated algebraically and, thus, in the computer [75] .



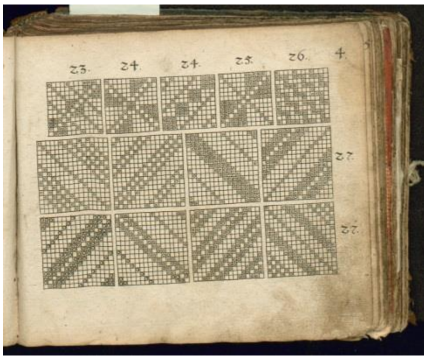


Figure 32. Early weaving notation (Images from [76]).

The process of reading point paper design and pressing keys to creating punch cards does not only remind of the piano player, but it was used also in the encoding of music for the “pianola” musical instrument.

4.3.2 Silk textile manufacturing

4.3.2.1 Sericulture

Raising silkworms is called sericulture and is an agricultural-based livelihood that depends heavily on the weather and the attentiveness of the farmer. Workers feed the silkworms fresh, chopped mulberry leaves eight times a day. The silkworms are moved to clean feeding trays once a day. Cocoons are sorted, inspected, and sorted according to their quality.

Mulberry leaves, particularly those of the white mulberry, are the sole food source of the silkworm, the cocoon of which is used to make silk.

Science has contributed to the development of the modern silk industry. Luther Burbank developed a white Mulberry in the early 1900s - with twice as much foliage - for Japanese silk growers. Louis Pasteur invented techniques for raising disease-free silkworms, after diseases ravaged the industry in Europe, and in 1870 published *Les Maladies des Vers à Soie*.

4.3.2.2 Silk loom preparation

Extensive instructions are provided in the HdS, Film Project, “Einrichten des Golwebstuhles”, (“Setting up the Gold Loom”) where the preparation of the silk or gold loom is presented. In this documentary, visual documentation of the required tasks is provided. In the HdS, Film Project, ”Stadtspaziergang auf Seiden Pfaden” (“Hanging by a thread”), 2018, guidelines are provided to estimate the amount of thread required depending on the size of the fabric to be manufactured (see Figure 33 and Figure 34). Both documentaries feature commentary, which has been transcribed from German and translated to English.

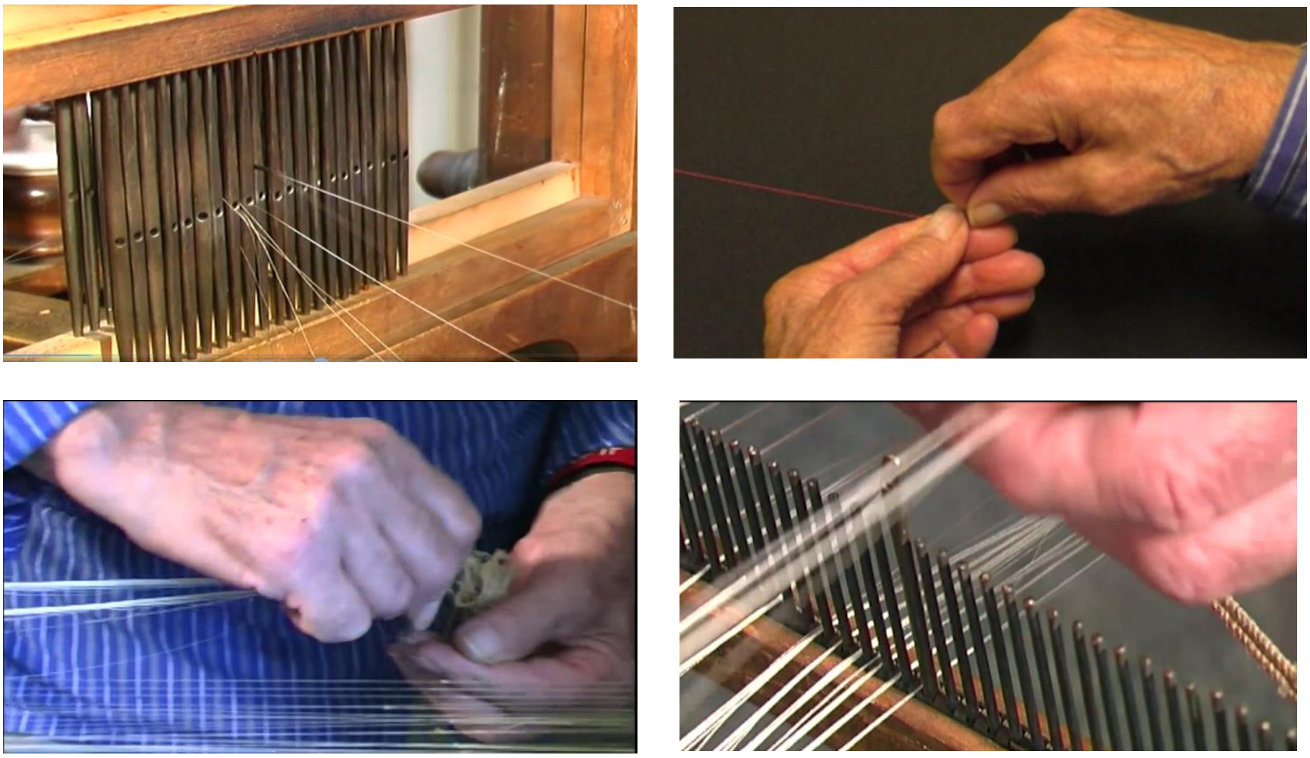
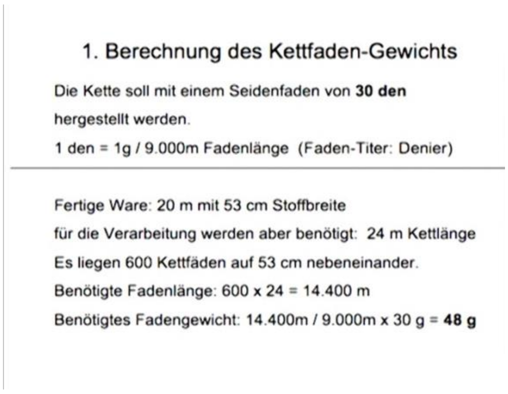


Figure 33. Silk loom preparation (video stills from [158]).



1. Berechnung des Kettfaden-Gewichts

Die Kette soll mit einem Seidenfaden von **30 den** hergestellt werden.

1 den = 1g / 9.000m Fadenlänge (Faden-Titer: Denier)

Fertige Ware: 20 m mit 53 cm Stoffbreite

für die Verarbeitung werden aber benötigt: 24 m Kettlänge

Es liegen 600 Kettfäden auf 53 cm nebeneinander.

Benötigte Fadenlänge: 600 x 24 = 14.400 m

Benötigtes Fadengewicht: 14.400m / 9.000m x 30 g = **48 g**

How much thread has to be wound on to each bobbin?

14,400/8 Bobbins = 1,800 m or 6g

Calculation of the weight of the warp thread

- 1 den = 1g/9,000m yarn length (thread : denier)
- Finished fabric: 20 m, 53 cm in width

For the processing, it is necessary to have: 24m warp length 600 warp threads lay next to each other over a width of 53 cm. Required yarn length: 600 x 24 = 14,400 m. Required yarn weight: 14,400/9,000m x 30g = 48g.

Length of yarn on bobbin. 14,400 m yarn length to be divided between 8 bobbins. With a total yarn weight of 48g for 14,400m at least 6g silk yarn has to be reeled on to each bobbin

Figure 34. Still from HdS documentary, on the estimation of required yarn quantities (video stills from [158]).

4.3.2.3 Silk yarn manufacturing

The general process of silk yarn manufacturing is the following.

Table 3. Silk yarn manufacturing [Beisswenger, 2019].

Reeled Silk (Silk throwing of winding)	Reeled, or filament silk, is the highest quality yarn and is very white and shiny. Reeled silk is a continuous fibre. Only high-quality cocoons, those with a perfect shape, can be used for reeling. Cocoons are soaked in warm water to soften the gummy sericin.
Spun Silk	The weaker filament of the silken envelope remaining from reeling, and the damaged, discoloured, or imperfectly shaped cocoons, become the raw material for lustrous, creamy coloured spun silk yarn. This cocoon “waste” must first have the sericin removed (degummed) with soap and water. Next, the fibre is cut into uniform lengths and carded to remove short tangled bits as well as the brown pupa inside the cocoons. Combing lays all the fibres parallel in a sliver, which is spun into a shimmering yarn. Spun silk is the most familiar yarn made available to hand workers.
Noil or Bourette Yarn	Short fibres containing crushed pupa left behind after making higher quality spun silk are made into noil yarn. The shortness of fibre length results in a lack of lustre and body. This is lower quality spun yarn using the same metric count system as the above-spun silk. Noil has the strongest silk odour due to impurities in the yarn. The majority of the smell dissipates after washing but can return when wet.

Doubling and twisting. The silk is too fine to be woven, so individual filaments of 6-20 cocoons are unravelled at the same time. The individual fibres are doubled and twisted to make the warp. The softened sericin dries, hardens, and binds the strands together to render one thread the size of a human hair. The silk is wound onto spools or bobbins. This stage of silk is very white and lustrous. The majority of reeled silk is supplied to large industrial looms for making silk cloth.

Stretching. The thread is tested for consistent size. Any uneven thickness is stretched out. The resulting thread is reeled into containing 500 yd to 2500 yd. The skeins are about 50 inches in loop length.

Dyeing. The skeins are scoured with a sulphur process to remove discoloration. The skeins are now tinted or dyed. They are dried and rewound onto bobbins, spools, and skeins.

A historical review of pigments and yarn dyeing is provided in Annex 2.1. In Figure 35, its main points are highlighted. In Figure 36, plants and flowers used for silk yarn dyeing by Krefeld workshops, still cultivated in HdS, are shown.

Figure 35. Origins of natural pigments and modern companies of synthetic pigments [Zabulis, 2019, flower and tree images from Wikipedia].

Figure 36. The garden of HdS [Qammaz, 2019].

4.3.2.3 Silk weaving

Silk weaving has been practiced in both hand and Jacquard looms. Different techniques of hand-weaving are met in different cultures [77] . The Mingei silk pilot focuses on the silk weaving workshops at the city of Krefeld, Germany, for the production of ecclesiastical textiles and paraments, which were typicallyweaved in Jacquard looms. A sample of such textile is shown in Figure 37.

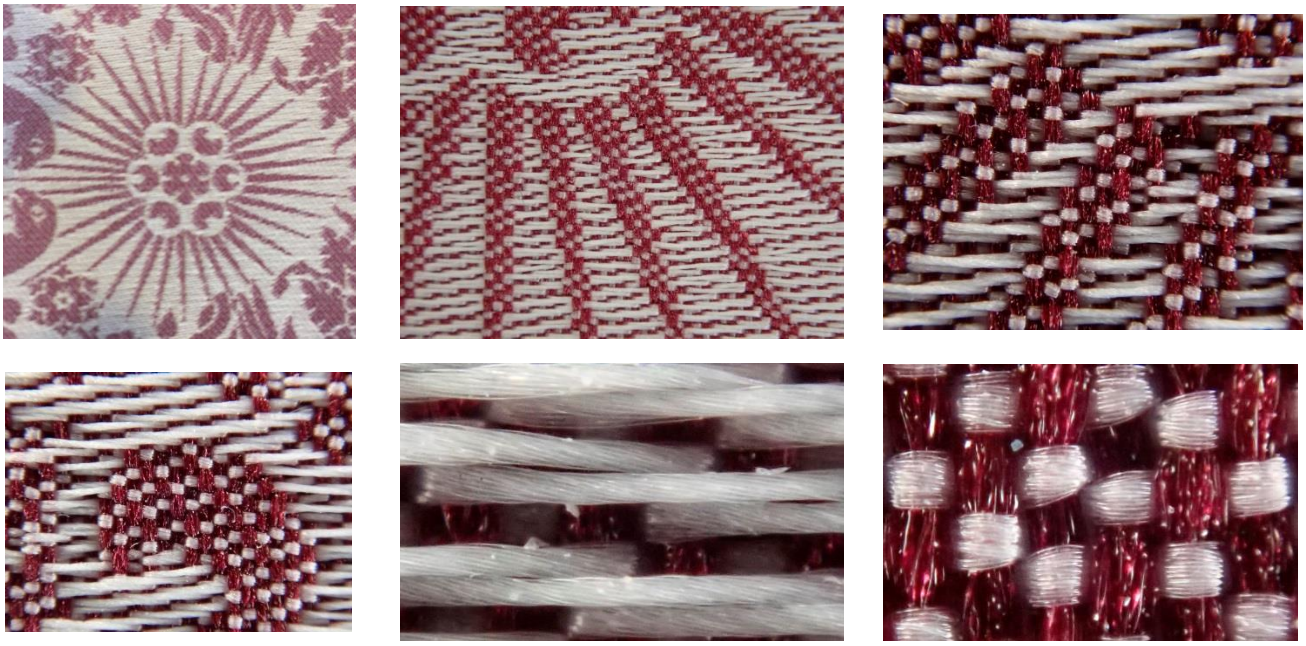


Figure 37. An HdS weft shown at increasing magnification [Stivaktakis and Partarakis, 2019].

4.3.2.4 Silk finishing

Silk possesses excellent properties and requires little finish [78] . Classical but limited finishes have been applied on silk for a long time. Mechanical finishes (e.g., calendering, decatizing, breaking, tamponing, etc.) and chemical finishes (e.g., weighting, crease-recovery, water, oil and fire retardancy, antimicrobial, anti-static finishes) that can be used on silk are overviewed in [79] .

4.3.3 Ecclesiastical textile, garment, and parament manufacturing in Krefeld

4.3.3.1 Silk yarn production

The cultivation and production of silk yarn by Krefeld workshop is provided in D1.3, Annex 8, Section 2.

4.3.3.2 Colour codes and uses

Colours played a role in the use of ecclesiastical textiles in the Catholic and Protestant churches, depending on the time of year. In Annex 9.3, the colours for the Church year are provided.

4.3.3.3 Textile production

In D1.3, Section 7.3.3.2 the description of the craft steps and corresponding workshop roles for Krefeld workshops is provided. Digitisation of these roles, has been recorded on M4 at the Krefeld plenary meeting and are included in the Mingei dataset. In Table 4, the titles of these roles are repeated for reference.

Table 4. Roles and processes in Krefeld silk textile workshops [Beiswenger, 2019].

Step	English	German
1	Pattern Designer	Musterzeichner
2	Point Paper Designer	Patroneur
3	Card Puncher	Kartenschläger
4	Preparing the warp	Kettherstellung, Schärer
5	Fitter	Vorrichter
6	Weaver	Weber

The amount of material produced is depending on the thickness and fragility of the weft and warp threads. Historically, materials used in Krefeld were often silk and goldthread, which are thin and fragile respectively. Additional to being expensive materials, the time to weave a piece of fabric with these materials makes the final product even more expensive.

4.3.3.4 Ecclesiastical textile, garment, and parament production

Knowledge is collected on the production of patterned textiles for ecclesiastical garments, textiles, and paraments, at the region of Krefeld and the Western Rhine, from the late 1700s until today. This knowledge is organised as follows:

- Annotated segments from the literature: D1.3, Annex 6.
- Historic information on the Gotzes Company and the Krefeld Industry is provided. The collection of knowledge, regards clients of garments, exports to notable clients in the Catholic Church, exports to the USA, and additional information on the practice and business of the Gotzes

Company, including technical innovations for the sale of garments by journeymen. Available in D1.3, Annex 8, Sections 8.6, 8.7, and 8.8.

- Section 8.6 regards the vocational, craft training at Krefeld and its relation to religion.
- In Section 8.7, the function of silk workshops, market, working conditions, as well as Krefeld and its people are narrated through the century-lifespan of the Gotzes Company and its continuation today. Historic information on clients of garments, exports to notable clients in the Catholic Church, exports to the USA, and additional information on the practice and business of the Gotzes Company, including technical innovations for the sale of garments by journeymen.
- In Section 8.8, in-depth description of the ecclesiastical parament & garment products and market is provided through the history of the Gotzes Company.

4.3.4 Dictionary of the silk pilot

An illustrated dictionary of terms is provided. The glossary is focused on the topics of interest in the Mingei silk pilot, rather than being an encyclopedia of textile production terms. As a next step, we will link these definitions with a formal vocabulary of weaving to treat synonyms and translations. The current version of this dictionary is provided in Annex 8.1.

4.3.5 Geographical and location-based information

The collected and digitised data on the socio-historical context of the silk pilot are provided in Annex 9.1.

4.3.6 Inventions relevant to textile manufacturing

The digitised information is provided in Annex 9.4.

4.5 Relevant narratives

4.5.1 The computer science story

The influence of barrel organs on the inspiration of the Jacquard attachment is provided in D1.3, Section 7.2.1.

Jacquard's invention transformed patterned cloth production, but it also represented a revolution in computing and, in particular, the storage of data. Until then, computing state-of-the-art was Blese Pascal's "Pascaline" invention, a mechanical calculator invented in the early 17th century. The machine performed addition, subtraction, multiplication, and division. The invention did not have storage (memory) and operated in the base-10 system rather than the binary (which is preferred as it simplifies computing hardware).

The story of Jacquard's invention of the punched card for the computer storage of data is provided in D1.3, Section 7.2.8. This information is enhanced and better organized below.

1820s: The spread of Jacquard's reaches Manchester.

Ada Lovelace (1815-1852), born Augusta Ada Byron, the only legitimate child of Annabella Milbanke and the poet Lord Byron. Her mother, Lady Byron, had mathematical training (Byron called her his 'Princess of Parallelograms') and insisted that Ada, who was tutored privately, study mathematics too - an unusual education for a woman.

In 1843, she published a translation from the French of an article on the Analytical Engine by an Italian engineer, Luigi Menabrea, to which Ada added extensive notes of her own. The Notes included the first published description of a stepwise sequence of operations for solving certain mathematical problems. The collaboration with Babbage was close and biographers debate the extent and originality of Ada's contribution.

From another perspective, when British mathematician Charles Babbage released his plans for the Analytical Engine, widely considered the first modern computer design, fellow mathematician Ada Lovelace famously observed: "*The Analytical Engine weaves algebraic patterns, just as the Jacquard loom weaves flowers and leaves*", Ada Lovelace, mathematician (1843). With his Analytical Engine, Babbage envisaged a machine that could receive instructions from punch cards to carry out mathematical calculations. Ada Lovelace took Babbage's idea a step further, proposing that the numbers the engine manipulated could represent not just quantities, but any data. She saw the potential for computers to be used beyond mathematical calculation and proposed the idea of what we now know as computer programming.

The Analytical Engine was never completed, however, Hollerith continued from where Lovelace and Babbage stopped.

Herman Hollerith (1860 –1929) developed an electromechanical punched card tabulator to assist in summarizing information and, later, accounting. He was the founder of the Tabulating Machine Company that, in 1924, joined with other companies, including the Computing-Tabulating-Recording Company, into a new company named IBM.

Hollerith developed a mechanism using electrical connections to increment a counter, recording information. A key idea was that a datum could be recorded by the presence or absence of a hole at a specific location on a card. He patented his idea in 1889, Patent No. 395,782 of Jan. 8, 1889.

Hollerith produced new models of his invention. He also invented the first automatic card-feed mechanism, and the first key punch. In Figure 38, shown is Hollerith's Type 001 manual (non-electric) numeric key punch. The first key punch (i.e. card punch operated from a keyboard), allowed a skilled operator to punch must faster than on previous models [80] .

Moreover, Hollerith took what was perhaps the first step towards programming by introducing a wiring panel in his 1906 Type I Tabulator, allowing it to do different jobs without having to be rebuilt.

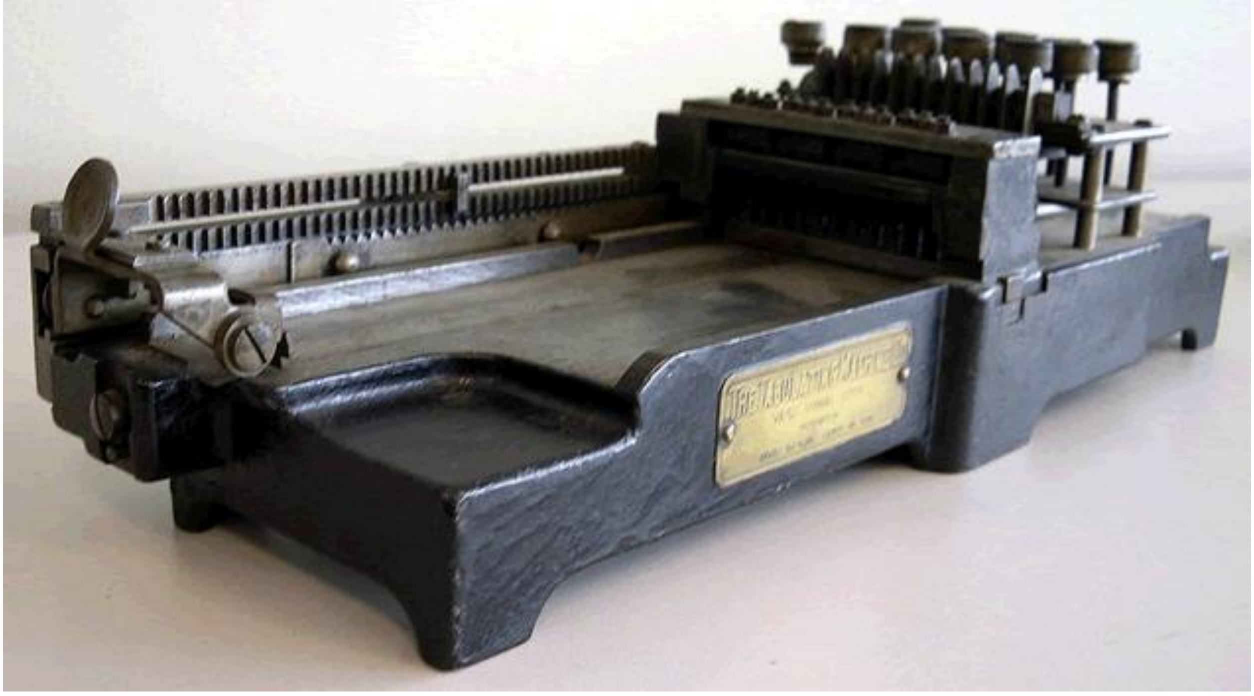


Figure 38. Hollerith's Type 001 numeric key punch (image from [155]).

4.5.2 Weaving myth

In Greek mythology, Arachne (or “spider” in English) was a talented mortal weaver who challenged Athena (Minerva in Roman mythology), goddess of wisdom and crafts, to a weaving contest. This hubris resulted in her being transformed into a spider. There are many versions of the story's weaving contest, with each saying that one or the other won. The myth inspired several works of art. In Figure 39, two of them are shown. Left: Right Minerva and Arachne (1706) by René-Antoine Houasse. Right: The Spinners, or, the Fable of Arachne (1644–48) by Velázquez.

Figure 39. Depictions of the myth of Arachne [images from [104] and [105]].

4.5.3 Chinese silk legend

In 2640 BC, while Xi Ling Shi (also known as Xilingshi, Lei-Tsu or Leizu), wife of Emperor Huangdi (a.k.a. the Yellow Emperor), was sitting in her garden underneath a mulberry tree drinking tea. A silkworm cocoon fell into her cup. As she watched it dissolve, she saw that the cocoon was made out of one long, translucent thread. The heat unwrapped the silk until it stretched across her entire garden. When the silk ran out, she saw a small cocoon and realized that this cocoon was the source of the silk.

Another version says that she found silkworms eating the mulberry leaves and spinning cocoons. She collected some cocoons and then sat down to have some tea. While she was sipping a cup, she dropped a cocoon into the steaming water. A fine thread started to separate itself from the milkworm cocoon. Leizu found that she could unwind this soft and lovely thread around her finger.

She persuaded the Yellow Emperor to give her a grove of mulberry trees where she could domesticate the worms that made these cocoons. She is attributed with inventing the silk reel, which joins fine filaments into a thread strong enough for weaving. She is also credited with inventing the first silk loom.

5. Mastic

In this section, the results of the application of the Mingei collection of knowledge to the Mastic pilot are presented, up to M10 of the project.

The collaborating institution is Piraeus Bank Group Cultural Foundation (PIOP) in Athens, Greece.

Mastiha, or mastic, is a product from the mastic tree, which exclusively grows in the southwest of Chios Island in Greece. This HC is therefore highly localised (indigenous craft) and part of the fabric of local life. The 24 villages from where mastiha is harvested are known as Mastihochoria, or Mastic Villages, their name is an indication of the importance of mastiha for the region. It is an outdoor craft, which relies on the cottage industry while it is also centralised and organised through the Chios Mastic Growers Association.

The production of mastiha, an ancestral practice, unaltered over time, is a family occupation that requires laborious care throughout the year, and in which men and women of all ages participate on equal terms. Tasks are divided across genders and ages. The culture of mastiha represents a comprehensive social event, around which networks of alliances and mutual help have been established in society. Traditions and legends survive in the vernacular language, some of religious nature. The knowledge for growing mastiha follows certain rules and traditional characteristics, which ensure its authenticity, while also promoting improvisation and individuality. The craft and local life still witness age-old traditions related to the production of mastiha, even if the cultivation and application of mastiha are constantly subject to innovation.

PIOP achieves through its network of Thematic Museums to (1) record and promotes Greece's cultural heritage and identity, (2) preserve the traditional, artisanal, and industrial technology of Greece, and (3) link culture with the environment and sustainable development. The Chios Mastic Museum is built south of Chios Island, near the mastic village of Pyrgi. The museum has managed to establish a strong link with the local communities and is committed to ongoing research and presentation of this highly localised craft.

5.1 Existing content

The existing content was mainly retrieved by the vast archive that PIOP holds on mastic, its cultivation, production processes of mastic products, and historical, social material. Part of the PIOP archive is archival material and machines that were acquired by the Chios Mastic Growers Association. The archival material that will be used for the Mingei collection of knowledge will be mentioned with their initial file name, as they exist in the PIOP archive. The file names of the archival materials uploaded to the Mingei portal are subject to change.

5.1.1 Literature

Literature regarding the mastic tree, mastic production, and historical, social facts can be found in essays developed by academics for PIOP for the Chios Mastic Museum. Furthermore, there is additional bibliography available in Korais Central Public Library of Chios. Curated material of the Chios Mastic Museum is also available in English.

Literature that is gathered is available in Word and PDF formal while Excel files exist indicating tax records of the years 1566 and 1720. In addition, an Excel file contains information on the press appearance of articles related to mastic from 1873 to 1978. The files are in Greek and English language. For indicative segments of the texts, see Annex 2, Section A2.2. All available files can be found in DS.Mingei\PIOP\Literature\

5.1.2 Audio-Visual material

5.1.2.1 Photographic material

Photographic material include JPG and TIFF files. The files include (1) photographs, advertisements and the emblem of the Chios Mastic Growers Association, (2) photographs of mastic shops and merchants, (3) geographical and geological maps and diagrams, (3) photographs of women at work, (4) historical depictions of Chios, emblems of Genoan and Zaccaria rule, as well as photographs of a Genoan galley from the Genoa Maritime Museum, (5) photographs and diagrams of houses from the Mastichochoria, (6) photographs and sketches of the mastic tree, (7) pharmacological announcements related to the mastic, (8) portraits, (9) photographs and sketches of the Mastichochoria, (10) photographs depicting the mastic processing (i.e. plowing, embroidering, collecting, sifting and cleaning, cleaning with water, and pinching), (11) product packages and advertisements, (12) photographs of machines, objects and tools, (13) religious-related depictions, (14) photographs and diagrams of the settlements, and (15) photographs related to customs and traditions.

Press clippings regarding mastic production and its societal and economic effects on the communities of Chios have been scanned and organised chronologically. Meanwhile, there are also available printed materials from the Chios Mastic Growers Association that depict older health insurance and presence lists of the Association. Selected files can be found in Annex 3.2. All files can be found in DS.Mingei\Mastic\ExistingContent\Images.

5.1.2.2 Video material

In total there are eleven (11) video files concerning mastic, of which: (a) four are documentaries produced by television channels and cinematographers, (b) five are documentation videos of history researchers and ethnographers that cooperated with PIOP for the production and collection of material for the Chios Mastic Museum. The videos include interviews with mastic producers, men, and women that used to work at the Chios Mastic Growers Association. Other videos include documentation of educational activities related to the mastic, and (c) two advertisement clips of the ELMA chewing gum. The video files are to be found in DS.Mingei\Mastic\ExistingContent\AudioVideo.

5.1.2.3 Audio material

In total there are twenty (20) audio files, of which: (a) six are of an interview with a former employer at the Chios Mastic Growers Association and topics include chewing gum production, distillation, and description of the factory and the machines, (b) four are radio advertisement of the ELMA chewing gum, (c) one is of a woman singing a traditional song regarding mastic cultivation, and (d) nine recordings from the traditional feast of ‘Agha’.

The audio files are available at DS.Mingei\Mastic\ExistingContent\AudioVideo

5.2 New content

New content to be acquired aims to enrich the collection of knowledge regarding mostly audiovisual material and digitisations. The new materials are to be collected during the project meeting at Chios in September 2019. The sections below indicate in detail the content that will be acquired in the next steps of Mingei for the mastic pilot.

5.2.1 Audiovisual content

Audio visual material include recorded interviews with mastic producers as well as photographic material from planned visits to the Chios Gum Mastic Growers Association, Mediterra and several meetings at the Chios Mastic Museum, including experiential activities conducted by Masticulture. Mediterra is part of the Chios Gum Mastic Growers Association and is the company that manages the marketing and sale of mastic products. Masticulture is an ecotourism organisation that offers authentic experiences of Chios. Photographs and 3D scanning were conducted in an old traditional house of a family of mastic producers in Pyrgi.

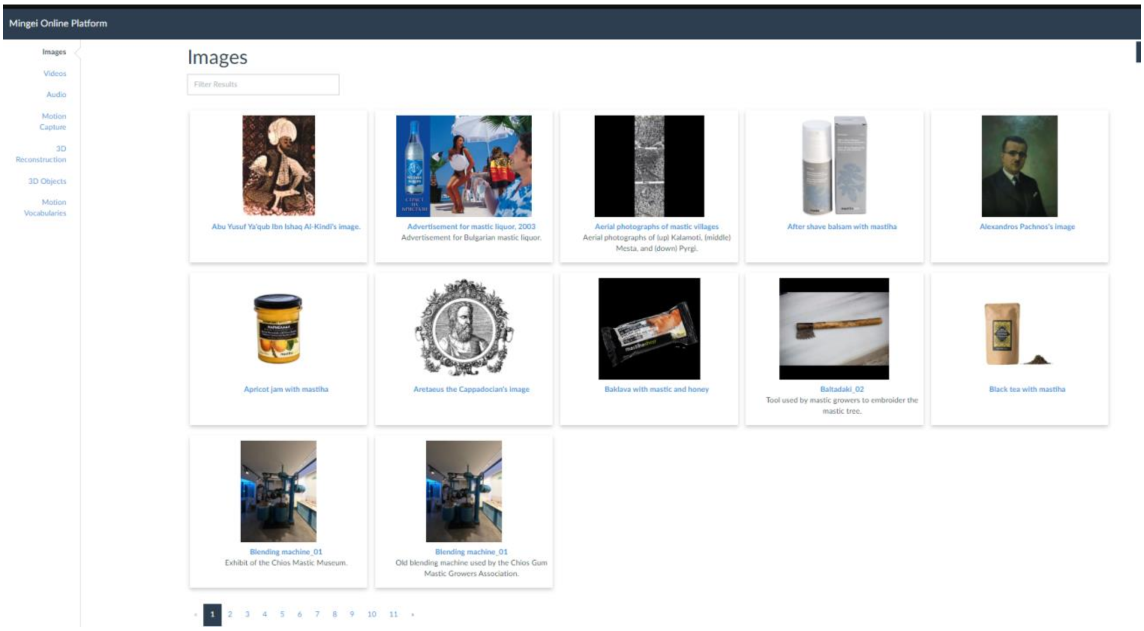


Figure 40. Collected visual material on the Mingei Online Platform (images from[170]).

Furthermore, videos were recorded tracking several routes in the villages of Mesta, Olimpi, and Pyrgi. This content is available on the MOP (see Figure 40) and at the paths below

- DS.Mingei\Mastic\RGBVideo\
- DS.Mingei\Mastic\Images

5.2.2 Digitisation of objects and environments

Videos, photographs and 3D scanning of museum items, such as conventional tools and industrial machines, were acquired. In addition, traditional garments relevant to mastic cultivation and indoor working scenes were digitised, to capture the setting and context of the workspace. Furthermore, photographs and 3D scanning were conducted in an old traditional house of a family of mastic producers in Pyrgi.

As the mastic cultivation craft is in direct relationship to the environment, we captured a range of outdoor scenes. A mastic tree was recorded and 3D scanned during the day in order to capture and reconstruct it while photographs were taken also at night hoping to capture sparkles of the mastic resin on the bark and the soil.

Moreover, as the cultivation of mastic as a collective occupation of the residents of Chios, it had an influence on the architecture of the island. As such, architectural elements and city architecture were also captured in 3D.

Figure illustrates some of the 25-modelled tools, on the MOP. These models are the result of post-processing of the initial reconstructions. This is required to isolate the tool from the reconstruction, merge multiple scans of the same tool, enhance textures, etc. The software tool for this purpose is reported in D1.3. The images are hyperlinked to the YouTube channel of the Mingei project. Demonstrations of the original reconstruction are shown in the figure below (Figure 41). The files are available at https://zenodo.org/record/3813287#.XtkY41UzbmE

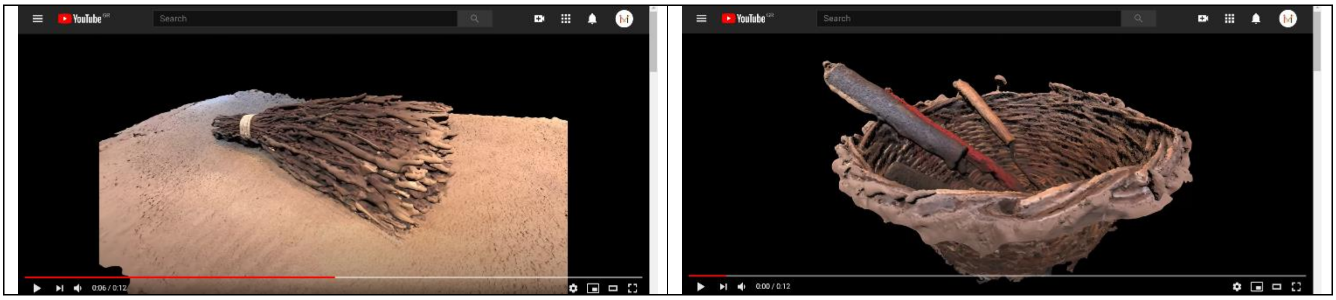


Figure 41. 3D reconstructions [Evdemon, Zabulis, 2019].

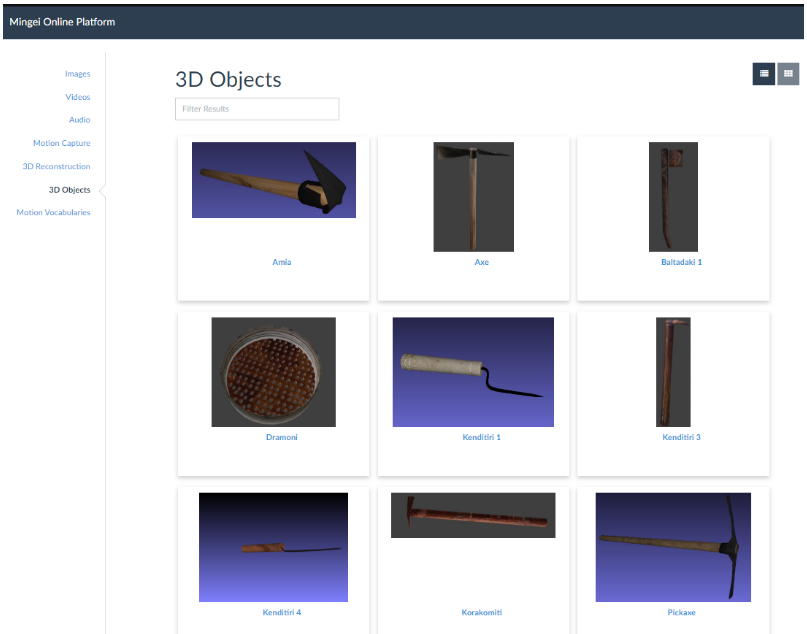


Figure 42. Collected 3D reconstructions and modelling of mastic cultivation tools on the Mingei Online Platform (images from [170]).

Photograph and reconstruction of a mastic-processing machine are shown shown in Figure 43.

Figure 43. Photograph and 3D reconstruction of mastic processing machine [Zabulis, 2019].

Online videos of this reconstruction and other mastic processing machines can be found on the YouTube channel of Mingei, at the following links.

- https://youtu.be/e013XgVWLuA
- https://youtu.be/_DMa53UFvGE
- https://youtu.be/_601rZkRlMU
- https://youtu.be/V40FOJF-9Ks
- https://youtu.be/SmCRWrlgrxI
- https://youtu.be/uqGFGO0m5l8
- https://youtu.be/EOE_4R5weM4
- https://youtu.be/7A5EmdgUXhk

- https://youtu.be/_7RTCDwniQw

The reconstruction of a clothed static person is depicted in Figure 45 and Figure 46. Photographs of the scene are provided in Figure 44.

Figure 44. Photographs of a clothed static mannequin [Evdemon, Zabulis, 2019].

Figure 45. 3D reconstruction of clothed mannequin [Evdemon, Zabulis, 2019].

Figure 46. Detail of 3D mannequin reconstruction [Evdemon, Zabulis, 2019].

In this example, we use photogrammetry to reconstruct details on the **clothing and hands** of a person (see Figure 48). Photographs of the mannequin are shown in Figure 47.

Figure 47. Photographs of mannequin [Evdemon, 2019].

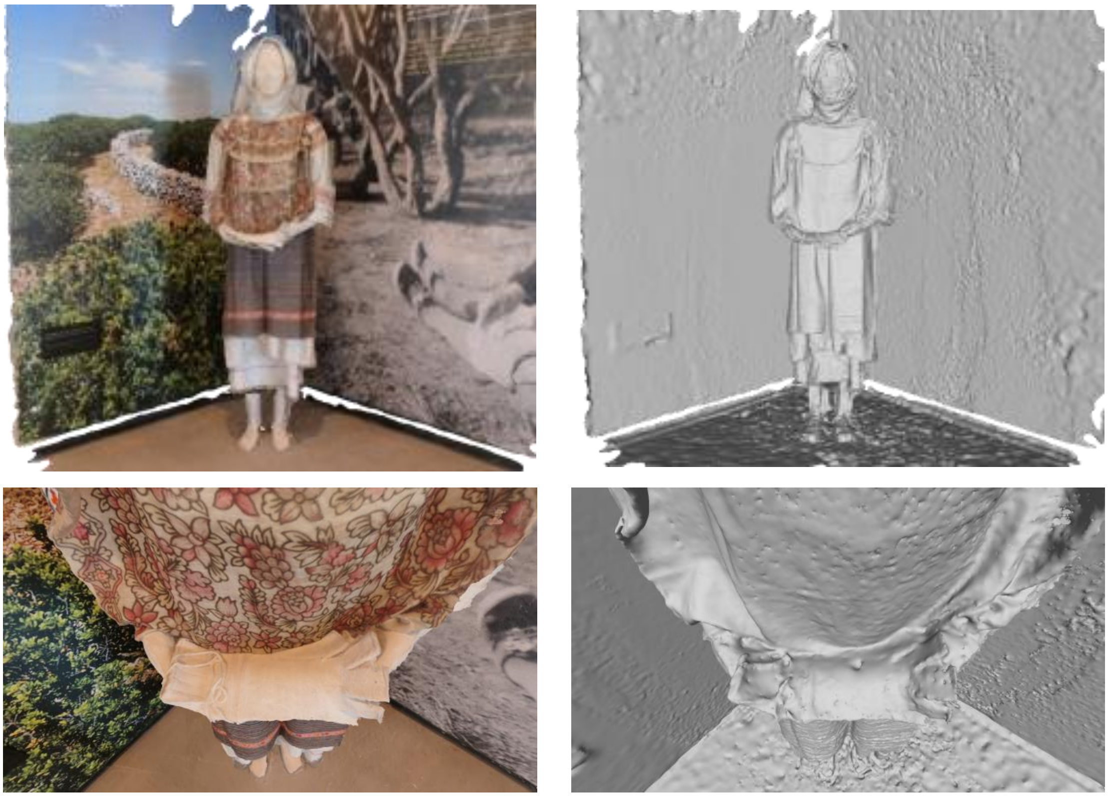


Figure 48. 3D reconstruction of clothed mannequin [Evdemon, Zabulis, 2019].

Online videos of the reconstruction, as well as those of other traditional garments relevant to mastic cultivation, can be found on the YouTube channel of Mingei (see Figure 49)

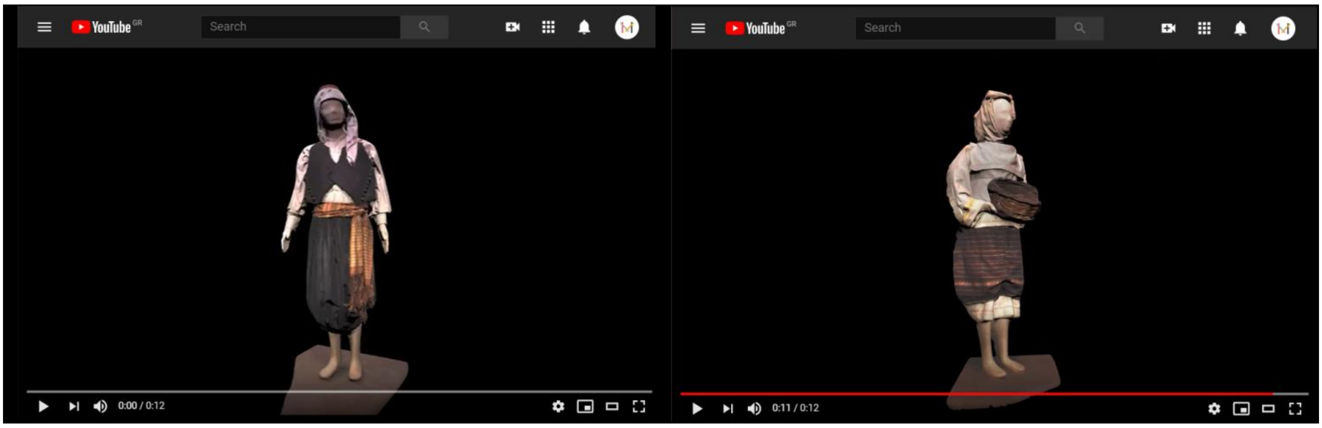


Figure 49 Videos showing reconstructions of traditional garments, in the Mingei YouTube channel [Evdemon, Zabulis, 2019]..

In this example, we test for agricultural and rural environments and have two trees as subjects such as the one shown in Figure 50. We chose a complicated tree structure to assess the reconstruction of structural details on its truck and around its base. The structure on the trunk and near the ground plane was sufficiently reconstructed. Nevertheless, tree leaves create too many occlusions and is too small for the spatial range of the scanner. Online videos of the reconstructions can be found on the YouTube channel of Mingei.

Figure 50. Photograph of a tree [Evdemon, 2019].

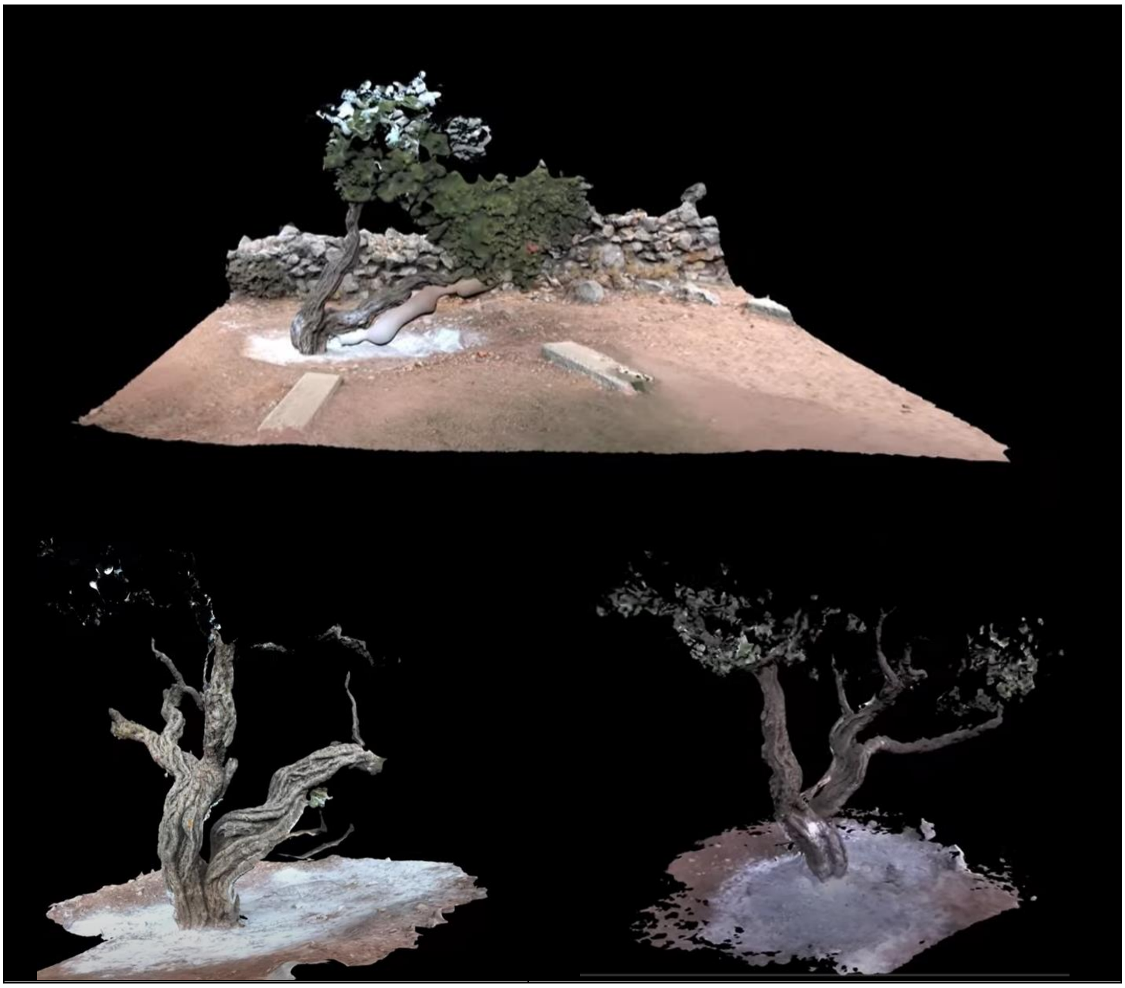


Figure 51. Videos showing reconstructions of mastic trees, in the Mingei YouTube channel [Evdemon, Zabulis, 2019]..

We provide reconstruction of a **small indoors scene** of mastic processing, with pieces of furniture and a mannequin (Figure 52). Online video of the reconstruction can be found on the YouTube channel of Mingei, at the following link: https://youtu.be/-h8Cmt9mEm0

Figure 52. Small indoor scene [Evdemon, Zabulis, 2019].

In the example below (see Figure 53)., we demonstrate the reconstruction of the exterior of a wall made from stone. The structure exhibits structural variability due to the rugged surface of stones and exhibits the potential of capturing rugged structures. This is important for two reasons. First, to confirm that we can realistically digitise the architecture of the buildings and workshops relevant to the pilot. Second, to indicate the potential of the digitisation approach to capture the products of other cards, in this case, dry-stone walling. Online video of the reconstruction can be found on the YouTube channel of Mingei, at the following link: https://youtu.be/9eAvIL6Uf44

Figure 53. Overview photograph of stone wall and 3D reconstruction [Evdemon, Zabulis, 2019].

In the example below, we test for an environment that combines a building structure and a rural environment. The example presents the Chios Mastic Museum of PIOP and its neighbouring mastic field. The reconstruction of the museum is essential in the pilot. The purpose is to model and demonstrate the layout of cultivated trees and their arrangement on the slope of the hill, which is their natural environment. In addition, we use this experiment to demonstrate the combination of **aerial and terrestrial** imaging, using a handheld camera. In Figure 54, we provide an overview of the reconstructed area. RGB views rendering of the reconstruction are shown in Figure 55 and depth views of the reconstruction are in Figure 56.

Figure 54. Aerial photograph [Evdemon, 2019].

Figure 55. Rural building and dirt roads (RGB views) [Evdemon, Zabulis, 2019].

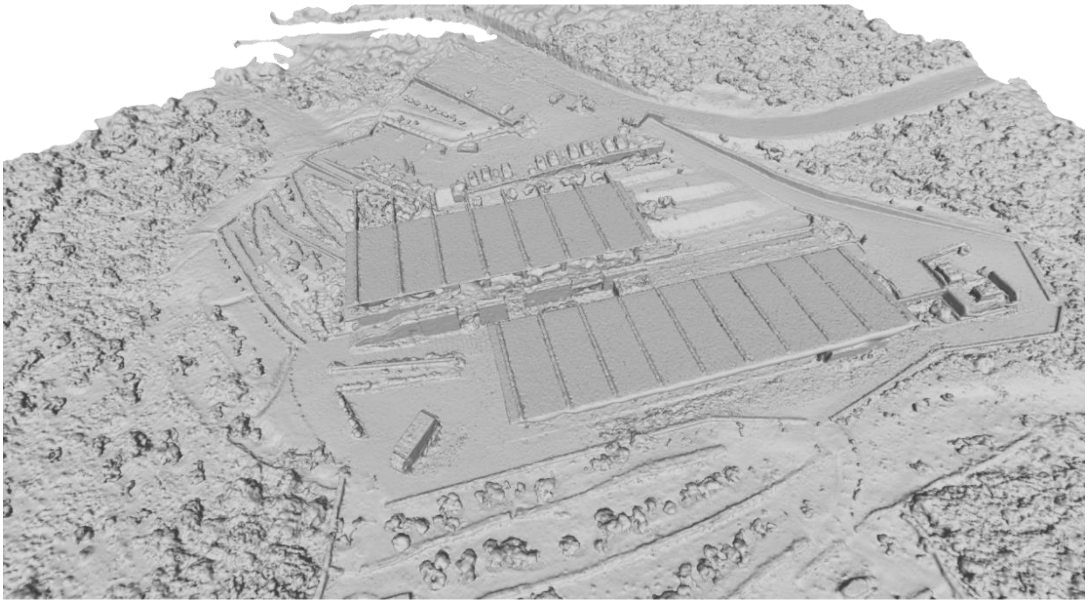


Figure 56. Rural space and building (depth views) [Evdemon, Zabulis, 2019].

In the context of the same example, we focus on a situation where the aerial scan poorly reconstructs the space below an eave (Figure 57), due to visibility constraints. To improve the reconstruction, we added images acquired from a terrestrial view, under the eave, where the UAV may not fly. In Figure 58, the improvement in the reconstruction of that area is shown; the left column shows the reconstruction of the aerial view, and the right column the combined reconstruction.

Figure 57. Photograph of area below building eave [Evdemon, Zabulis, 2019].

Figure 58. Combination of aerial and terrestrial views [Evdemon, Zabulis, 2019].

The 3D model is available on the MOP and can be displayed online through 3D view that we have developed for this case. In addition, we produce also a video of the reconstruction, which features alternative-rendering approach (i.e. depth views, or views that show the mesh triangescan). The alternative rendering provides better than RGB understanding of structure as well as indicates the structural complexity of the digitisation (see also D1.3 for justification of ways to present 3D content). We demonstrate such examples in other recostrcutions below.This video production can be found on the YouTube channel of Mingei. The image below is hyperlinked to the online video.

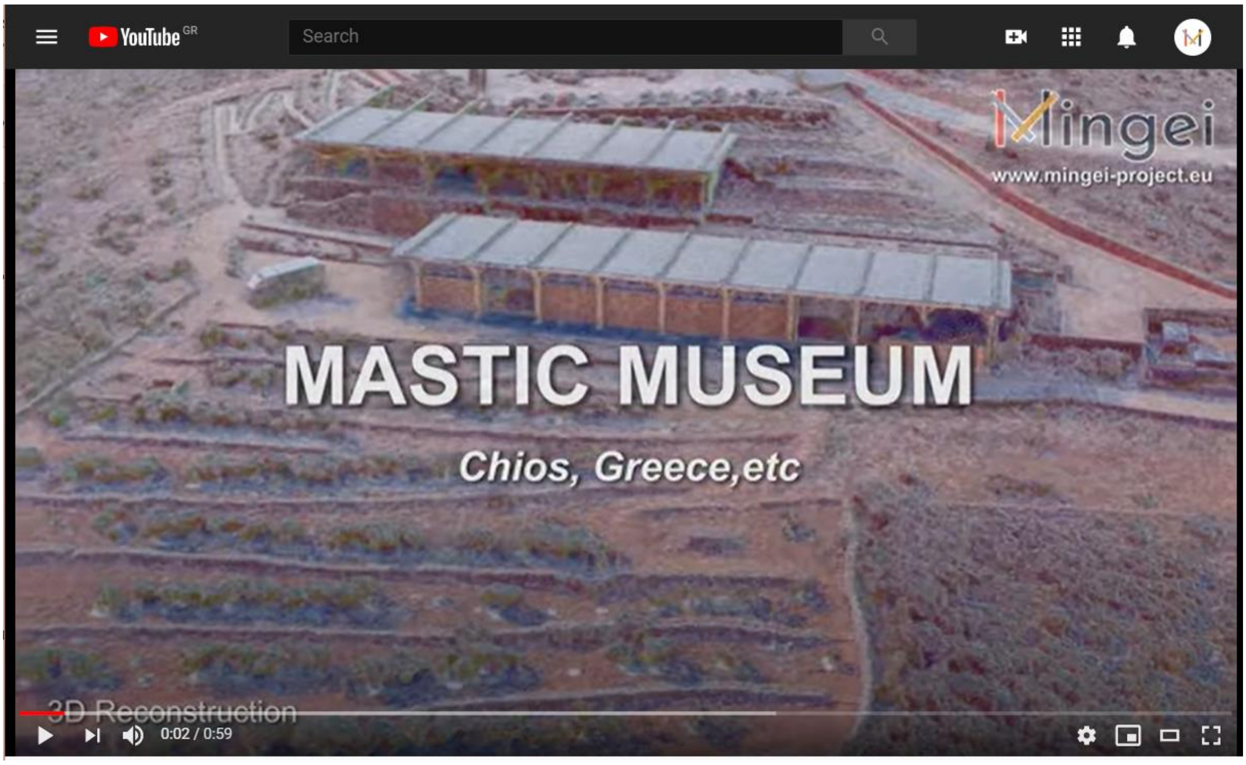


Figure 59. Video showing the 3D reconstruction of the Chios Mastic Museum of PIOP [Evdemon, Zabulis, 2019].

In the figures below (Figure 60, Figure 61, and Figure 62), the architectural environment of mastic production villages is shown through **aerial 3D reconstruction**; their characteristic structure reveals fortification against pirates and storage buildings for mastic at the centre of the village that was guarded. In this dataset, **aerial** images were acquired via a UAV overlooking a village. The subject is a large building complex. The building structure is challenging, due to the complex, rural city planning and fortification. The configuration of buildings is far from a simple "Manhattan" tessellation. We observe that building structures are reconstructed with fidelity and the narrow alleys, streets, and village squares are clearly outlined (see Figure 62). For reference, the corresponding portion of the same segment of OpenStreetMap.org is shown. The centre of the location is approximately at 38.2470313, 25.9422563 and the North direction is upwards.

Figure 60. Aerial photograph of a village [Evdemon, 2019].

Figure 61. 3D reconstruction of village (top view) and map [Evdemon, Zabulis, 2019].

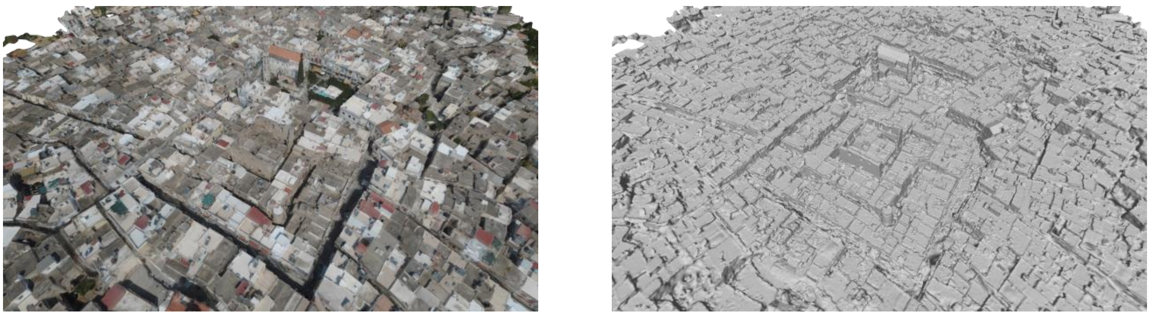


Figure 62. Village reconstruction [Evdemon, Zabulis, 2019].

Online videos of the reconstruction as well as additional village reconstructions can be found on the YouTube channel of Mingei (see Figure 63).

Figure 63. Videos showing the 3D reconstruction of four mastic villages [Evdemon, Zabulis, 2019].

All items are available on the MOP (see Figure 63) and in the directory DS.Mingei\Mastic\3DReconstruction.

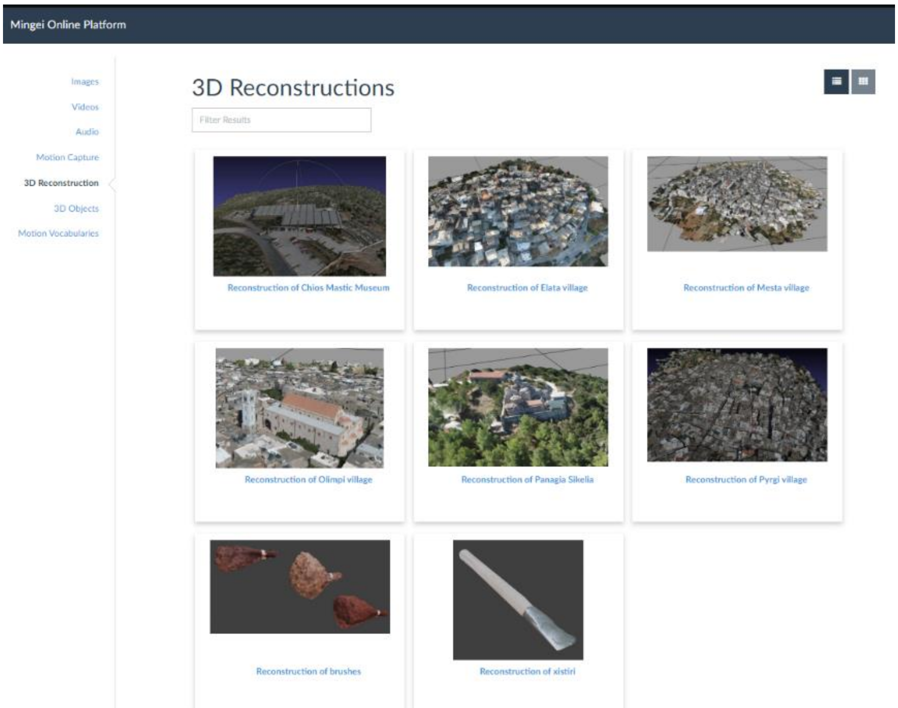


Figure 64. Screenshot from the Mingei Online Platform (image from [170]).

5.3.3 Digitisation of human motion

Motion capture was conducted with two mastic cultivators in the premises of the Chios Mastic Museum. The cultivators performed agricultural procedures in a mastic field. Those were to (a) clean the soil under the mastic tree, (b) spread the white clay, (c) make incisions on the tree, (d) gather mastic gum, and (e) sieve the collected mastic gum. The procedures were performed separately. Their visualisation is the object of WP5 and is presented separately in the deliverables of this WP.

In Figure 65, 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 toward providing tourism and education services to foster and expand thematic tourism related to HCs.

Figure 65. Ecotourism promotional video. Hyperlink for online view.

Files are available at DS.Mingei\PIOP\Human Motion

5.3 Craft and contextual knowledge

Contextual information concerning mastic is organised according to the Knowledge Collection form in two overall sections. It is also indicated if audiovisual and text material for each section exists, and if more material is to be acquired, as part of new content for the Mingei collection of knowledge.

5.3.1 Description, equipment, products and places

5.3.1.1 Description of craft

Processes performed by the producers

Cultivation of new trees: The **cultivation** of new trees takes place during the winter, from the beginning of January until mid-February. The producers cut branches from a male tree of good quality and plant them in depth of 40 to 60 centimetres. It is rather easy for a plant to be successful and it does not need special care in the beginning.

Pruning, cleaning, fertilization, and irrigation: **Pruning** of a tree begins in its third year and then takes place every year during the winter, from the beginning of January until mid-February. The dry branches are removed so that the tree can become stronger and facilitate air and sun supply for the trees. The wounds from the cut branches are covered with a substance (katrami) to protectthem from microorganisms. **Fertilization** of the field takes place in January or February and the producers use ammonium sulphate when the soil is poor and potassium nitrate or calcium ammonium nitrate for red soil. An ecological fertilizer is beans (Vicia faba) which are planted in October. When they reach the time to bloom, they are plowed in order to stop their growth. Because of the bacteria staying in the nearly bloomed beans, the soil becomes rich in nitrogen, which is essential for the growth of mastic trees. Young trees do not need water. **Irrigation** starts after the first year of the tree and it takes place two, three or four times per day depending the weather conditions. The older trees are resistant to drought. It is important to note that persistent humidity can damage the trees to the point of drying and become sensitive in infections.

Cleaning the soil: At the end of June until beginning of July, producers clean, level and press the soil under the trees. Then the soil is covered with white clay so that the mastic resin that will fall will stay clean.

Kendima (embroidering): **Kendima** (as it is called in Greek; embroidering) takes place in July and August. The producers create vertical or linear incisions on the bark of the tree. The incisions are 4 to 5 centimetres deep and 10 to 15 centimetres long. The number of the incisions depends on the size of the tree. Vertical wounds heal faster. After kendima, the resin is left 10 to 20 days to dry.

Collecting: **Collection** of the dried mastic resin takes place from mid-August until mid-October. Usually, big mastic pieces of resin fall on the soil while mastic 'tears' remain and dry on the bark and the branches.

Sifting and Cleaning: **Sifting** helps to separate mastic gum from gathered dirt and leaves.

Cleaning with water: After sifting, the producers clean the gum with soap and plenty of water. Producers that live in a village near the sea prefer to go to the seaside to clean the gum. It is easier in that way to separate them because the salty water keeps the dirt and leaves on the surface of the water while the mastic gum stays at the bottom of the basin.

Tsimbima (pinching): **Tsimbima** (as it is called in Greek; pinching) is the cleaning of the mastic gum with special knives in order any last dirt attached to the gum. It is performed by women.

Classification: Producers make a first classification of the mastic gum that is collected according to the types exemplified to Annex 2, Section A2.2. After the classification, the mastic gum is sent to the Chios Mastic Growers Association.

Available assets include photographic, video and text material.

New content to be acquired include motion capture of some processes.

<u>Processes performed by the Chios Gum Mastic Growers Association</u>

General processing upon arrival of mastic: When the Association receives mastic gum from the producers further classification takes place, according to the size of the gum. In general, they separate the pittas (usually large, round pieces), chondri ('fat' pieces) and psili (thin pieces). In this way, they store the gum and gradually process it further depending on the demand. Sifting, cleaning with water, drying, weighting, tsimbima (pinching) take place.

Chewing gum production: For the production of mastic chewing gum, first the mixture is prepared which is made out of mastic, sugar, butter, cornflour, and water. The ingredients are placed in the blending machine to produce the mixture. After 15 minutes, the mixture is taken out of the blending machine and it is placed on a marble counter. Then it is formed to pieces of maximum height 3 centimetres and left to cool. After cooling, the pieces are transferred to the press and engraving machine where they are pressed and gum dragees are formed. In the end, the dragees are cut and put in the candy machine to create their coating made out of syrup.

Mastic oil production: Mastic oil is produced through distillation.

Mastic incense production: Incense is produced with a special press machine that crushes mastic gum of lower quality.

Packaging: The Chios Gum Mastic Growers Association was also responsible for packaging their products. For this reason, they also have packaging machines to wrap the products, and printing machines to create the covers of the products.

Marketing: The Chios Gum Mastic Growers Association took charge also of the marketing strategies for the promotion of the mastic products. In [62] mentioned that the choice of photographic material and design that the Association selected reflects has a cultural meaning for the Chios society.

Available assets include photographic, video, audio and text material.

<u>5.3.1.2 Equipment</u>

<u>Tools</u>

A dictionary of tools is provided in Annex 8.2.

<u>Materials</u>

Below is a list of material that get involved in the mastic production and processing:

Mastic resin	Primary product of the mastic tree
Ammonium sulphate, Bean (Vicia fabe), Calcium ammoniate nitrate, Potassium nitrate	For fertilization
Katrami	To cover and proof the cut branches of the tree after pruning
White clay	To cover the soil below the tree before kendima (embroidering)

Available assets include text material.

<u>Objects</u>

For objects related to mastic, see Annex A3.2.

Available assets include photographs and visual material. Objects that are digitized include the crate, the basket, the jar (borboulaki), the sieve, and the sini.

Work clothing

For information on work clothing, see Section 5.3.2.9. Clothing.

5.3.1.3 Products

Products of mastic include alcoholic beverages, chewing gum, mastic gum (dried mastic pieces for chewing that is the raw material without production processing), oil, and incense, as an ingredient for cooking desserts and for dietary supplements. There are also many scientific articles ([51] [52] [53] [54]) that mention the use of mastic in medical and pharmaceutical equipment such as liquid adhesive, surgical sutures, micro-capsules, toothpaste, and bandage.

Available assets include photographs and text material.

5.3.1.4 Environment

Ecology

Adamakopoulos et al. [55] conducted a research regarding the recognition of the natural environment of Chios for PIOP and the purposes of the Chios Mastic Museum. As they mention, Chios is characterized by long dry summer and mild winter. Maximum temperature is reached in July in 30C degrees while the lowest temperature is reached in January in 6 C degrees. The average rain height is 590 mm. Chios is characterized as one of the sunniest areas of Greece, while intense north winds characterize its winter.

The vegetation of the island is comprised of Mediterranean maquis vegetation, trees, and local cultivation. Due to environmental and geological similarities with neighboring Middle Eastern countries, many of the plants appearing in Chios are also present in those areas.

Mastic cultivation is unique and exclusive in the northern part of Chios. Its cultivation renders the soil fertile and for this reason, producers apply supplementary uses of the land. The field land is also used for herding animals of the village.

Nowadays traditional producing activities have been replaced with more technological and modern methods. For this reason, it is observed that more biodiversity is apparent around the villages and the cultivated areas than areas between the villages and/or fields that have been abandoned.

Available assets include visual and text material.

Geology

Adamakopoulos et al. [55] mention that Chios is an island with great geological interest because of the age of its rocks and the vast variety of fossils and tectonic structure. The current tectonic structure of the island was formulated mainly during the Alpine fold and thrust. The island is located on the eastern part of the Aegean arc where many deep rifts exist. Thus, the island has great geothermal and seismic activity.

Available assets include visual and text material.

5.3.1.5 Geography of workshops

Housing

For a description of a traditional house of the mastic villages, see Annex A2.2, where the curated material from the Chios Gum Mastic Museum exists. Available assets include photographic and text material. New content includes photographs and 3D scanning of an old traditional house in the village of Pyrgi.

Mastic field

Mastic fields are part of the landscape and natural environment of northern Chios. In an ordinary mastic field, mastic trees are planted in rows with enough distance of 4 to 5 meters but the twigs can reach each other. In mountainous areas, mastic fields can be found arranged in gradual layers. Available assets include photographs and video material.

Settlement description

Vournous [56] mentions that most of the mastic villages are organised in uneven squares while the land properties formulate long restricted areas with the smallest side facing the street. The designated street arrangement can be found in the villages of Kalamoti, Lithi, and partially in Vessa. Furthermore, there are open spaces that are used by more than one family, and thus property issues get more complicated while giving the houses an extra function and significance.

For more details regarding the inhabitation of rural areas in Chios and the creation of settlements, see Annex A2.2, where the curated material from the Chios Mastic Museum exists. Available assets include photographic and text material. New content includes visual depictions of the villages of Mesta, Olimpi, and Pyrgi.

5.3.2. Socio-historical context

See ANNEX 9.2.

6. Glass

In this section, the results of the application of the Mingei collection of knowledge to the Glass pilot are presented, up to M10 of the project.

The collaboration institution is Conservatoire National des Arts et Métiers in Paris, France.

Glassmaking brings together artistic skill with a thorough technical and sensory understanding of the material. With a set of simple tools and processes, glassblowers are able to produce an almost endless variation of objects, from the decorative and fragile to the robust and functional. Glassmaking and glassblowing exhibit a range of expressions from handicraft to industrial, while it has been globally practiced for centuries.

Founded in 1794, the Conservatoire National des Arts et Métiers (CNAM) in Paris, is Higher Education Institution, and home to the Musée des arts et métiers, a museum of technological innovation, traditional and industrial arts and crafts. CNAM is one of the oldest technical and industrial academic institutions and university museums in the world. Glass and the glassmaking exhibition of the permanently exhibited “Materials Collection” is considered one of the most important for CNAM and its visitors.

6.1 Existing content

Existing content on glassblowing is linked with the Bontemps collection of the museum and has been mainly retrieved through the Library of the CNAM, the Documentation Centre of the Musée des arts et métiers and the data base of the museum collection.

6.1.1 Literature

Literature has been gathered concerning (a) the history of Georges Bontemps who was a famous French glassmaker, (b) the history of Choisy-le-Roi glass factory in France, (c) the history of CNAM, and (d) the timeline of glassblowing and manufacturing of clear, colourless glass. Literature is in French and English.

The available literature exists in PDF mostly in French. All available files exist in the directories below:

- DS.Mingei\Glass\ExistingContent\DigitalText
- DS.Mingei\Glass\ExistingContent\OnlineContent\

6.1.2 Audiovisual material

Acquired was photographic material depicting tools and processes of glassblowing, as they are performed at CERFAV. In addition, a collection of photographs of the glass objects that are part of the CNAM collection and are exhibited at the museum has been acquired. Furthermore, historical depictions have been collected to become part of the visual assets collected for the Glass pilot.

Indicative photographic material can be found in Annex 3, Section A3.3. All files are available at DS.Mingei\Glass\ExistingContent\Images

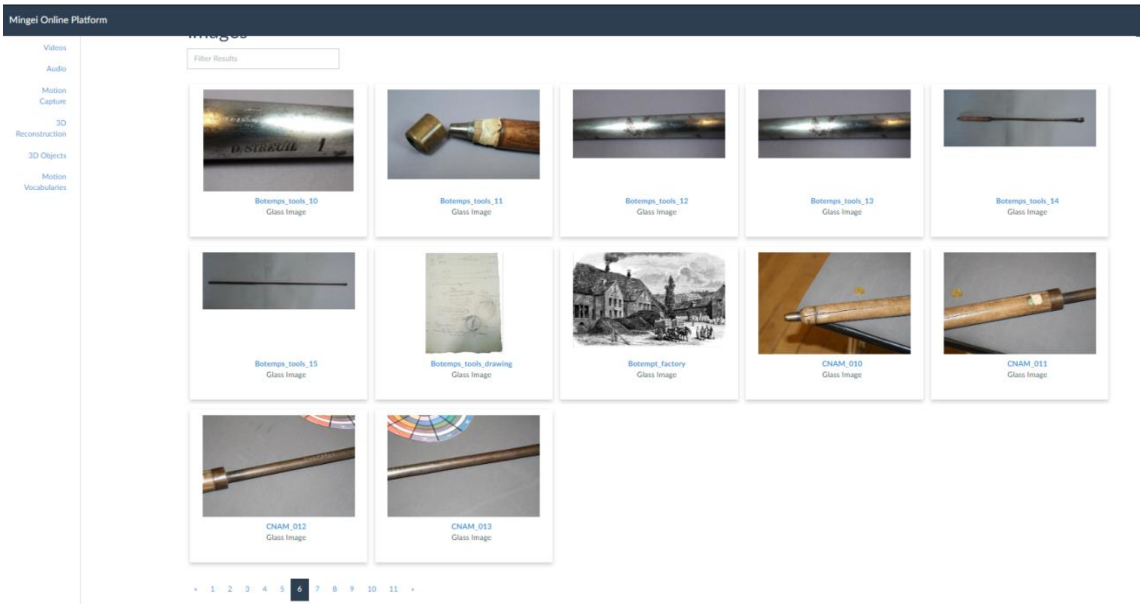


Figure 66. Screenshot of the Mingei Online Platform (images from [170]).

6.1.3 Digitised objects

CNAM has in its archive a digitized, 2D scanning of a manuscript of Georges Bontemps and Péligot concerning glass manufacturing.

The file is available at DS.Mingei\Glass\ExistingContent\DigitisedObjects

6.2 New content

New content for the glass pilot has been acquired during the planned ethnographic fieldwork at CERFAV in September and October 2019, where a Bontemps carafe was produced in the workshop in order to observe and capture social and body interactions that take place during glassblowing. Furthermore, a co-creation session took place during this time with the glass master and his students. Below are the materials that we collected. An intensive archive work about the depiction of historical glassblowing was also performed.

6.2.1 Literature

Textual information has been collected regarding the interaction of tools, mater, body, and space, and the interaction between the glass master and his students. Reports will be produced after observation of these aspects of glassmaking during fieldwork. Furthermore, after interviewing the glass master, a relevant report indicates the new information acquired concerning his way of working, his educational, cultural and social background, as well as the methods he uses to transmit his craft. In addition, historical archives have been digitised at CNAM and are available in DS.Mingei\Glass\Images.

6.2.2 Audio Visual material

Audio and video recordings of the interview with the glass master from fieldwork were acquired. Furthermore, video files depicting typical actions during glassmaking were produced in order to document the action and keep an archive. For understanding the way people, materials, and tools move around the space of the workshop, maps were drawn and digitised for further study. All videos are available on the MOP and in the following directories of the Mingei dataset

- DS.Mingei\Glass\Images
- DS.Mingei\Glass\RGBvideo

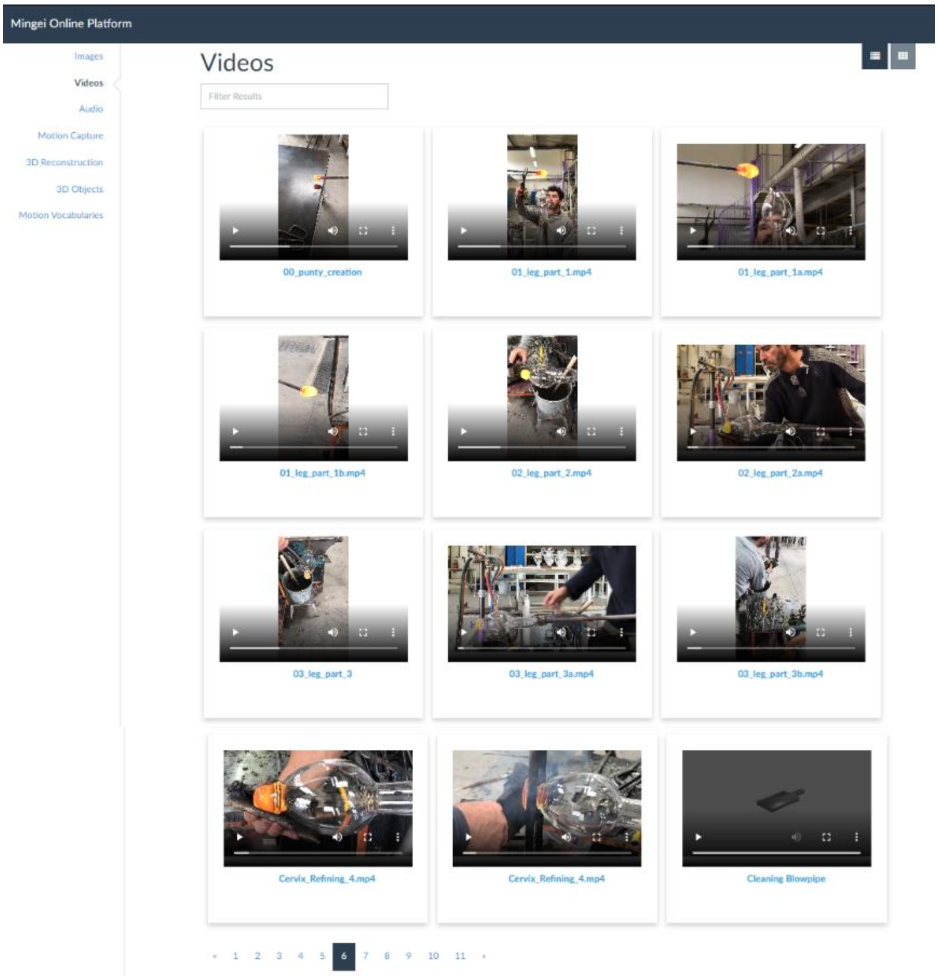


Figure 67. Screenshot of the Mingei Online Platform (images from [170]).

6.2.3 Digitisation of objects

New historical images about glassblowing were digitised in order to understand the innovation and routine of glassblowing. Mostly, these pictures are engravings from the 18th and 19th century and drawings from the 20th century.

Furthermore, the tools and machines used in the glassblowing process were digitised. The workshop is also drawn in order to be able to map the 'choreography' of the glass master and his assistant during the glassblowing process. The different carafes produced by the glassblower during the re-enactment process were also digitised to understand the difficulty to found the historical gesture. The files are available at https://zenodo.org/record/3813287#.XtkY41UzbmE

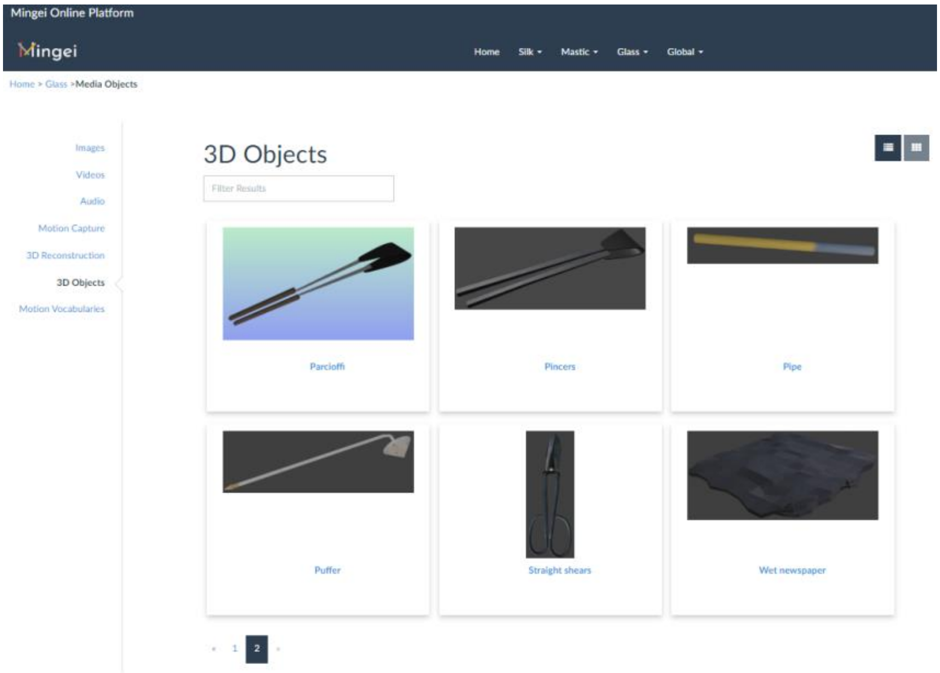


Figure 68. Screenshot of the Mingei Online Platform (images from [170]).

In addition, the carafe and its individual parts were modelled. The figure below shows the reconstruction of the carafe. The image is hyperlinked to a video on the Mingei YouTube channel demonstrating the reconstrcvution result. The modelling approach is described in D1.3.

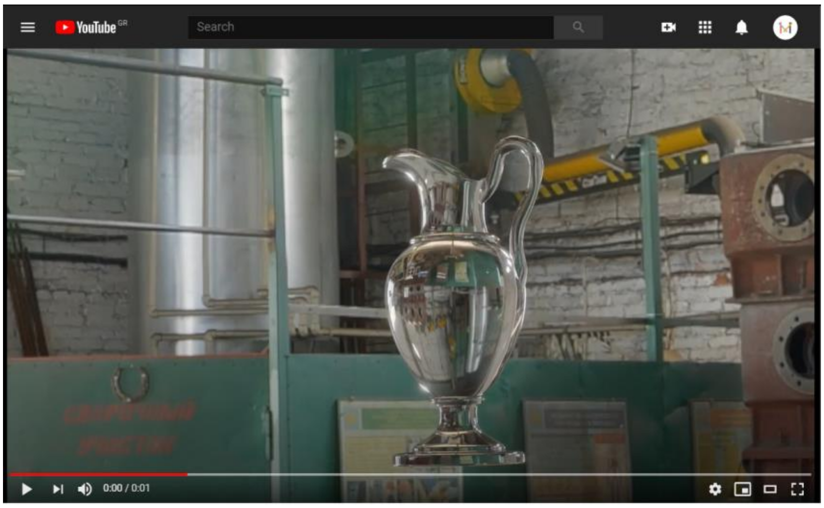


Figure 69. 3D reconstruction result.

All the material produced (2D scans, 3D scans) are available on the MOP and in the directories below

- DS.Mingei\Glass\3DReconstruction
- DS.Mingei\Glass\Images

6.2.4 Digitisation of human motion

Motion capture recordings provided a rich dataset of motions of the glass master during glassmaking. Their visualisation is the object of WP5 and is presented separately in the deliverables of this WP.

In addition, a detailed ethnography of working in a glass workshop and a documentation of gestures and techniques, enabled a detailed understanding of the multiple steps involved in creating a glass product with multiple parts, such as a carafe. Short video segments with glass-making gestures are annotated and documented (see Figure 70 and Figure 71).

All material is in on MOP and the directories below

- DS.Mingei\Glass\MoCap
- DS.Mingei\Glass\RGBVideo

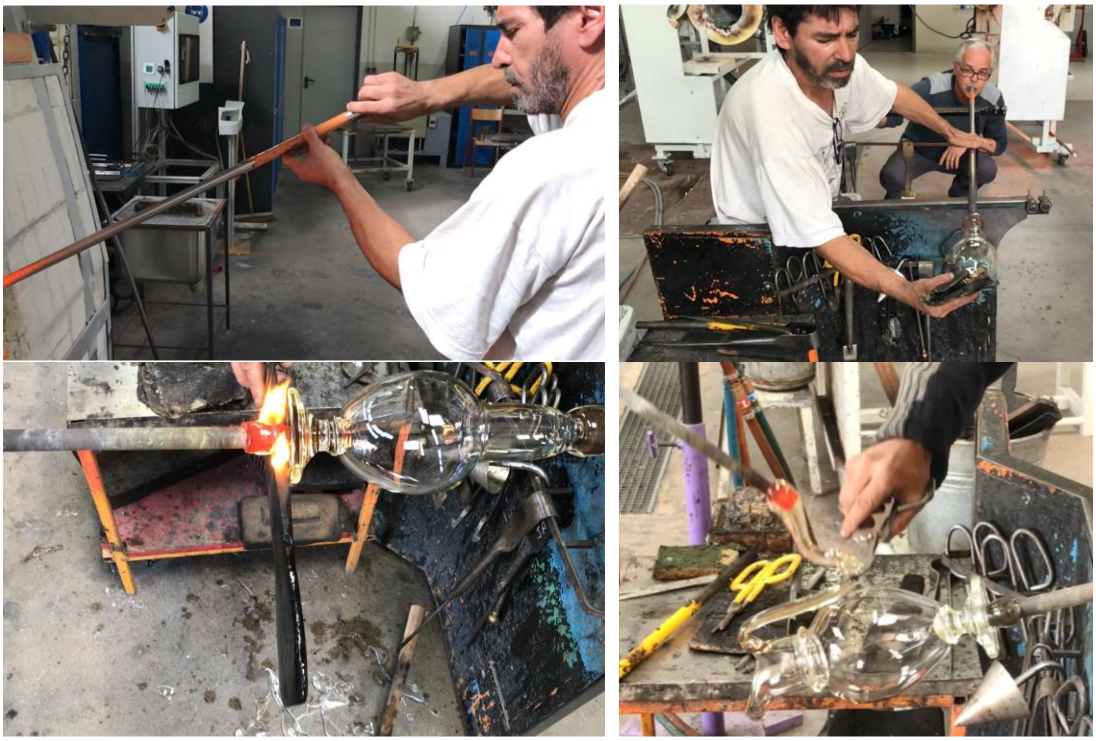


Figure 70. Glass making (1/2) [Dubois, 2019].

Figure 71. Glass making (2/2) [Dubois, 2019].

We have furthermore created 3D representations of these actions (see Figure 72). Using those tools, motion is visualised their 3D and 2D combinations to create hybrid depictions of motion.

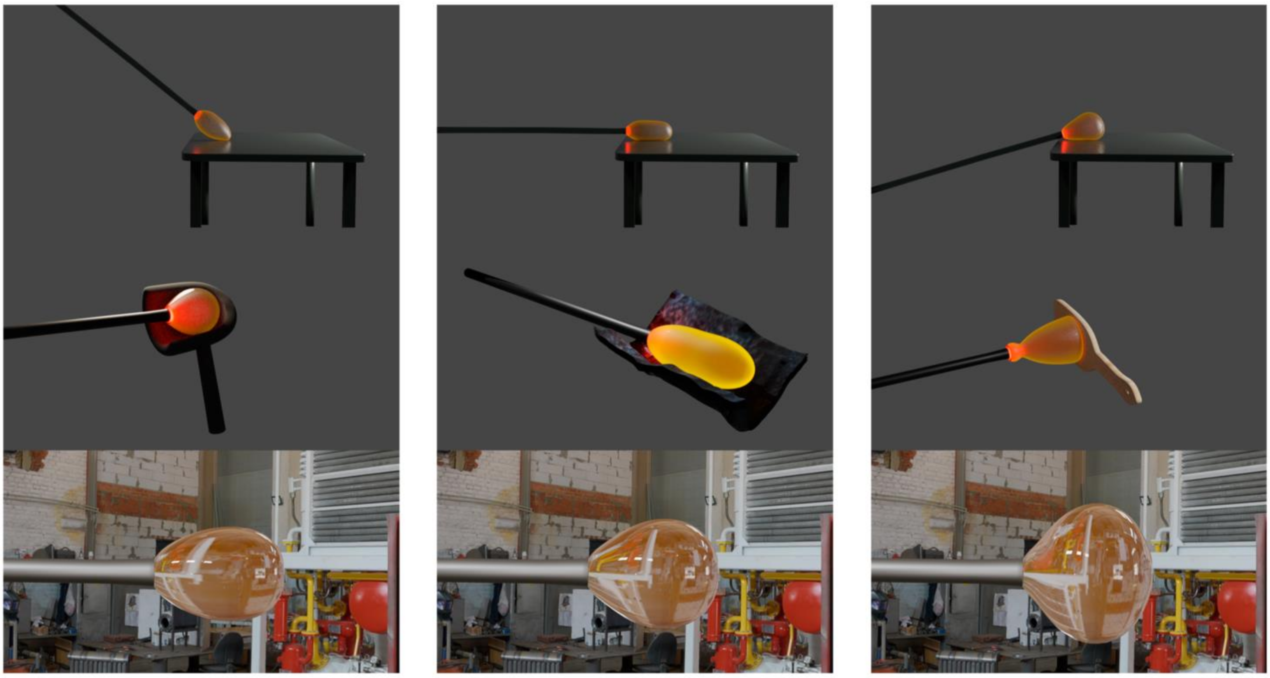


Figure 72. Computer-aided, presentation of glassmaking processes from [246] . Top: Marvering. Middle: Shaping. Bottom: Illustration of the glass deformation during glass blowing.

6.3 Craft and contextual knowledge

6.3.1 Description of glass, process of glassmaking, and dictionary

6.3.1.1 Description of glass [96]

Glass is a rigid material formed by heating a mixture of dry materials to a viscous state, then cooling the ingredients fast enough to prevent a regular crystalline structure. As the glass cools, the atoms become locked in a disordered state like a liquid before they can form into the perfect crystal arrangement of a solid. Being neither a liquid nor a solid, but sharing the qualities of both, glass is its state of matter.

There are three **classical states of matter**:

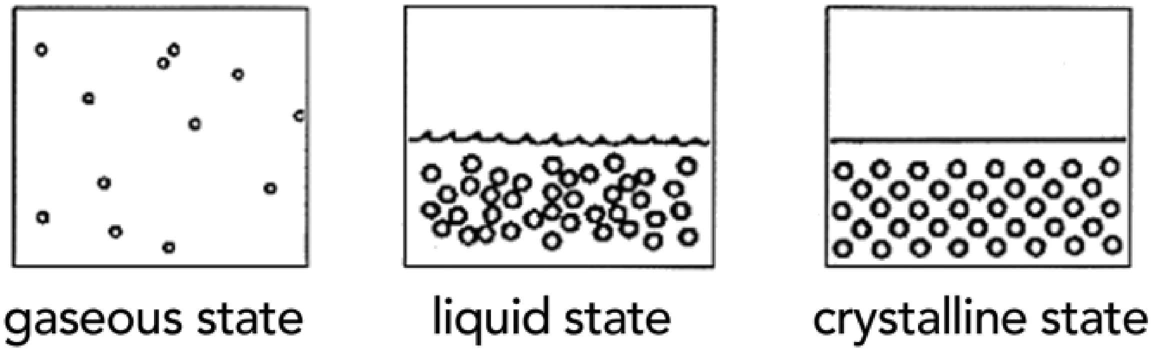


Figure 73. Glass states (image from [156]).

- Gaseous state = individual molecules separated from one another by relatively great distances and moving chaotically. No interaction between molecules except for collisions with one another.
- Liquid state = molecules are held close by attractive forces, but are not held rigidly in position. They move about, changing from one disordered state to another.
- Crystalline state = strong attractive forces hold molecules rigidly in position. Each molecule occupies a definite position, in a perfectly ordered three-dimensional lattice.

Glasses have the mechanical rigidity of crystals, but the random disordered arrangement of molecules that characterizes liquids.

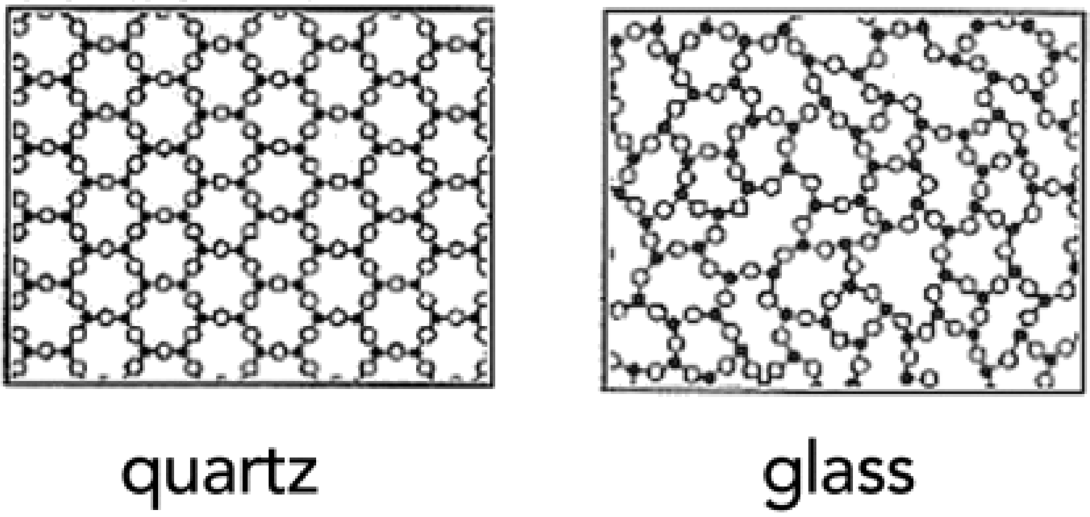


Figure 74. Quartz and glass (image from [156]).

From bottles to spacecraft windows, glass products include three **materials[4].**

1) Former: This is the main component of glass, which has to be heated to a very high temperature to become viscous. Silicon dioxide (contained in sand) is the most common former.
2) Flux: Helps formers melt at lower temperatures. This is usually soda ash or potash, which was traditionally made from marine plant ashes, or by burning bracken or trees, respectively.
3) Stabilizer: Keeps the finished glass from dissolving, crumbling, or forming unwanted crystals. Calcium oxide in the form of limestone, a mineral, is a common stabilizer.

The mixture of dry materials used to form glass is called the batch. The batch is heated in a furnace to about 2400˚F. Broken glass, called a cullet, is added to the batch to facilitate the melting process. An imbalance in the batch due to an excess of alkaline flux or too little stabilizer will cause crizzling, a chemical instability resulting in a fine network of cracks and deterioration of the glass.

The **colour of the glass** may be changed by adding metallic oxides to the batch. Examples of common colorants include:

- Iron - Colours glass green.
- Copper - Colours glass light blue.
- Manganese dioxide - Can decolorize colored glasses. However, in higher amounts, this element can create purple and, in even higher amounts, glass that appears black.
- Cobalt - Colours glass dark blue.

[4] A comprehensive online resource where more information can be retrieved is provided by the Corning Museum of Glass, including video recordings of raw material states, glass coloring, a broad dictionary of terms relevant to glass and glassmaking,.

- Gold - Colored glass deep red, like rubies[5].

Chemical composition determines what glass can do. There are already tens of thousands of workable glass compositions and new ones are being developed every day. The following elements help to create **special types of glass**.

When added to glass, lead makes glass brilliant, resonant, and heavy. Glasses containing a large percentage of lead are known interchangeably as crystal, lead crystal, and lead glass[6].

Boron aids in the production of borosilicate glass,glass is known for its resistance to thermal shock. Glass cookware and labware are the most well-known applications of this glass.

Immediately after glasses are formed, they are most often **annealed**, or slowly and evenly cooled, in order to reduce internal stresses. If one area of a piece of glass is thick (staying hotter longer) and another area is thin (cooling down quickly), and that piece of glass is not properly annealed, the steep temperature gradient between those areas causes stress and the piece will most likely crack apart.

Glass has the following **properties:**

- Mechanically strong: Glass has great inherent strength. Weakened only by surface imperfections, which give everyday glass its fragile reputation. Special tempering can minimize surface flaws.
- Hard: Surface resists scratches and abrasions.
- Elastic: Gives under stress - up to a breaking point - but rebounds exactly to its original shape.
- Chemical corrosion-resistant: Affected by few chemicals. Resists most industrial and food acids.
- Thermal shock-resistant: Withstands intense heat or cold as well as sudden temperature changes.
- Heat-absorbent: Retains heat, rather than conducts it. Absorbs heat better than metal.
- Optical properties: Reflects, diffracts, transmits, and absorbs light with great accuracy.
- Electrical insulating: Strongly resists electric current. Stores electricity very efficiently.

Available assets include text material.

6.3.1.2 Process of glassmaking

The following processing steps were observed during a one-day session at CERFAV in May 31, 2019. The steps describe the basic process that takes place during glassmaking. The process will be further documented in September and October 2019.

1. He takes the blowpipe
2. He blows in it to see if it's not clogged
3. He puts it on fire to heat it

[5] An audiovisual description by curator Dedo von Kerssenbrock-Krosigk of the Corning Museum of Glass, highlights crizzling gold ruby glass.

[6] An audiovisual description by glass artist William Gudenrath displays the 1674 patent of English glassmaker George Ravenscroft to make colorless lead glass.

4. He picks up the glass in the furnace
5. He cools the cane
6. He sits at his chair
7. He waters his paper tool
8. He turns
9. He blows with the thumb to form the post
10. He turns standing
11. He picks up a second time in the furnace
12. He turns with the wet paper tool
13. He blows
14. He stretches
15. He uses the jacks
16. He balances
17. He turns and the assistant blows
18. He uses the jacks
19. He re-heats
20. He turns and the assistant blows
21. He re-heats
22. He shapes with the jacks
23. He re-heats
24. He balances
25. He shapes with the wet paper tool and the assistant blows
26. He heats the tip with a blowtorch
27. He cuts
28. He puts in the lehr

The main technical actions of the Bontemps' carafe production, which will be studied in rich detail, are:

- Blowing the belly of the carafe
- Sticking the legs and foot of the carafe to the belly
- Trimming the neck of the carafe
- Creating the handle of the carafe

These actions will be recorded as photographs, videos, 3D digitisation, and verbalisation by the glass master. All these materials will be uploaded to MIngei's database.

6.3.1.3 Dictionary

The glass dictionary can be found in Annex 8.3.

6.3.2 Socio-historical context

See Annex 9.3.

7. Conclusion

In this deliverable, the foundation for the knowledge to be collected for the project pilots has been set.

We avoid stating that the knowledge we have collected is complete but, rather, sufficient for the needs of pilots. The reasons for this are:

- It is only in rare cases that one can claim to have complete knowledge of a topic.
- Mingei aspires to avail an open platform where knowledge can be extended.

Regarding the pilots, we claim that we have:

- Set the objects materials, machines, and tools upon which a craft is based, creating illustrated dictionaries that can support multilingualism and colloquialisms.
- Demonstrated how specific craft steps can be analysed into specific actions, and implemented this collection for the basic tasks of weaving, glassmaking, and mastic cultivation steps.
- Collected sufficient craft knowledge and sufficient contextual information, to present the context of each studied craft instance, in geography and along the history.

Regarding the protocol, we report that the experience obtained from the earliest pilot deployment (silk) provided guidelines which, when applied to mastic, facilitated the collection of knowledge. We plan to report these findings and guidelines in the second version of the Mingei protocol, in D1.3, version 2, M12.

We underscore that there is more knowledge to be collected, such as the motion annotation and modelling of in-depth modelling of more craft steps, knowledge obtained from experience, and knowledge on how to better transmit craft skills (i.e., such as the good practice guide for the Jacquard card puncher, in Section 4.3.1.6). There is also further contextual information to be mapped relating crafts to a better understanding our common history, tradition, and culture (i.e., in Section 4.3.6.9). Moreover, there is knowledge to be further discovered and, hence, calling for the ability to be able to enrich this knowledge collection.

To this end, the Mingei protocol, through its formal representation of collected knowledge, ensures its extensibility, so that it can eventually represent wider cultural, tangible, and intangible dimensions.

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