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<http://www.mingei-project.eu/>

Executive summary

Until now, motion data are mainly used in research context, cinema and game industry to enhance the reproduction (motion mapping) of motion in 3D or 2D space. In this deliverable, the approach followed by Mingei for the advanced visualization of data stemming from video recordings and visual tracking of human movement is presented. With the term **advanced visualisation**, we refer to the process of either **generating and visualising new information within motion data** (e.g. trajectories, velocity, etc.), or **using and post processing video recording and motion data to perform artistic visualisations**.

The obvious usage of such data, which is the 3D visualisation of the Mingei datasets for craft representation to produce appealing 3d presentations of craft processes and techniques, is not discussed in this deliverable. This process, of integrating tools and machines into a 3D virtual environment (i.e. workshop) is presented in depth in the context of D5.2. The outcomes of this process are the re-enactment of craft processes and techniques by avatars in virtual environments using motion-mapping technologies. Thus, in this deliverable, Mingei is presenting methods to achieve more in terms of analysis and in terms of visualisation. To this end, research work reported, is focusing on two dimensions of movement visualization.

The **first dimension regards visualization of motion in the 3D space** and the **production of analytics that could be used to infer useful information** from motion. For, example such information could include the effort spend by a human operator while using a machine (e.g. a loom) or the calories spent when harvesting mastic tears.

The **second dimension is inspired by the visualization of motion in art, graphics, design and cinema** moves forward into proposing an approach for the artistic visualization of motion where the goal is to transfer artistic concepts from the world of art to the world of digital movement visualization.

These dimensions are presented through the introduction of two tools developed by Mingei namely: (a) the **Human Motion Analyser & Visualizer** and (b) **MotiVo artistic visualizer**. These tools are designed to offer easy integration of several visualization components and currently Mingei has released within the consortium their first version that contains the implementation of initial visualisation components. The tools and the integrated components are the results of the work in T5.5, within the first year of the project. During the second year, both enhancements of existing and new visualisation components will be added to formulate the final Mingei visualisation toolchain.

Regarding the methodology of implementing the visualisations, the two aforementioned dimensions, although resulting to different visualisations, are receiving the same input source. This source will be called from this time on the **“Mingei datasets for craft representation”**. These

datasets have been created using data stemming from IMU based MoCap sessions, video recording sessions and post processing of video using model based pose estimation approaches. Synchronised video and MoCap data of craft processes were segmented using the Mingei Animation Studio (AnimIO) software presented in D1.3 and D4.2. The segmentation process resulted to gesture vocabularies that are represented in video format and MoCap data format using both the IMU based tracking and the model based pose estimation. These vocabularies are considered important for Mingei in order to build experiences on top of craft practices but also for the scientific community, as such vocabularies do not exist and new research algorithms can be implemented and tested on these reference datasets.

The **Human Motion Analyser & Visualizer** currently supports:

- **Velocity visualization:** Using the “Mingei datasets for craft **representation**” as input, for each joint of the 3d human model a line is created to depict the resultant velocity of each joint
- **Dataset normalization:** A process for achieving a more normalized dataset using an implementation of a smoothing filter in Matlab¹. The method currently used is the moving average smoothing algorithm. It is a low pass filter with filter coefficients equal to the reciprocal of the span.
- **Movement visualisation:** currently the following visualisations are supported: (a) Single joint trajectories visualisation where users may select the joint to be visualized in order to produce analytics for a single joint and (b) multiple joints trajectories visualizer that offers the possibility to select multiple joints for visualisation such as for example all the joints of the right hand or all only the fingertips, etc.

MotiVo artistic visualizer currently supports the following components:

- Motion Blender which creates a directional motion effect by overlapping key pose frames into a united content.
- Motion Annotator that takes a key frame as well as a trajectory file containing the coordinates of the X and Y axis in 2D and produces a motion visualisation on top of the provided key frame.
- Manual Motion Annotator that supports the need to manually annotate motion especially where semantic information is to be added to the visualisation.
- Image filters that receives as input an image file and provides a list of image filters that can be applied to an image similar to the ones used in popular image processing software adapted to the needs of artistic visualisation
- Scene composer takes as input an overview of the scene from a static moment in the course of a craft action e.g. (passing the shuttle through a loom). This static motion frame is then

¹ <https://www.mathworks.com/products/matlab.html>

used by a computer vision tracker capable of tracking the position and orientation of hands and objects. The tracker is estimating the Rotation and Translation and Scale of the object tracked (i.e. hand, or tool) and overlays the model on top of the given frame for abstraction and emphasis on the spatial arrangement of the critical actors in the scene.

The deliverable is structured as follows:

- **Section 1** provides an introduction to the context and purpose of this deliverable focusing on the topic of visualisation and how this has been used by artists through history to depict both visual and semantic information. Thus, the introduction gives an overview of the theoretical background upon which the implementation of technologies was based taking into account that the 3D re-enactment through motion remapping of MoCap data to avatars is covered in depth by D5.2.
- **Section 2** provides an overview of the theory of perception and how it affects the research work conducted in Mingei. To this end the main relevant perceptual concepts and laws are presented together with the rationale of how they can be applied to enhance the visualisation outcomes of Mingei.
- **Section 3** provides an overview of related work on Motion visualisation.
- **Section 4** provides a summary of the technologies used in Mingei for motion digitisation. Overall Mingei is exploiting motion data stemming from IMU based MoCap sessions, video recording, key frames from video recordings and MoCap data generated through model based pose estimation. These were acquired from the following data sources: (a) MoCap and video capturing sessions in Krefeld, (b) MoCap and video capturing sessions in Chios, (c) MoCap and video capturing sessions in CERVAF, (d) Model based pose estimation based on the video sources from Krefeld, Chios and CERVAF and (e) Extracted key-frames from the video sources.
- **Section 5** makes an overview of the implementation of the 3D Motion Analyser and Visualizer. In the current state of development this tool receives as input MoCap data and assigns this data to a basic stick motion animation avatar. The selection of this kind of avatar for this analysis tool is mainly due to the rationale that for scientific purposes the simplest visualisation is optimal in order to visualise only the important parts of the motion and the inferred information of interest to the researcher. In future versions, new avatars may be integrated if needed for visualisation purposes.
- **Section 6** provides an overview of the implementation of the 2D Human Motion Artistic Visualizer (MotiVo). Through the implementation the currently supported visualisation features are presented such as: (a) motion blending of key frames, (b) 2D visualisation of 3D trajectories within Key poses, (c) manual annotation of motion with visual cues to create static motion visualisations, (d) image filters for post processing of key-frames and (e) integration of 3D objects into 2D key frames to enhance the visualisation capacity of the tool. The section concludes with

some usage guidelines to allow end-users to get the most out of the MotiVo tool.

- **Section 7** provides conclusions and future work. Future work will be implemented and reported in the second version of this deliverable to be submitted on M24.

- **ANNEX1:** presents the operation instructions manual of MotiVo. This user manual is expected to become part of the Mingei Protocol Implementation handbook containing steps, technologies and Mingei tools for craft representation and presentation.

- **ANNEX2:** presents the completed test use case of the MotiVo approach which regards the implementation of an illustrated comic book that present the creation of the Bontemps carafe. The illustrated figures were created using the tool and by facilitating key-frames extracted by the video recordings of the creation process at CERVAF. For the selection of key-frames the ethnographic research conducted by CNAM at CERVAF was used as a guide of identifying the major steps of the carafe making process and the important moves / gestures that should be highlighted in the comic book.

This deliverable is submitted in the context of T5.5. of Mingei. This is the first version of the deliverable reporting progress achieved during the first year of the project. The second version of the deliverable will present the final Mingei solutions on Gestures Visualization integrated in the protocol and pilot experiences. This final version, will be submitted on M24.

Keywords

Visualisation, Motion visualisation, Motion Analytics, Motion Capture, Motion blending, Trajectories visualisation, Image filters, 3D objects, 3D objects pose estimation

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Abbreviations

HC	Heritage Craft
MoCap	Motion Capture
CH	Cultural Heritage
CHI	Cultural Heritage Institutions

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1 Introduction

1.1 Motion visualisation

1.1.1 Traditional and contemporary art and painting

In the visual arts, human motion and activity is often conveyed through still depictions or sculptures. The depiction of motion is an important part of artistic expression. Over the years, artists have depicted both motion (e.g., Claude Monet, *En Plein Air*, 1886) and lack of motion, (e.g., Johannes Vermeer's *Woman Holding a Balance*, 1664) as a way to stimulate interest. We call a “**visual abstraction**”, a drawing that encapsulates events lasting more than one moment and, possibly, occurring in more than one location. In essence a visual abstraction is a manipulation of realistic imaging, so as to convey an understanding of the events occurring within this time (and possible space) interval. Visualisation of motion in static media provides an abstraction of the, essential, motion intended to be depicted.

Motion has been effectively conveyed in static media, by superimposed and juxtaposed visualisations. The principle is that the depiction utilizes the “visual interpolation” or “filling-in”, in the temporal dimension. Motion visualisation has been explored though superimposition and juxtaposition of one or more depictions. Superimposed forms were used to capture motion within a short time interval, creating visual art that summarizes motions over a relatively short time interval.

From all the art forms, Kinetic art is the most prominent on in terms of motion as it represents a reductionist approach, which emphasizes mostly on motion and de-emphasizes both form and colour. It provides fertile ground on which to begin an exploration of the relationship between the physiology of visual perception, brain activity and the aesthetic experience of visual art. In kinetic art objective motion plays a dominant part or one in which the perception of motion is strongly induced by a static figure (e.g. image, sculpture). Based on [29], there are three interdigitating stages in the genesis and development of modern kinetic art.



Figure 1. Claude Monet, *En Plein Air*, 1886 [29].

In the first stage, the compositions that characterize it are relied maximally on form and colour and minimally, if at all, on actual motion. Marcel Duchamp, created works of art in which actual movement was of critical importance. In his painting, he discarded completely the naturalistic appearance by keeping only the abstract lines of some twenty different static positions in the successive action of descending' [24].

In the second stage, objects were actually set in motion, so that the movement of the object itself became part of the work of art. The artistic creations falling into this stage have powerful stimuli, not only in the area of brain specialized in visual motion, but also in the brain area whose cells respond especially well to oriented lines and edges in motion. It was based on the manifesto called 'Ricostruzione Futurista dell'Universo' (1915) which used categories such as 'Dinamico' and it incorporated motion, including different

categories of motion such as velocity. The second stage was demanding the execution of dynamic sculptures and relied heavily on colour, thus it was still heavily dependent upon stimulating those areas of the brain which are concerned with colour, in addition to the areas specialized for visual motion. Finally, the third stage was mainly focused on the detachment of movement as far as possible from both the form and the colour.



Figure 2. Nude Descending the Staircase (source: Wikipedia, 2019) [24].



Figure 3. Nude Descending the Staircase: Corresponding still photos by Edward Muybridge (source: Wikipedia, 2019) [25]

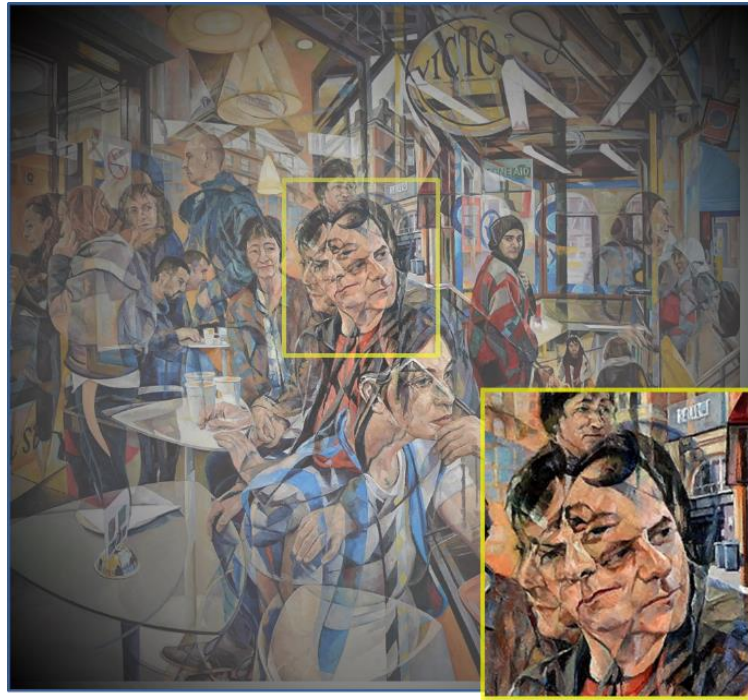


Figure 4. Example of painting motion through simultaneous artistic multi perspective depictions (source image: mymodernmet, multi-perspective painting by Clive Head, 2019, edited by Mingei) [26]



Figure 5. Étienne-Jules Marey, Cheval blanc monté, 1886, locomotion du cheval [27]

Another inspirational aspect of motion story-telling visuals is the artwork by Rodolphe Töpffer and Le Corbusier. They both contributed to the history of illustration as Töpffer pictured Le Corbusier obsessively by reducing complex photographs into drawings made with a few lines [22]. The overlaps with Töpffer were particularly vivid in Le Corbusier's sketches of human body actions,

creating figures with a dynamism and liveliness (**Figure 6**). Le Corbusier's trademark line style transformed his architectural representations to a graphic narrative communication tool.

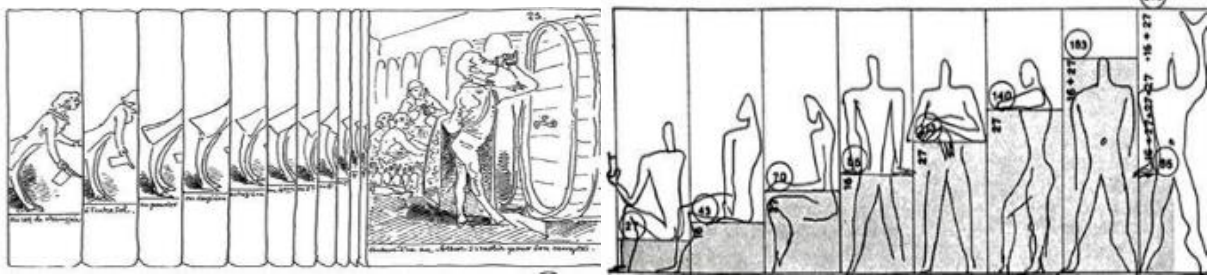


Figure 6. Reduction of complex photographs into drawings (source: [22]).

1.1.2 Juxtaposed Illustrations

Juxtaposed illustrations and images in deliberate sequences have been used in design and comics [23], to convey motion. Visualizing motion as a sequence of juxtaposed key pose depictions, provides a clear understanding of the illustrated motion. Annotations provide visual clues of motion and assist the understanding of visual interpolation.

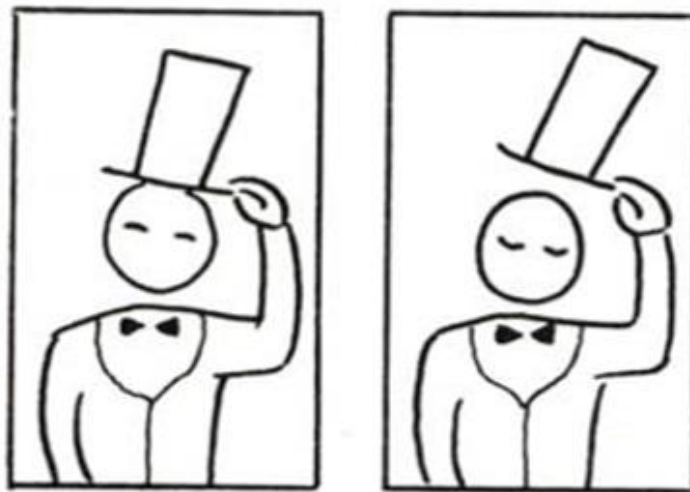


Figure 7. Theory and usage of visual interpolation [112].



Figure 8. Usage of visual interpolation in instructions [113].

1.1.3 Graphics design

Juxtaposition is used in illustrated instructions as an ordered representation of images combined with written information and sketches of pointing arrows and other forms, aiming to direct the reader (**Figure 9.** Motion and action visualization in instruction manuals). Although this was conventionally a manual task for illustrators, nowadays technology is offering many tools for digital creativity. It is common for graphic designers and illustrators to use image processing software to simplify the creation process and enhance their visualization techniques. Although these tools are considered a commodity for illustrators and designers today, they still require insight and art skills from the illustrator. In the domain of motion visualization, specialists should still do this manually.

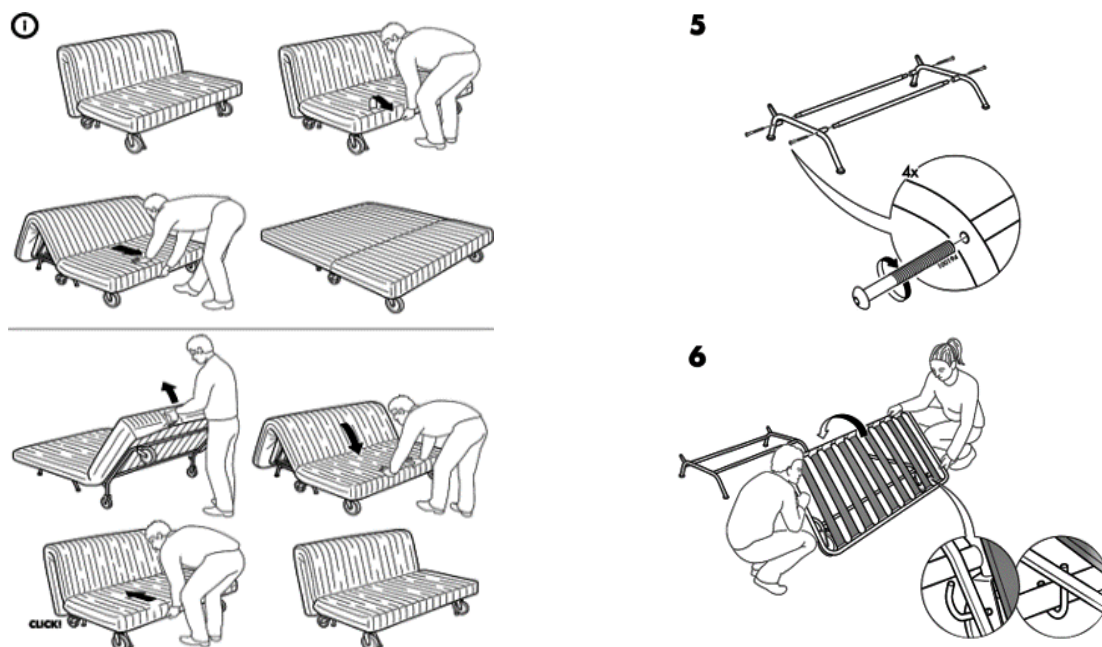


Figure 9. Motion and action visualization in instruction manuals [114].

1.1.4 Photography and video capturing

In photography and film recording, motion blur is a fundamental cue in the perception of objects in motion. This phenomenon is consisted by a sequence of frames and manifests as a visible trail along the trajectory of the object, resulting by the combination of relative motion and light integration taking place in film and electronic cameras. In general, sequences containing a moderate amount of motion blur are perceived as natural, whereas its total absence produces jerky and strobing movement. Perhaps the most obvious way to try to represent motion is through the use of blur in a relatively long-exposure photograph. In such a photograph, given a stationary framework and a moving object, one can begin to grasp motion in the still image [105].

Besides photography, the effect of motion blur is also used in 2D computer graphics [106] [107]. The simulation of motion blur is vital for both animated sequences and still images among the objects on a scene. In the last decades, many graphic experts have developed tools for representing motion such as software products (e.g. GIMP, Adobe Photoshop). They provide simple motion blur filters applied on static images. Moreover, for more a professional result, advanced motion blur filters are available with software products.

Motion blur technique is broadly used for representing motion in static media however, the potential problem deriving from it, is the correct directionality of an action. It is common for viewers to misapprehend the begging and the end of the depicted motion and thus the overall action of a scene.

In the context of portraying motion, action lines or speed lines or zip-ribbons [108] [109] [110] are also used even better the direction of the motion itself in a single static image. Action lines are a set of arrays containing lines attached to the moving object without deforming it. In mathematics, they are called vectors. Vectors are lines that have two properties direction and extent (i.e., speed) and have developed out of Greek parallelograms as

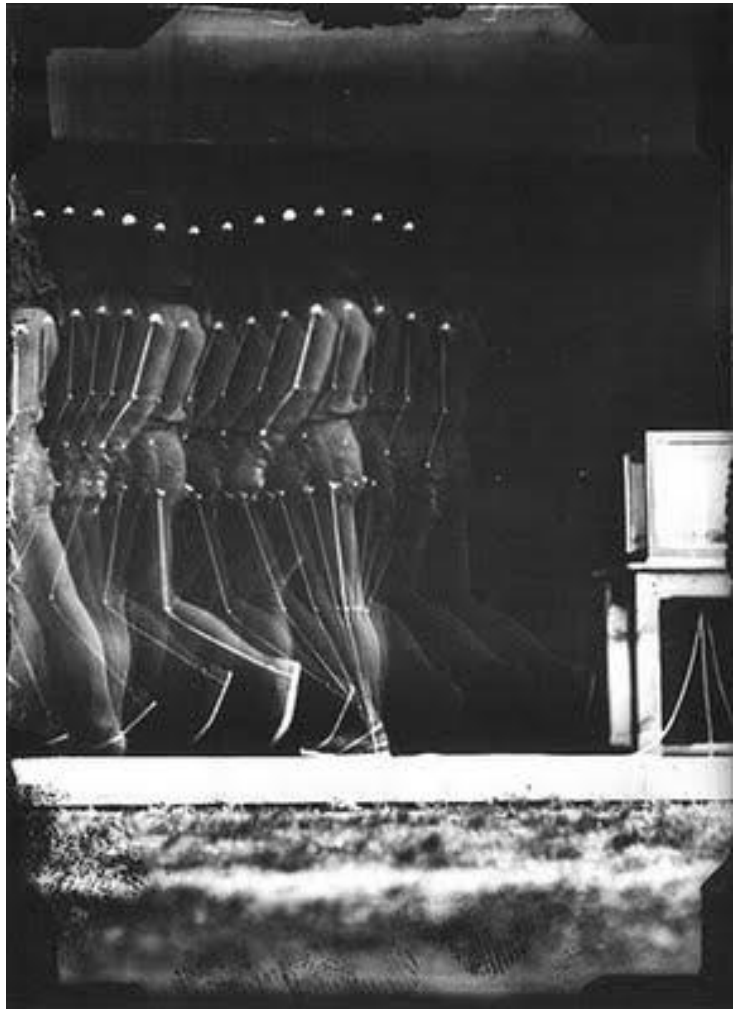


Figure 10. Man walking, chronophotography [28].

representations of forces and motion, but more particularly out of the mathematics of the early 19th century. If the attached vectors are long and dense, it means faster motion, whereas vectors pointing up mean upward motion etc.

Action lines are mostly seen in cartoons and sometimes they are drawn as arrows with the tail representing the first instant and the head representing the most recent action. In contrast to motion blur, action lines solve the problem of clarity and directionality, without resigning to the problem of non-rigidity.

1.1.5 Cinema

In cinema, motion visualization techniques are also ubiquitous. Strong poses that fit the composition's objective, fractures of time and space as well as camera "tricks" are commonly used. For example, in the *Vertigo* movie by A. Hitchcock, the camera moves towards or away from an object while adjusting its focal point so that it remains the same size relative to the rest of the scene. This effect creates an illusion to the audience about visual motion.

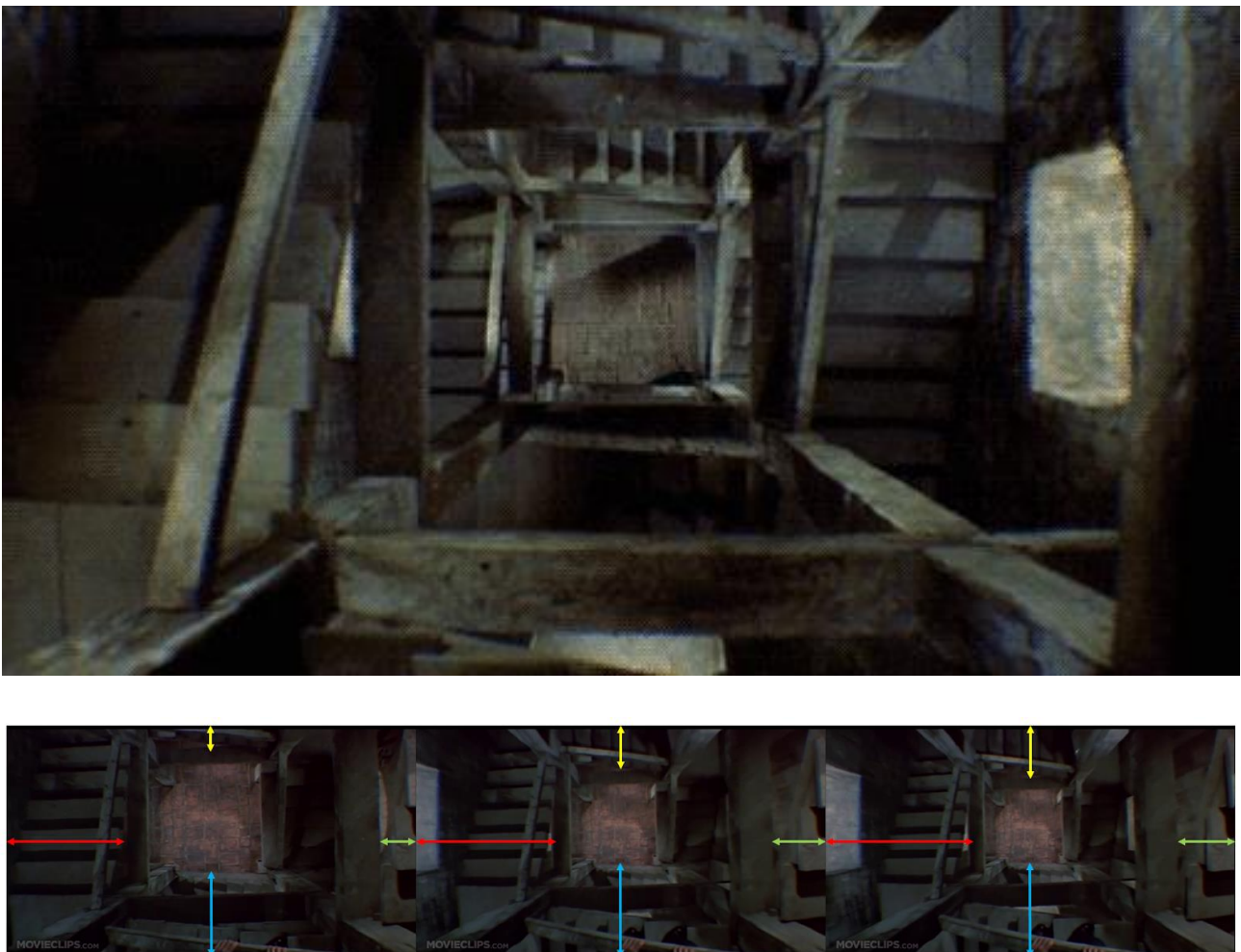


Figure 11. Dolly zoom from Hitchcock's *Vertigo* [33]

1.2 Motion summarisation and Art

The representation of **motion** and **activity** in **longer time intervals**, or **scenes** has been treated in art for manipulating time so that multiple time instances are seamlessly included, or “**gracefully superimposed**”, in the painting, without apparent distortion of reality. For example, in the Calling of Saint Matthew by Michelangelo Merisi da Caravaggio, the activity of each person is depicted when looking at each form in the painting. However, if literally considered, the depicted person behaviours would not take place simultaneously. That is, the painting summarised the characteristic behaviour of each character over, say, the depicted event. For the observer, perception of time is obliged due to the complexity of the painting and the time required for comprehending the depicted scene. This appears to be on purpose, as contrast salience tends to guide gaze in an elaborate visual path that visits the depicted characters and reveals the interaction among them (see **Figure 12**).

Picture description: In terms of perception, light is creating a visual path in the painting and then it strikes on the boy at the centre of the picture who is gazing at Christ. Then, the eye of the viewer is manipulated by contrast changes in the cloak of Christ's follower and captured to the reflected light at Christ's face. Then, back to the painting the contrast changes to the hand of the person next to the child pointing to St. Matthew is used to put back the attention to the calling in this ingenious composition.

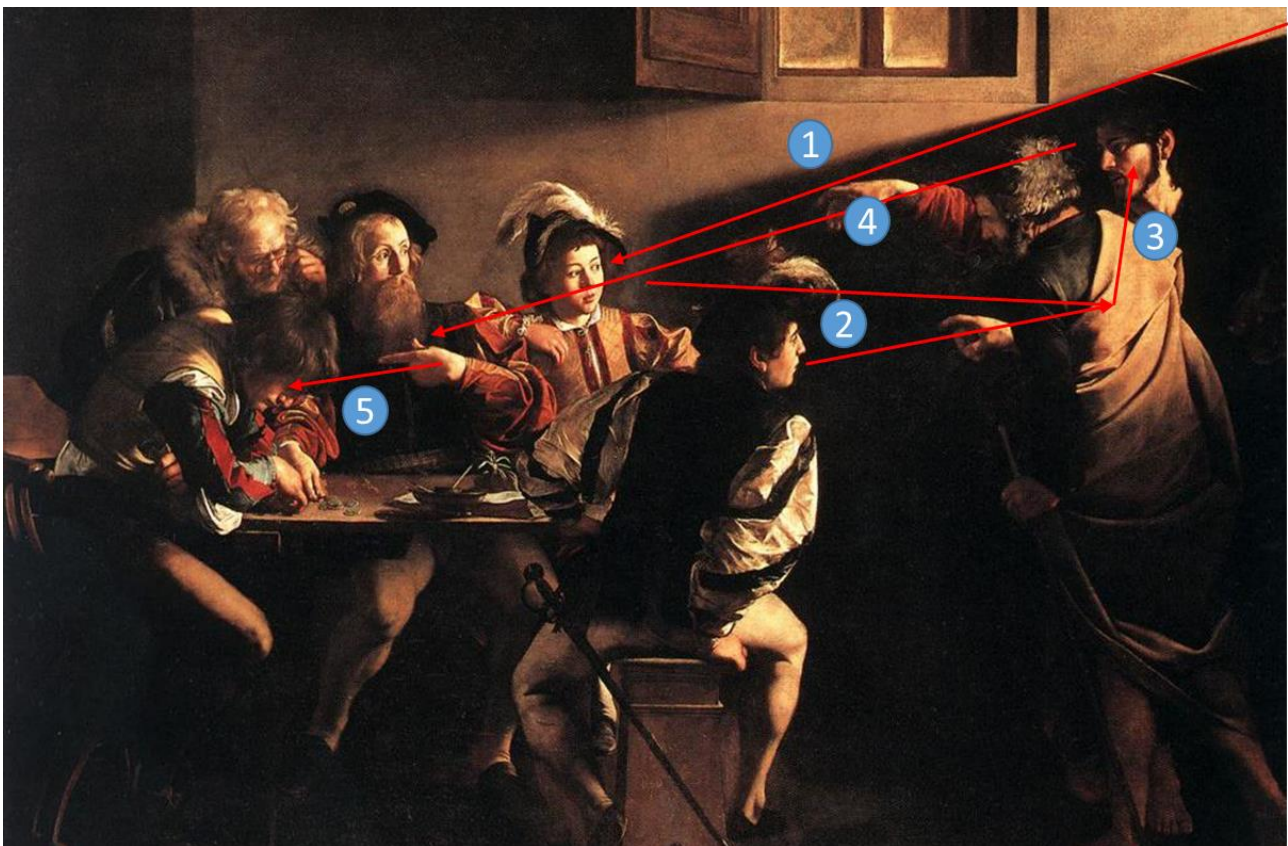


Figure 12. Analysis of the Calling of Saint Matthew [31]

1.3 Can motion visualisation be facilitated by digital means?

The summary of artistic concepts presenting above are the result of **careful observation, human artistic expression and the exploitation of scientific outcomes and theories by visual artists (e.g. theory of simultaneous colour contrast)**. As a result, human intellect plays important role in the formulation of artistic depictions of motions something and thus reduces the possibility of machine replication. To this end, **the goal of this research is to carefully study human perception, motion visualisation in art, cinema and design so as to implement a collection of basic applied visualisation schemes in order to transfers artistic concepts in the digital world**. In this context, we present an interactive system that simplifies the process by offering a number of visualization tools that provide insightful and visually pleasant results requiring minimum expertise and knowledge from the user side. Using these tools, motion is visualised by parameters such as the blending of key poses of an activity, the visualisation of motion trajectories, the application of image filters to visualisations and the combination of 3D and 2D visualisations to create hybrid depictions of motion.

In Mingei **we argue that using this toolkit CH professionals, craft personas and end users will be able to create their own visualisations out of video recordings, key poses and image depictions of craft processes and techniques in order to enhance the educational and presentation value of digital content**.

Furthermore, as movement entails important kinetic information we argue that MoCap technologies can be used not only for re-targeting motion to virtual characters (as presented in depth in D5.2) but also as a valuable information source upon which intelligent analytics can be applied to generate new information such as the torque used for operating a machine, the kinetic energy spent translated even into calories, the total time and effort of creating an item, the distance spent within an art workshop, etc.

1.4 Main contributions of Mingei

The sum of all these Mingei encounters during the first year of the project is summarised through the presentation of two movement visualisation and analytics technologies that can be used to provide a 2D or 3D synopsis of the movement while also capable of visualising other forms of information such as velocity acceleration, torque, etc.

The first outcome regards movement information analytics that provide further insights about the characteristics of the movement in order to conclude on the referential motion patterns or postures. Moreover, the user has the possibility to select the joint for which s/he wants to get analytics related to kinematics (such as trajectories speed, acceleration, etc.). Concerning visualisation, the user will have the possibility to visualise frame by frame the movement and to adjust the padding or skip frames.

The second outcome presented in this deliverable regards a system which simplifies the artistic visualization process by offering a number of ready to use visualizations that deliver visually pleasant results requiring minimum expertise and knowledge from the user side. Using these tools, users can visualize motion by processing variables such as colour strength, direction and define the key poses of an activity based on their own experience. The user input are discrete image frames retrieved from video motion segments and short motion segments. The introduced system is called *MotiVo*.

2 Theory of perception and movement visualisation

2.1 Perceptual grouping

Perceptual grouping occurs when human brain perceptually is putting parts together into a whole. More specifically, it refers to principles by means of which a set of discrete elements are partitioned into groups by the visual system, thus forming higher-order perceptual units [65]. These perceptual grouping principles are powerful in the sense that humans usually cannot ignore them. Modern neurophysiology explains that human minds do not directly perceive objects and visual scenes. First, we analyse each image with respect to basic features [66]. In dynamical models, neurons coding for elements of a group mutually excite each other, and thus, dynamically highlight the group. Metaphorically, neural activity between the neurons spreads like an electric current in a net of wires. This activity spreading can explain how elements group behind occluders.

Perceptual grouping occurs in all sensory modalities, such as vision [67], audition [68], somatosensation [69] and figure-ground segmentation [70], [71]. Perceptual grouping was first studied by Max Wertheimer, one of the fathers of Gestalt psychology [72], [73].

Potential usage of perceptual grouping in Mingei: Mingei aspires to create tools than facilitate the theory of perception to enhance the visualisation of Motion in HCs. More specifically in this section we are interested in visual perceptual grouping and figure-ground segmentation to assist non-technical experts and non-artists in the semi-automatic creation of readable visualisations and movement summarisations.

2.2 Gestalt psychology

Gestalt psychology or Gestaltism is a school of psychology that emerged in Austria and Germany in the early twentieth century, based on work by M. Wertheimer, W.Köhler, and K. Koffka [74]. Gestalt psychologists emphasized that organisms perceive entire patterns or configurations, not as individual components [75]. This view is quoted as, "*the whole is more than the sum of its parts*" [76]. The earliest Gestalt work concerned perception, with particular emphasis on visual perceptual organization as explained by the phenomenon of illusion [77].

In 1912 Wertheimer discovered the phi phenomenon, an optical illusion in which stationary objects shown in rapid succession, transcending the threshold at which they can be perceived separately, appear to move [78] [79]. Wertheimer understood that the perceived motion is an emergent experience, not present in the stimuli in isolation but dependent upon the relational characteristics of the stimuli. As the motion is perceived, the observer's nervous system and experience do not passively register the physical input in a piecemeal way. Rather, the neural organization as well as the perceptual experience springs immediately into existence as an entire field with differentiated parts. In later writings this principle was stated as the law of Prägnanz or the law of good Gestalt.

The law of Prägnanz implies that, as individuals perceive the world, they eliminate complexity and unfamiliarity so they can observe reality in its most simplistic form. Eliminating extraneous stimuli helps the mind create meaning. This meaning created by perception implies a global regularity, which is often mentally prioritized over spatial relations.

2.1.1 Gestalt laws of grouping (or principles of grouping)

Gestalt psychologists attempted to discover refinements of the law of Prägnanz, and this involved writing down laws that allow us to predict the interpretation of sensation, what are often called "gestalt laws". Wertheimer defined a few principles that explain the ways humans perceive objects. Those principles were based on similarity, proximity, continuity [14]. These laws took several forms, such as the grouping of similar, or proximate, objects together, within this global process. These laws deal with the sensory modality of vision.

2.1.1.1 Law of proximity

The Gestalt law of proximity states that "objects or shapes that are close to one another appear to form groups". Even if the shapes, sizes, and objects are radically different, they will appear as a group. Elements grouped together create the illusion of shapes or planes in space, even if the elements are not touching [10]. For example in **Figure 13**, the circles closer to each other, are perceived as groups rather than random collections.



Figure 13.Law of proximity [81]

Potential usage of the law of proximity in Mingei: Enhance the visibility of objects close to each other related semantically with a specific craft activity and remove focus from other elements. Use selective focus and foreground background segmentation techniques to enhance visual grouping.

2.1.1.2 Law of similarity

The Gestalt law of similarity states that perception lends itself to seeing stimuli that physically resemble each other as part of the same object. This similarity can occur in the form of shape, colour, size, shading and other qualities and allows people to distinguish between adjacent and overlapping objects based on their visual texture and resemblance (**Figure 14**). The principles of similarity and proximity often work together to form a Visual Hierarchy [15]. Either principle can dominate the other, depending on the application and combination of the two.



Figure 14. Law of similarity [82]

Potential usage of the law of similarity in Mingei: Mingei is going to explore the law of similarity in terms of colour as other elements of the motion scheme are defined by the video capturing method and setup. In this sense giving more contrast to areas and objects of interest in relation to other non-interesting element can enhance visibility taking into account that the human perceptual system is sensitive to contrast changes.

2.1.1.3 Law of closure

The Gestalt law of closure refers to the mind's tendency to see complete figures or forms even if a picture is incomplete, partially hidden by other objects, or if part of the information needed to make a complete picture in our minds is missing (Figure 15). This reaction stems from our mind's natural tendency to recognize patterns that are familiar to us and thus fill in any information that may be missing.



Figure 15. Law of closure [83]

Potential usage of the law of closure in Mingei: In the case of visual recordings of craft processes and techniques where tools and machines are involved, occlusions tend to reduce the visibility and readability of the scenes. In the case of curators, the law of closure together with the law of past experience can assist us in the creation of a tool to enhance key frames extracted from process recording. Taking into account the past experience of the curator on the subject and the capability

inferred from the law of closure the curator can manipulate and add to the scene 3d models of objects so as to reduce occlusions and make it more readable.

Currently an example of this technique as implemented by Mingei is presented in the illustrated craft magazine that explores manual annotation and scene carbonization techniques is presented in ANNEX 2 of this deliverable. It is expected that such a visualization will be greatly enhanced with the integration of the aforementioned technique.

2.1.1.4 Law of Symmetry

The Gestalt law of symmetry states that the mind perceives objects as being symmetrical and forming around a centre point (e.g. object division into an even number of symmetrical parts). Therefore, when two symmetrical elements are unconnected the mind perceptually connects them to form a coherent shape. Similarities between symmetrical objects increase the likelihood that objects are grouped to form a combined symmetrical object (**Figure 16**).

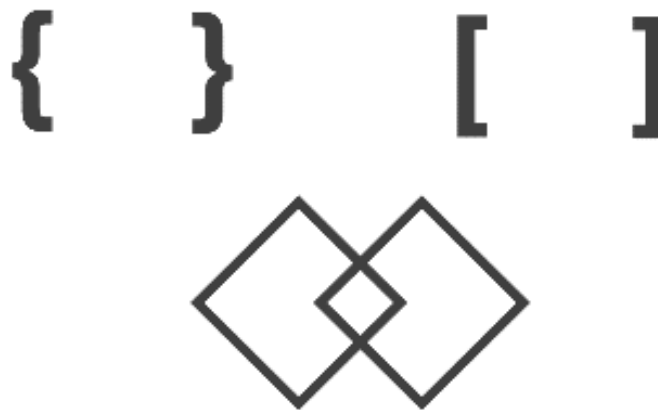


Figure 16. Law of symmetry [84]

Potential usage of Symmetry in Mingei: For non-craft experts annotating scenes Mingei aspires to enhance the visibility of scenes based on the law of symmetry. Partially occluded objects will be easier to identify by giving the possibility to the user to access a collection of 3D objects (tools) used in the craft and thus enhance his/her past experience. Thus, it will be easier to identify this objects even in half occluded scenes increasing the range of possible users of the produced technology.

2.1.1.5 Law of Common Fate

The Gestalt law of common fate states that visual objects moving along the same velocity along parallel trajectories will be perceived by a human observer as grouped [16]. Experiments using the visual sensory modality found that movement of elements of an object produce paths that individuals perceive that the objects are on. Human minds perceive elements of objects to have trends of motion, which indicate the path that the object is on (**Figure 17**). This allows humans to

make out moving objects even when other details (e.g. colour, outline) are obscured. This ability likely arose from the evolutionary need to distinguish a camouflaged predator from its background. The law of common fate is used extensively in user-interface design [17], for example where the movement of a scrollbar is synchronised with the movement (i.e. cropping) of a window's content viewport.

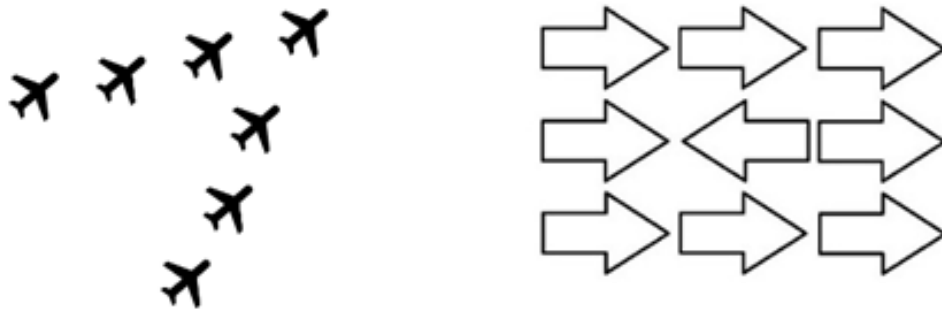


Figure 17. Law of common fate [85]

Potential usage of the law of common fate in Mingei: Taking into account that in the context of this deliverable static motion visualizations in 2D are discussed this law is important so as to simulate motion when no actual motion exists in a static frame. To this end in **Mingei** the way that motion and direction is depicted in **Figure 17** will be employed through a manual motion annotation tool that provides end users the possibility to integrate semantically rich visual information to static motion visuals.

Examples of the law of continuity as applied in the context of Mingei are presented in the context of section 5.6.

2.1.1.6 Law of Continuity

The Gestalt law of continuity (also known as the law of good continuation) states that elements that are arranged on a line or curve are perceived to be more related than elements not on the line or curve. In cases where there is an intersection between objects, individuals tend to perceive the two objects as two single uninterrupted entities. This allows differentiation of stimuli even when they come in visual overlap. For example in **Figure 18**, the human eye follows the less abrupt path, following the straight line or the curved path through the compositions on the left, more so than the jarring paths on the right.



Figure 18.Law of continuity [86]

Potential usage of the law of continuity in Mingei: The essence of human movement in HCs entails the usage of tools and machines that happens through dexterous human movements. The visualization of such movements in 3D is simple as Mingei has established a motion retargeting methodology and tool usage demonstration methodology (see D5.2). In the case of movement summarization in 2D this should be bound to the law of continuity thus giving the essence of movement through the interpolation of static frames. The interpolation can have different qualities according to the desired focus (e.g. focus on the end of movement vs focus on the start of movement). Furthermore, the visualization of key points trajectories (e.g. trajectory of the wrist) is capable of enhancing the visualization quality providing directly visual information of movement.

Examples of the law of continuity as applied in the context of Mingei are presented in the context of section 5.6.

2.1.1.7 Law of Past Experience

The Gestalt law of past experience implies that elements tend to be grouped together according to the observer's past experience. If two objects tend to be observed within close proximity, or small temporal intervals, the objects are more likely to be perceived together. This law is unique for every individual as they do not have the same visual experiences in life. For example, a past experience we all share is the traffic lights; red colour indicates 'stop' while green light indicates 'go'.

Potential usage of the law of Past Experience: The Law of past experience is horizontal and plays an important role in many of the other uses of the laws in this section. Mingei aspires to use and enhance past experience of the users by providing visual vocabularies for each craft form.

2.1.2 Figure–ground organization

Figure-ground organization is a type of perceptual grouping for the interpretation of elements via vision according to shapes and location. Figure-ground organization structures the perceptual field into a figure and a background. The human brain separates whole figures from their background in order to understand the content. It is considered as one of the first things humans do when they are looking at any composition and it is extensively used as an intentional visual design technique in which an existing image's foreground and background colours are purposely swapped to create new images (**Figure 19**). E. Rubin and the Gestalt psychologists identified some of the visual properties associated with figures known as “*classical configurational cues*” such as convexity, symmetry, small areas and enclosure.



Figure 19.Figure-ground organization example [87]

Potential usage of figure-ground organization in Mingei: Background – foreground extraction techniques have been used by visual artists and cinema in order to transfer the point of interest of the viewer from the background to foreground and vice versa. This is something also called by visual artists and photographers as selective focus. E.g. blurring the background of a photograph will make a portrait style photograph looking like an actual portrait while on the contrary in not everything will seem to be in the same focus. This is not the way human mind is working.

Image processing algorithms in the domain of computer vision have identified this foreground background segmentation problem and an algorithm called grub cut has been explored for foreground extraction [80]. Mingei will exploit this technique to create background image masks that will allow the distinction of background information with foreground in craft visualizations with the application to illustrated craft practices.

Currently an example of an illustrated craft magazine that explores manual annotation and scene carbonization techniques is presented in ANNEX 2 of this deliverable. It is expected that such a visualization will be greatly enhanced with the integration of the aforementioned technique.

2.3 Application of the theory of perception in comic books

Modern comics from their earlier days have faced the problem of representing motion in static mediums. Many cues can convey the impression of motion in a static image. The first cue used for displaying motion in a single panel, was motion lines or speed lines. Motion was depicted by attaching motion lines on the moving object in order to define the trail of an action. At first, motion lines (or zip-ribbons) were irregular and messy but over the years, they became refined and even diagrammatic. Experiments have focused on the human brain's comprehension of motion lines, in cases of static panels that contain normal motion lines, anomalous lines (i.e., reversed direction), or no motion lines at all. These studies have demonstrated that motion in panels, using normal lines, were viewed faster than when no lines were present, which were in turn perceived faster than in the case of anomalous lines [88] [89]. Moreover, it was found that a specific level of neural coding moving stimuli generate responses that are related to motion lines and human perception can be biased by motion lines due to their connection with the visual system when of viewers [91].

Bill Everett and Jack Kirby were the first to use motion lines in their hero's narratives as they were depicting action with drama. Motion lines can be drawn in many different ways according to the extent of the motion activity and speed that is taking place in a static medium. In case of low speed action, the moving object and the background are presented in a clear and static style while the motion lines are defined as a path of motion imposed over the scene (Figure). Another technique of motion lines with high-speed effect is the one of a stable object that remains focused while the background is streaked. This technique has been mainly adopted in Eastern cultures such as Japan.

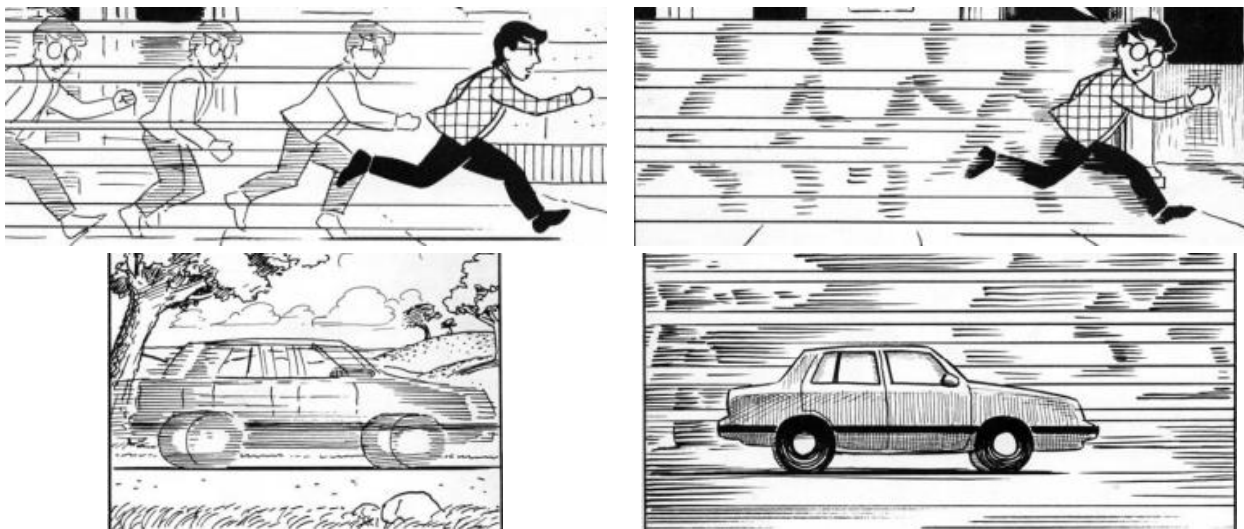


Figure 20. Motion lines [112]

In addition to the pre-mentioned techniques, many comic artists used multiple images displaying different poses of a sequential action, inspired by the futuristic paintings (Figure). Similar to this, in the sixties and seventies, Marvel creator Gene Colan incorporated photographic streaking effects,

which they were again multiple key poses but this time, not some realistic character depictions rather than sketched figures (e.g., shadows) that formed the action trail (Figure) [90].

An alternative of representing motion in comic narratives has been the sequential depiction of separate static panels each showing a partial act of a motion event in chronological order. This technique is naturally perceived because of the mental human visual process namely Closure or Visual Closure. Visual closure is a perceptual ability that allows humans to perceive correctly complete visual patterns even if they are not fully presented or presented in a segmented way. Human minds can perceive the “overall visual pattern” of the observed scene and detect, differentiate and understand the visual information by seeing little detail in order to recognize visual stimuli. These visual stimuli may be incomplete faces, figures, landscapes, letters, numbers, scenes etc. Visual closure is strongly related to the Gestalt laws of closure and experience, as they were presented in Section 2.2. Both they refer to the interpretation of incomplete figures as whole. Visual closure is an especially important skill for children learning to read, since it is what enables a reader to recognize a sight word instead of having to sound it out each time. ‘Closure’ as mentioned by McCloud, is extensively used for storytelling in order to provoke the feeling of suspense or challenge the audience. Closure is constant in electronic media such as filmmaking and television. Especially in comics, (visual) closure is the agent of change, time and motion and it is far from continuous. In comic panels, time and space are fractured creating a series of unconnected moments but it is the closure that allows human perception to connect these moments and create a continuous reality [25].

Closure is significant for understating transitions between separate storytelling images in comics nevertheless; it has different impact according to the category of sequence transitions. There are several categories of sequence transitions in comics such as Moment-to-Moment, Action-to-Action, Subject-to-Subject, Scene-to-Scene, Aspect-to-Aspect and Non-Sequitur.

1. **Moment-to-moment (or slow motion):** This transition is used in comics and gives a “slow motion” feel by making each second an important one. It requires little closure because it uses the least amount of time (i.e., changes in panels take only seconds).
2. **Action-to-Action:** It is the most common type of transition used in comics and it fully presents the transition steps of an action or scene. Action to Action transition often features single subjects in distinct frames. The first panel is commonly the beginning of an action and the last one is the end. Sometimes there are numerous panels in between depending on the complexity of the action.
3. **Subject-to-subject:** This transition is taking place within a scene or idea. The degree of the reader involvement is necessary to render these transitions meaningful. Time between the panels is simultaneous in many stories as well as space.
4. **Scene-to-scene:** This transition takes place across significant distances of time & space. The Scene to Scene transition is a powerful tool especially used in order to transport the audience to different times and places, with little to no explanation as to what has happened in between.

5. **Aspect-to-Aspect:** In Aspect to Aspect transition, time is completely either excluded or freeze and the representation of different aspects such as a place, an emotion, a mood of a scene are taking place. For the most part in this transition, “the wandering eye” activates the interpretation of an action by looking around and taking quick snaps to understand the context.
6. **Non-Sequitur:** This transition offers irrelevant panels with no logical connection among them. This category relies on the idea of putting dissimilar images together and giving a meaning and a relationship automatically.


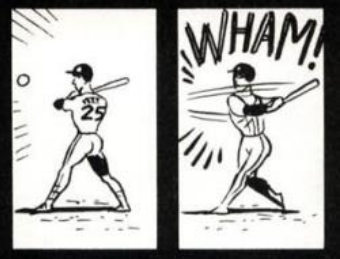




Moment-to-moment	Action-to-Action	Subject-to-subject
		
Scene-to-scene	Aspect-to-Aspect	Non-Sequitur
		

Figure 21. Comic book sequences [111]

3 Background & Related Work

Today, technology is offering a number of alternative ways to digitize human motion such as MoCap and Visual tracking technologies [4, 5]. Such technologies can provide an accurate digitized representation of movement in the 3D space [6, 7]. To accomplish that, key frame extraction techniques as well as features of motion visualization have been the focus in art and media community. At the same time, in the domain of computer graphics a great range of visualizing tools are available that allow the simplification of the production of 2D and 3D visualizations.

3.1 3D Visualisation techniques

Key Probe is a key frame extraction technique, relied on an algorithm appropriate for rigid-body and soft-body animations that converts a skeleton based motion or animated mesh to a key frame-based representation [8]. M. Wang and S. Guo in order to select a meaningful representative moment from an action performance, they have introduced Action Snapshot, a novel method that automates the process of generating meaningful snapshots taking as an input dynamic scenes and produces a narrative image based on information theory [9].

3D visualisation has also been proven valuable in the demonstration of Motion Capture (MoCap) data. Such an example is TooltY [10] a 3D authoring platform for demonstration of simple operations (e.g. usage of hammer, scissors) in 3D environments. In sports, human motion visualization is also used in virtual environments for displaying 3-dimensional models of swimmers by digitizing their motions and creating personalized virtual representations [11]. In the same context, Lucent Vision is a visualization system which has been developed for the sport of tennis. It uses real time video analysis, extracts motion trajectories and provides a variety of visualization options [12].

Action summarization is prevalent in human motion visualization community, as it can easily produce motion effects in still image frames, including videos and other means of art. For example, Action Synopsis is a method that takes as an input a variety of human motions either as 3D animation sequences or as video clips and presents motion in still images [13]. Creating compact narratives is challenging for video frames as well, such as the process of composing foreground and background regions of video frames into a single interactive image using a series of spatio-temporal masks [14].

Depth information of animations assists on summarization of 3D animation sequences into a single image. More specifically, there has been proposed a method that extracts important frames from the animation sequence based on the importance of each frame by its amount of contribution to the gradient and constructs a composite depth image and its gradient image [15].

Similar work has also been developed for the artistic motion visualization. H. Yang introduced a framework that produces rough drawings of images that tend to emphasize on thicker strokes for the most important features [16]. M. G. Choi also proposed an interface, where the user can browse overall motion by viewing the stick figure images generated from the database and retrieve them directly by using sketched stick figures as an input query [17].

Although these techniques are offering a wide range of motion visualization tools, some focusing on MoCap whereas others work exclusively on motion visualizations, there is still a need for an interactive yet easy tool addressing novice users. This evolution results in the need of new visualization techniques, further to the rendering of motion using a simplified 3D humanoid skeleton.

3.2 2D visualisation techniques

Over time, due to technical state-of-the-art alternatives of human motion digitation [92] [93] [94], a large number of existing studies in the broader literature have examined 2D motion visualization techniques. Action summarization technique is prevalent in human motion visualization community, as motion effects can be produced by processing a series of animated scenes and extracting still image frames as a result. Thus, a wide range of methods and tools has been developed over time. For instance, “**Action Synopsis**” takes as input human movements, encoded either as MoCap animations or videos and presents motion in still images [95]. **Action Snapshot** [96] is a method based on information theory that automates the process of generating a narrative still image by obtaining the optical key poses of animated scene sequences. A similar work [97] authored by Simon Bouvier-Zappa et al. is an interactive system that generates artist-inspired motion cues and synthesizes a single 2D image of an animated character derived from 3D skeletal motion capture data. M. Choi et al. has also introduced an interface [98] that creates compact narratives from videos, by composing foreground and background scene regions into a single interactive image, using a series of spatiotemporal masks in the form of 2D stick figures. In addition to the previous approaches, there are ‘Motion belts’ [99] which is a method that visualizes motion data by unfolding a motion into 2D stripes of key-frames. In the paper [100], it is also presented a motion notation approach namely ‘MotionNote’ which processes motion data and reconstructs a humanoid model including motion notation on a two-dimensional (2D) equirectangular perspective grid (EPG)[101]. Another tool is [102] for the real-time visualization of motion features in 2D image sequences through an eigenvector analysis of the spatio-temporal structure tensor at every pixel location. In [103], a 2D-based approach is presented, that post-processes computer generated images using the motion visualization techniques of speed lines, arrows and repetitive contours. EMVIZ [104] is an interactive artistic visualization system that generates dynamic visual representations of human movement qualities derived from a framework of Laban Movement Analysis (LMA) and addresses to an 'everyday' audience.

3.3 Mingei’s contribution

In this research work, we identify a gap between MoCap and artistic motion visualization. We propose a merging of these dimensions into a single workflow that can lead from MoCap to visualization. As an example of this approach, we implemented MotiVo a 2D visualization editor. In this editor two tools are presented. The first produces motion visualization based on video key frames while the second in visualizing 2D movement trajectories calculated by a popular visual tracking Computer Vision library. To further assist users into their visualization tasks we also include some post processing tools that allow (a) the application of image filters to visualization sources and (b) the manual annotation of produced visualizations. Furthermore, out of the experience gained in this research several guidelines are offered for sufficiently capturing and visualizing motion using MotiVo.

4 Human motion acquisition in Mingei

For the purposes of the research, work conducted in T5.5 during the first year of Mingei two types of potential digital input were facilitated. The first type is still images, image frames, and the second type, is motion data.

4.1 Image and video sources

Traditional means of recording actions such as photographic documentation and video are of particular importance for this research work. Furthermore, video sources can be found on the web, on documentaries but also be easily recording in a number of alternative ways (web-cameras, hand-held cameras, mobile phones, etc.).

4.2 IMU based MoCap

For the recording of the motions during each task, the inertia measurement units (IMUs) full-body motion capture suit (Nansense, BioMed Bundle) (NANSENSE Inc, 2019) was used. All components are portable; therefore, it was possible to record the expert under both real and simulated conditions. The whole body movements were recorded including the hands' gestures. For the capture of the expert's gestures, the BioMed bundle motion capture system was used. This system consists of a full-body suit composed of 52 IMU sensors placed throughout the body and hands, as shown in Figure 1. The sensors allow measuring the articulated spine chain, shoulders, limbs, and fingertips in a rate of 90 frames per second.



Figure 22. Full-body motion capture suit from NANSENSE Inc. (source <https://www.nansense.com/>) [34]

This system was selected over an optical system because of the limitations presented in the recording environment. For the silk pilot, the environment consisted of an indoors workshop where space was limited due to the large structures of the looms, and silk preparation equipment. This was not a problem for the inertial system since for the recording the expert need only to wear the

suit. In the other hand for an optical system confined places are problematic due to possible occlusions, and the need for installation large equipment. In the Chios Mastic Museum, the recordings are outdoors where the Mastic trees are located, for this recording conditions the inertial system is more adequate due to its practical installation, and because optical systems are sensitive to light changes, and reflections, requiring a light-controlled environment. Finally, for the glass pilot, the recordings are in a high-temperature environment, a problem for optical systems due to its sensitivity to heat which affects the measurement of its infrared emitting diodes.

The processing of the MoCap dataset consisted of two steps, first the application of a low pass filter, and then the correction of erroneous postures either caused by electromagnetic interference or sensors drifting when the task was going on for too long and another calibration was required.

The entire process for the acquisition of the final DataSet to be visualized by T5.5 and reported in this deliverable is described in D5.1.

4.3 Model based pose estimation

For the Model based pose estimation T5.5. is getting input from the methods implemented on T5.4. and reported in D5.4.

These methods serve the goal of utilising documentary archives to extract 3D information about human motion and action in craft practice. Task 5.4 targets the development of methods and tools for the 3D tracking of the articulated motion of human hands and body, based on the visual information of conventional RGB videos. The purpose of this task is to utilize video archives and documentaries of craft practice that are available from past studies.

The objects (materials and tools) that are manipulated during craft practice are of interest as well. The use of machine is of interest and, in particular, the physical interface that a person interacts with (i.e., a level, a button, a trigger etc.).

As the motion of these objects is determined by human action, in T5.4, we treat object tracking accordingly and assume that contextual hand tracking information can provide priors that facilitate the task, i.e., such as the identity of the object and the fact that the person is holding a tool.

Object **pose estimation** refers to estimating the six (6) degrees of freedom (DoF) defining the position and orientation of a rigid object relative to a camera. Typically, a model is used to provide pose estimation with geometric knowledge about the object of interest.

Object **tracking** refers to the task of locating a set of objects in a video frame, assigning a unique identifier to each of them, and maintaining the track and the identity of each of the objects as they move around in subsequent frames. Key aspects of tracking are accurate object detection and

localization, object modelling (e.g. appearance or shape) and motion filtering (i.e. due to estimation errors).

In T5.4. a model-based approach is implemented for all components, based on available context dependent information (i.e. approximate model of human body, or 3D models of available tools and machines).

The entire process for the acquisition of the final DataSet from Model based pose estimation to be visualized by T5.5 and reported in this deliverable is described in D5.4.

5 3D Human Motion Analyser & Visualizer2D Human Motion Artistic Visualizer (MotiVo)

5.1 MotiVo rationale

Nowadays, technology is offering a number of alternative ways to digitise human motion such as MoCap and Visual tracking technologies. Such technologies can provide an accurate digitised representation of movement in the 3D space. This evolution results in the need of new visualisation techniques, further to the rendering of motion using a simplified 3D humanoid skeleton. At the same time, in the domain of computer graphics a great range of visualising tools are available that allow the simplification of the production of 2D and 3D visualisations. In this research work we identify a gap between motion capture and artistic motion visualisation. On the one hand, technology offers new capturing means and on the other new visualisation tools. We propose a merging of these dimensions into a single workflow that can lead from capture to visualisation. As an example of this approach we implemented MotiVo a 2D visualisation editor.

5.2 Motion extraction techniques

Activity is a key component of many forms of human expression such as dances, crafts, and rituals. Digitisation of human motion has been achieved by a number of methods. Two main method categories are **Motion Capture** (or MoCap), which requires human subjects wear technological items [1], such as markers or sensors, and **Visual Tracking** methods, which do not impose such requirement. MoCap technologies measure the movement of subjects in 3D. Two main technologies are used: optical and inertial measurement. The results encapsulate human motion in 3D with great detail and provide a complete representation of the recorded motion. Visual Tracking methods use visual sensors to record human subjects [3]. Motion is estimated in 3D by processing of the visual stream. The cost of the unobtrusive nature of these methods is the confrontation with the problem of treating visual occlusions and the inference of subject motion missing from the acquired images, due to these occlusions.

5.3 Test data used during implementation

For collecting data for our case study we used the following methodology. Initially we recorded in a video format a person performing typical activities such as for example hammering a nail. The data received from this process were post processed in the following ways:

- The video stream was segmented to video frames and frames of interest were then extracted from the video stream to produce a summarisation in frames of movements
- The video stream was used as a source for the [OpenPose](#) Computer Vision library. Open pose represents the first real-time multi-person system to jointly detect human body, hand,

facial, and foot key points (in total 135 key points) on single images. OpenPose produces an estimation of a Humanoid skeleton in the 2D plane of the image. Using the OpenPose output in this research work we isolated specific joints of the skeleton in order to produce the trajectories path for our visualisation algorithm.

5.4 MotiVo overview

MotiVo UI is structured as follows (see **Figure 23**):

- **Section #1:** This is the main menu of the tool from where main operations can be found such as open, save, load project, etc.
- **Section #2:** This is the main tab container where the various tools can be selected. Each tool is a tab page of this container
- **Section #3:** The section where the selected visualisation tool appears
- **Section #4:** A tab container with all project assets
- **Section #5:** The output window where tools are posting messages



Figure 23. MotiVo UI structure [41]

5.5 UI implementation

The main requirement of the system-UI architecture of MotiVo was to use a plug-in based concept where there is a distinction between the main system and visualisation tools. This distinction was

important to address the main goal of MotiVo implementation which was the development of an extendable motion visualisation system where new tools are added as new visualisation tools arise. In such a context, it was decided that the main system should support the creation of project files and the assignment of assets to these projects (images, videos, BVH files, image trajectories, etc.). All tools should be then, loaded as window components and should be drag-drop enabled i.e. they should be able to receive draggable input in the form of images, videos, etc.

Taking into account this main requirement and decision a dockable UI container architecture was selected based on the one followed by Integrated Development Environments. In such an architecture component can be loaded and unloaded on the fly and new components can be loaded as plugins by integrating a new dockable window to the main window manager. Furthermore, this was considered a good option as one of the target groups of this tools is technical people with expertise on using dockable layouts (with the rationale that such layouts are used both by graphics and code editing software). The only limitation is that typically such UIs may have a longer learning curve than simpler ones with the added value of extendability and extensibility in the future.

For the purposes presented above it was decided to structure the UI of MotiVo on top of the DevZest WPF Docking library that simplifies the integration of undo/redo-able tabbed docking, floating and auto hide window management into WPF applications.

Based on the proposed architecture the main shell of MotiVo was built that integrates the main containers (images, videos, BVH sources, image trajectories, etc.), the create and open project functionality and an output window container where all MotiVo tools can post output messages. Then the development of tools can be done autonomously in separate WPF projects as these are imported as plugins to MotiVo.

5.6 Software implementation details

5.6.1 Motion Blender

Motion blender creates a directional motion effect by overlapping key pose frames into a united content. More specifically, as a dataset, each user is able to import multiple strong pose images considered as the main actions of an activity. This dataset is different for every user. The combination of all the frames denote the summary of the overall event. Except for the visualisation of motion regarding the direction, the user can emphasize on each frame with varying volumes on contrast and colour intensity. The density of each image frame is correlated with a value which is determined by the user's preferences through the interface sliders.

Depending on the nature of activity, the given emphasis on the image frames is differentiated. In many cases the most significant action is the initial, the middle or the last. For example, when hammering a nail, the primary action is the last frame which indicates how exactly to hit the top of

the nail, therefore this action is highlighted the most. In contrast to the previous example, in dance choreographies all movements are equally important in order for the user to understand the total activity. The resultant image is altered at runtime and the output is a single image file.

5.1.1.1 Notation

A colour image I at coordinates (u, v) has pixel value $c = I(u, v)$, where c has values $\{R, G, B\}$. We do not treat monochromatic (grayscale) differently. If such input is given, the monochromatic channel is replicated in all the RGB bands and the image is treated as a colour image.

5.1.1.2 Averaged and Weighted combinations

Let n the number of key frames selected by the user. We denote with I_i the images of these key frames, where i is in $[1, n]$. In case of equal distribution between contrast and volume of the image frames, for each I_i we average the corresponding pixel RGB values from the colour arrays of each selected image. This can be achieved when the user sets all the values evenly. The combined result is a visualisation of all the images demonstrating the motion (see Fig.1)

$$I_s = \sum_{i=1}^n \frac{I_i(x, y)}{n}$$

Averaged equation

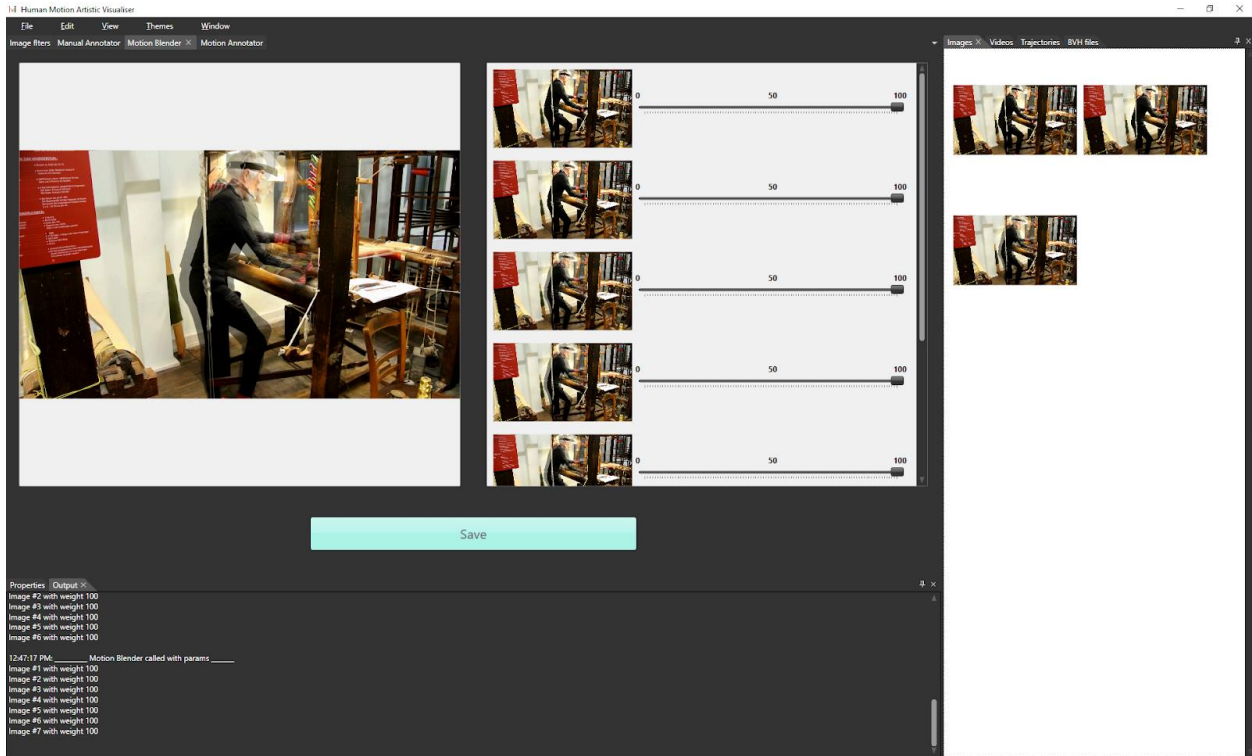


Figure 24. Averaged Motion visualization [42]

An extended approach of the previous scenario, is the weighted visualization of human motions. In this version, users are capable of altering the UI slider values thus setting different weight value w_i for each image frame to denote the contrast intensity depicted in the final result. For lower weight values, the frames have low opacity volume in contrast to high weights values where the R,G,B values are greater. The effect of fading and overlapping motion allows the human eye to easily perceive the chronological visualisation of motion. The image formation equation of the resultant images is the following (Fig.2)

$$I_s = \frac{\sum_{i=1}^n w_i * I_i(x, y)}{\sum_{i=1}^n w_i}$$

Weighted equation

Average and weighted visualisation of Motion blender were implemented in C# using the WPF. In order to rectify the problem of CPU overhead in pixel operations, the algorithms presented above were optimized using parallel loops and direct memory access.

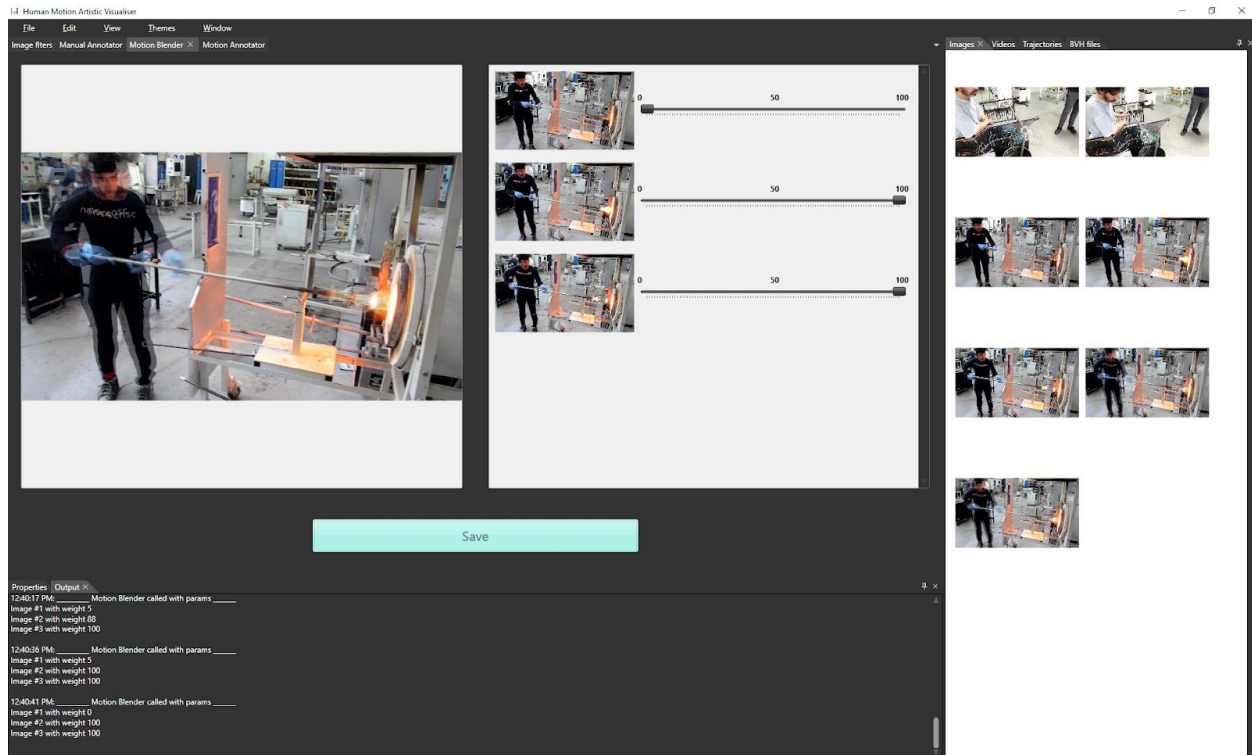


Figure 25. Weighted Motion visualization [43]

5.1.1.3 Optimization

In order to rectify the problem of CPU overhead and time delays for processing the pixel colour arrays, we optimized the algorithms using parallel iterations by extracting the colour values in the form of bytes instead of bits. Thus, we achieved to both convert the images derived from a directory to colour arrays consisting of pixel values and combining them altogether. The result was significantly optimized.

5.1.1.4 Experiments

We examined three cases in which the weights of the image frames are differentiated according to the scene and the action. The first case is based on the first motion, the second case on the final motion and the third case on the averaged weight values for all the motions that consist the whole action.

In the first case the key point movement is the start, meaning that how the action started is the most important whereas in the second case, the final motion indicates the actual meaning of the action. Finally, in the third case, the total number of movements are equally significant for the specific action.

Case one: In this case, as an action is taking place, the key motion is how it started. The user can focus on the first movement fading out during the action, indicating the direction. Setting the first

image weight to its maximum value of 100 and all the other values in descending order the result is representing as follows (see **Figure 26**).



Figure 26. Hammer a nail - Case one [44]

Case two: In this case the last motion that consists of the action is the key pose that we are interested in. As before the user can give emphasis in the last image frame using greater weight values for them (see **Figure 27**. Waving - Case two [45])

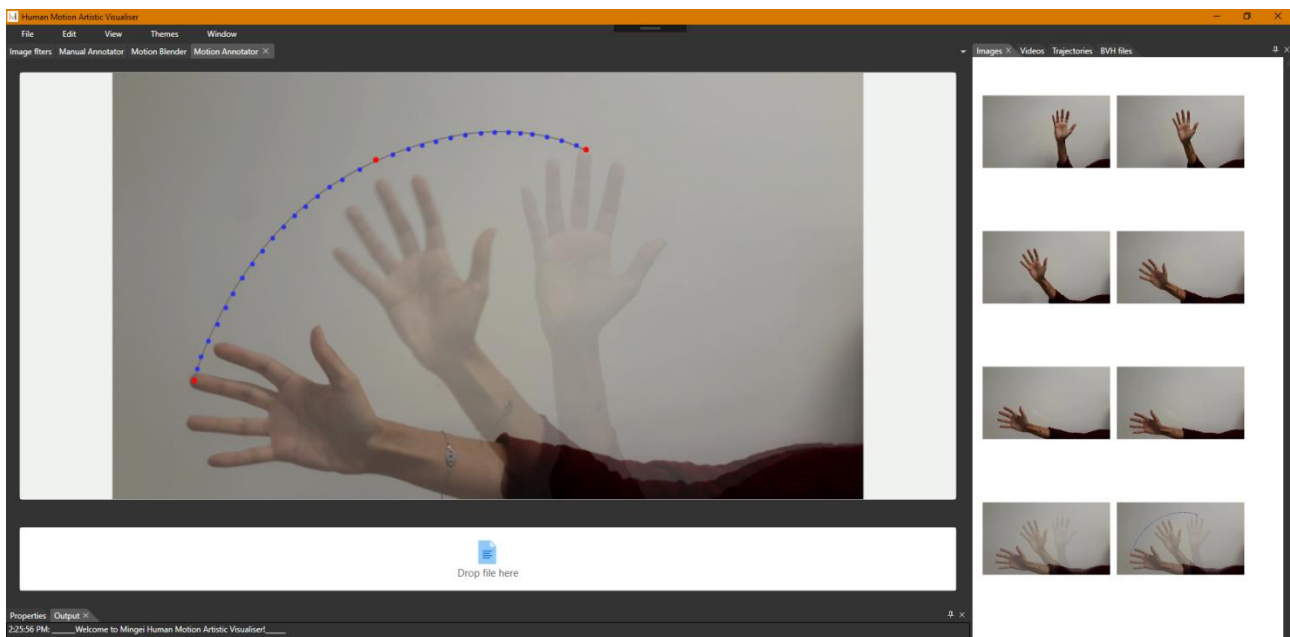


Figure 27. Waving - Case two [45]

Case three: In this case the averaged weighed motions are visualized giving an intuition of how exactly the motion has taken place. Dancing moves or choreographies are some of the examples with need of precision during the whole process (see **Figure 28**)



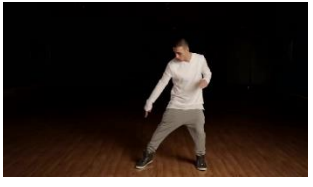
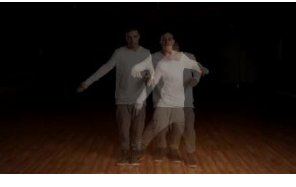








Input 1	Input 2	Input 3	Output
			
			
			

Figure 28. Dancing moves - Case three [46]

The tool produces clear results in stable camera focus. In cases of non-stable camera, the output is slightly blurred and disoriented (see Table.2). Thus, this tool works best for static camera videos, or video segments where the camera is static.

5.1.2 Motion Annotator

The second tool of the MotiVo user interface is called Motion Annotator. As an input it takes an image file as well as a trajectory file containing the coordinates of the X and Y axis in 2D. The x,y coordinates correspond to the canvas points of the input image. We have developed an algorithm that highlights with artistic designs the specific coordinates provided by the trajectory file. There are multiple ways of hi-fidelity artistic representations that can be visualized such as bullets, lines and arrows. The annotated points on the image frame denotes the direction of the motion. For example, in the case of hammering a nail as previously, by annotating the frame in points

highlighting the human hand trajectory during the activity, the tool creates a directive as a result (see Fig.3)

5.1.3 Manual Motion Annotator

In some cases, there is a need to manually annotate motion especially where semantic information is to be added to the visualisation. In such a case, in this research work we exploit the techniques used to create juxtaposed illustrations in cartoons and comics. The manual motion annotator is an editing component that allows users to load an image source from the project assets and manually annotate this source using ready to used concepts from cartoons and comics.

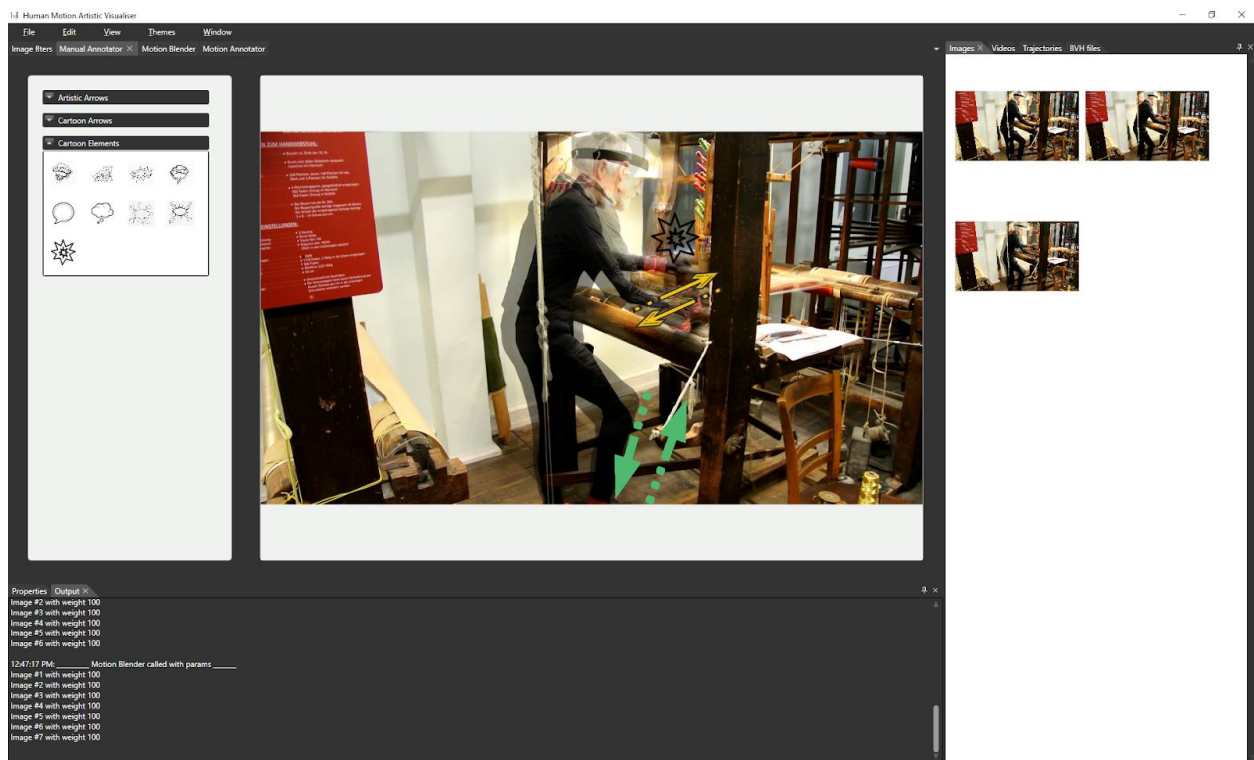


Figure 29. Manual motion annotation [47]

5.1.4 Image filters

The fourth tool of the MotiVo user interface is called Image filters. As an input it takes an image file that can be dragged from the project assets container to the tool. The control provides a list of image filters that can be altered to an image similar to the ones used in popular image processing software (see **Figure 30**) (original implementation of the filters on [20] and [21]). **Figure 31** presents some examples regarding the application of several image filters on the same source image.

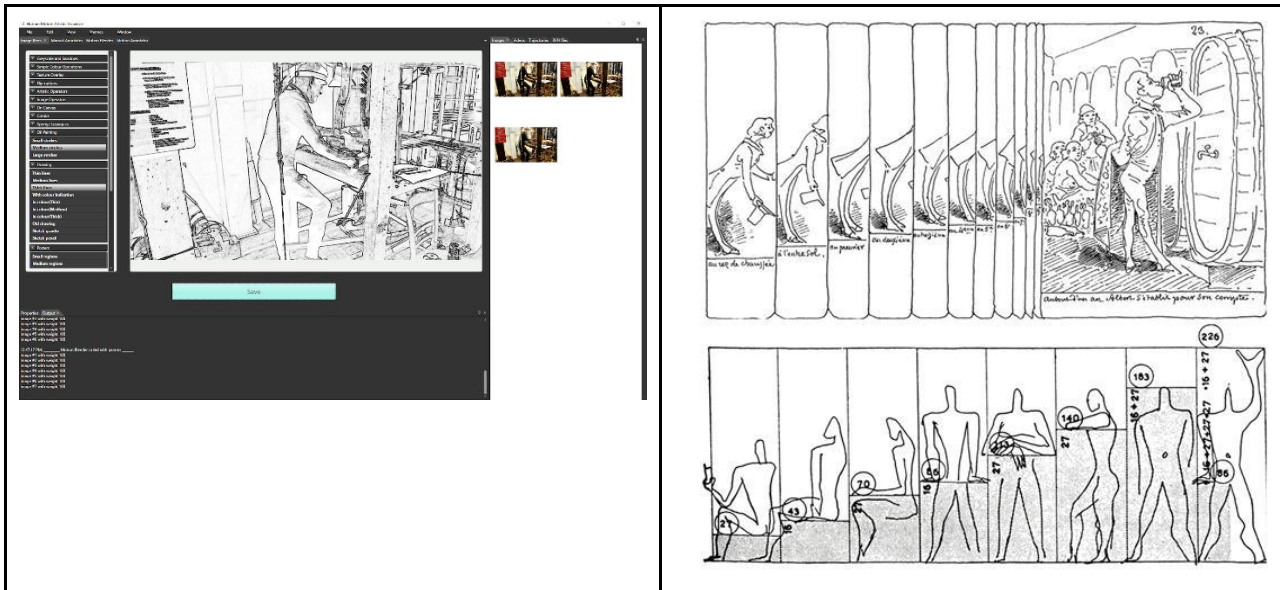


Figure 30. Application of edge detection filter (inspired by the work of Rodolphe Töpffer [22]) [48]

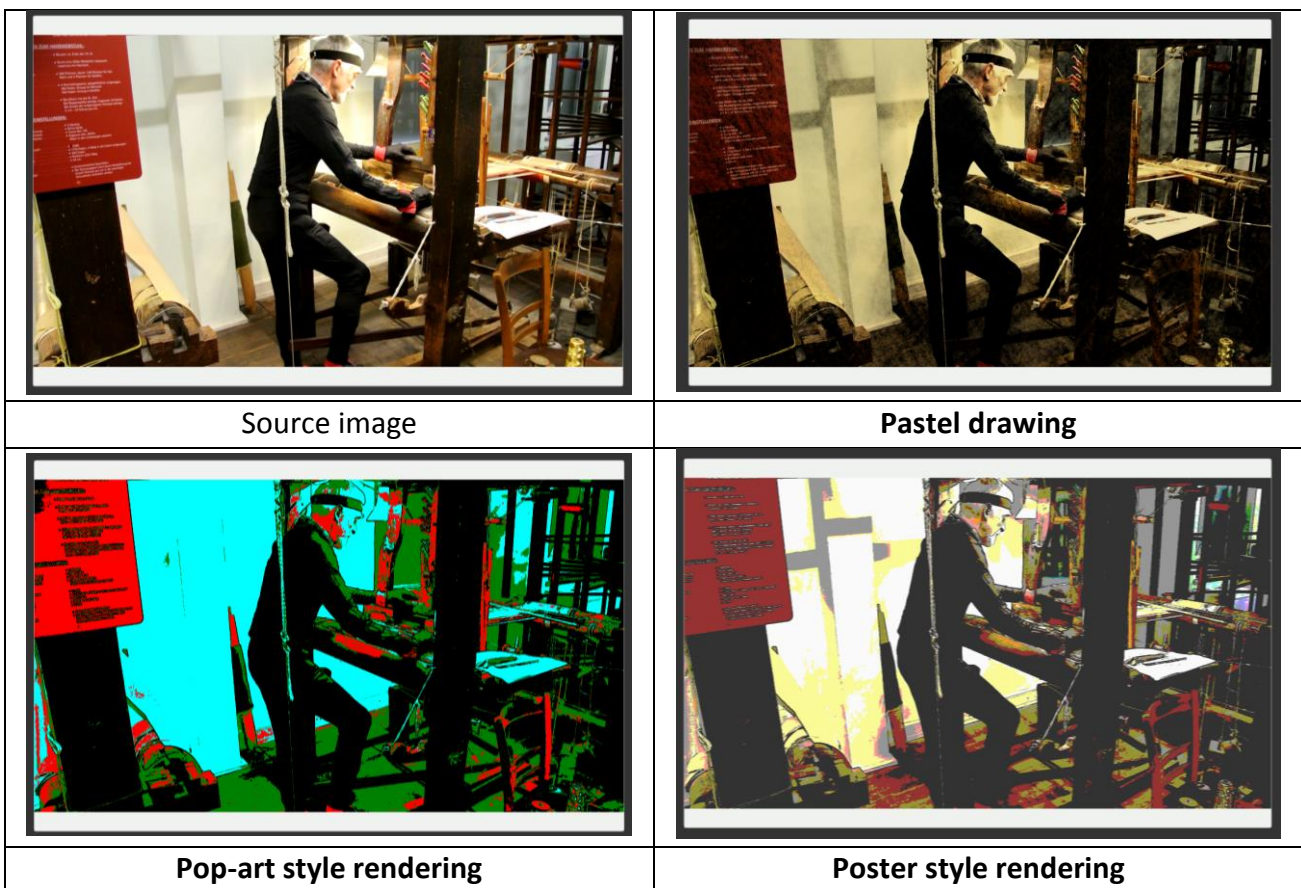




Figure 31. Application of various filters to a source image [49]

The complete list of image processing operations that can be applied via the MotiVo is presented in Table 1. This table presents the filter together with their implementation details.

Simple Colour Operations	
Invert	AForge Image Processing Library ²
Rotate	
Sepia	
Extract Red Channel	
Extract Green Channel	
Extract Blue Channel	
Red	
Green	
Blue	
Cyan	
Magenta	
Yellow	
Texture Overlay	
Clouds	AForge Image Processing Library
Rust	
Dirt	
Labyrinth	
Wood	
Marble	
Textile	
Flip	
Flip Horizontal	Custom Pixel Shader running on the GPU
Flip Vertical	
Flip Both Directions	
Artistic Operators	
Anaglyph	Custom Pixel Shader running on the GPU
Show brush-strokes (Darken)	AForge Image Processing Library
Show brush-strokes (Lighten)	
Highlight texture	Custom Pixel Shader running on the GPU
Old photo	
Triptych	
Glass tiles	
Water	
Water Calm	
Water Wave	
Image Operators	
Blur	AForge Image Processing Library
Sharpen	

² <http://www.aforogenet.com/>

Smoothing	
On Canvas	
Canvas	AForge Image Processing Library
Canvas Grayscale	
Canvas Sepia	
Comics	
16 Colours	AForge Image Processing Library
32 Colours	
64 Colours	
Sponge techniques	
Soft	AForge Image Processing Library
Soft (with colour)	
Medium	
Medium (with colour)	
Thick	
Thick (with colour)	
Oil Painting	
Small strokes	AForge Image Processing Library
Medium strokes	
Large strokes	
Drawing	
Thin lines	AForge Image Processing Library
Medium lines	
Thick lines	
Preserve colour indication	
In colour(Thin Lines)	
In colour(Medium Lines)	
In colour(Thick Lines)	Custom Pixel Shader running on the GPU
Old drawing	
Sketch granite	
Sketch pencil	
Posters	
Small regions	AForge Image Processing Library
Medium regions	
Large regions	
Watercolour Small regions	
Watercolour Medium regions	
Watercolour Large regions	
Watercolour	
Watercolour bright	Custom Pixel Shader running on the GPU
Mosaic	
Small tile	Custom Pixel Shader running on the GPU
Medium tile	
Large tile	
Round tile	

Pop Art	
Pop Art (Red Green Blue)	AForge Image Processing Library
Pop Art (Pink Violet Orange)	
Pop Art (Yellow Mauve Orange)	
Pop Art (Pink Blue Orange)	
Pastels	
Pastel Pencil Drawing	Custom Pixel Shader running on the GPU
Pastel Sticks	
Lighting	
Lighting	Custom Pixel Shader running on the GPU

Table 1. Available image processing filters [64]

5.1.5 Scene composer

The scene composer was inspired by the depictions of crafts in art and photography with the vision to be able to abstract human motion and tools to the minimum ingredients and thus being able to depict the essential parts of the craft in order to enhance human perception and understanding and thus assist the development of captivating visualisation for information and education.

The scene composer is a tool that takes as input an overview of the scene from a static moment in the course of a craft action e.g. (passing the shuttle through a loom). This static motion frame is then used by a computer vision tracker capable of tracking the position and orientation of hands and objects. In both cases we march from the hypothesis that the tracker has already the geometry and texture of the object to be tracked (e.g. a generic model of a hand or a 3D model of the tool to be tracked). In both cases the tracker is estimating the Rotation and Translation and Scale of the object tracked (i.e. hand, or tool) and overlays the model on top of the given frame for abstraction and emphasis on the spatial arrangement of the critical actors in the scene. Scene composer is inspired by robotics where computer vision trackers are used to estimate the location of objects and robotic manipulators to calculate appropriate grip postures for the manipulation of objects by the robotic manipulator (see **Figure 32**)

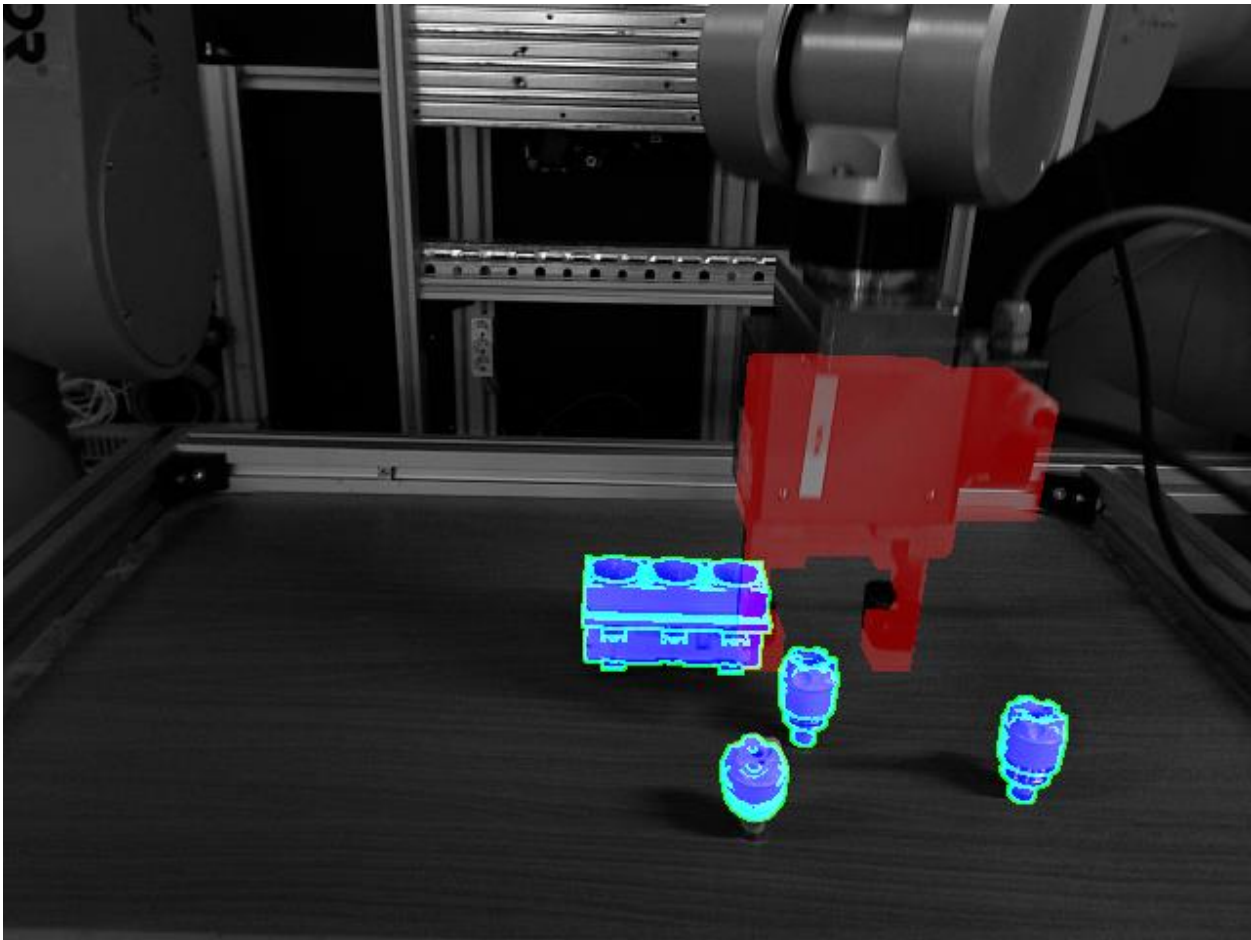


Figure 32. Objects and robotic manipulator tracking to estimate grip postures (inspiration for the scene composer implementation) [50]

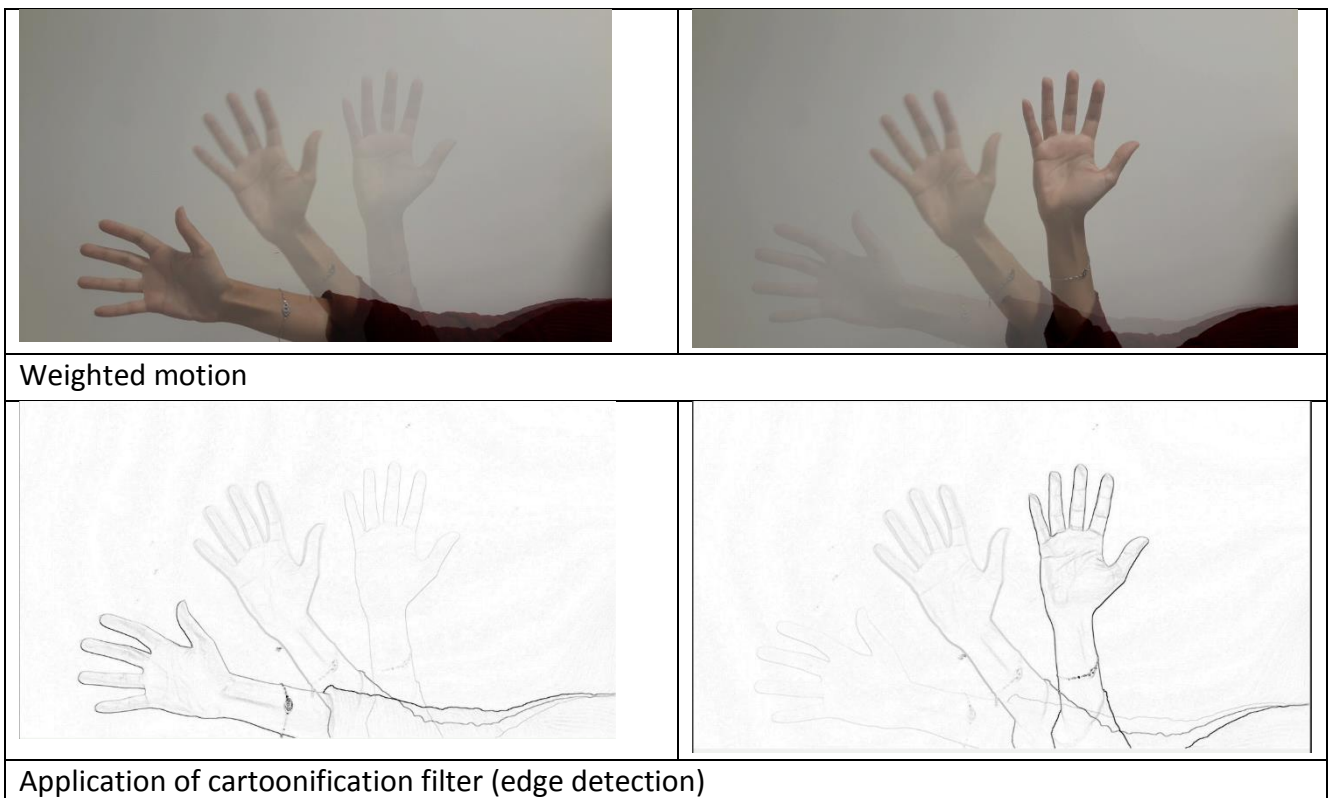
In the following figures the process of integrating information to static frames using the scene composer tool is illustrated. As shown in these illustrations on the right we have the 3D model of the tool that is used by the motion tracker and on the right the inference of the position of the tool in the static frame.



Figure 33. Visualisation of tool usage through the estimation of hand and 3D model pose within the static motion frame [51]

5.1.6 Combined tool usage

The following figures present examples of combined tool usage to achieve artistic visualisation results.



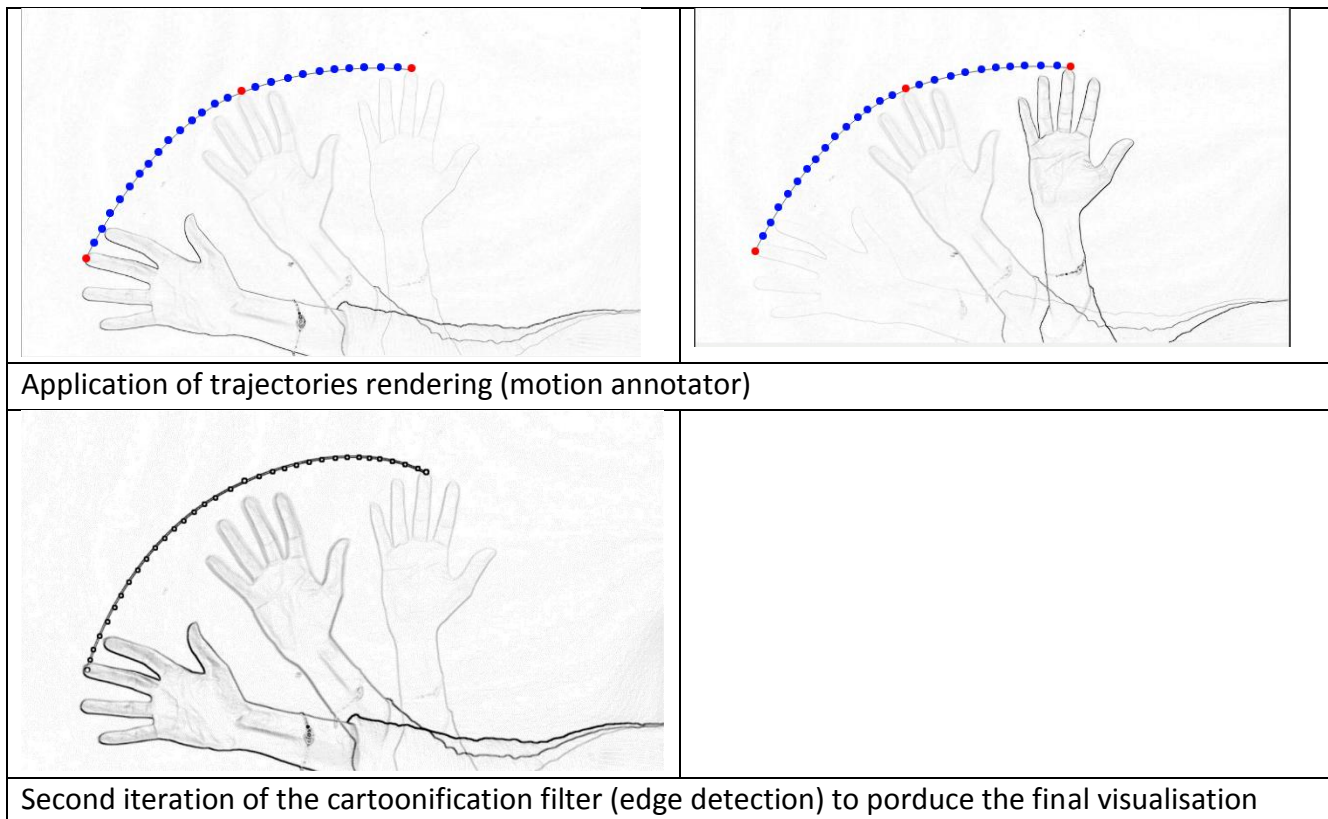


Figure 34. Combined examples (weighted motion, image filters and trajectories visualisation) [52]

5.7 Experiments and guidelines

For all the presented tools data stemming from three pilot sites of Mingei were used. Data contain both still images and video sources of the recording of practitioners in the context of the project activities. Based on this data experiment were performed to test several motion visualisation strategies. Out of the outcomes of such experiments a set of preliminary guidelines was formed to address the needs of each individual tool.

In order for the users to have a better experience with MotiVo, we propose some guidelines based on our own experiments as presented above.

5.1.7 Guidelines for using the Manual Annotator

- **G1:** Depending on the nature and style of the annotated image, users should choose graphic elements of similar style so as to fit the context.
- **G2:** For comic style images, annotations could be comic styled or even multi-coloured whereas in the case of simple and minimal images, artistic arrows or other elements are the appropriate ones.
- **G3:** The selected annotation stickers should have enough contrast to the image background so as to be visible.

- **G4:** *Due to the fact that we are trying to visualize motion in 2D space, users are advised to adjust the projection on the annotation stickers so as to indicate the depth and direction of motion.*

5.1.8 Guidelines for using Motion Blender

After experimenting with different input files and weight values for each image frame, we concluded that camera functionalities are playing a significant role in the final product.

- **G1:** *Motion Blender produces clearer results in stable camera focus in 2D space.*
- **G2:** *On non-stable camera the output is slightly blurred and disoriented without displaying the exact action in an aesthetical way. In this case several experiments may be required from the user side in order to acquire a sufficient visualisation*
- **G3:** *When working with moving camera select a frame of reference where the camera is static and another one with a lot of changes happening in the initial scene. This will improve the blending quality.*

However, we are going soon to extend MotiVo by creating tools capable of supporting visualization techniques for moving camera when linking with 3D information (Section Future Work)

5.1.9 Guidelines for using Motion Annotator

- **G1:** *The use of 2D trajectories can be sometimes be non-representative. The total number of Points (x,y) should be great enough in order the trajectory visualization to be precise. Despite the fact that we use Bezier splines to design curves, the input files content should be a good starting point for the Motion Annotator.*

5.1.10 Guidelines for using Motion filters

- **G1:** *Motion filters may be a powerful tool for post and pre-processing results. Experiment with motion filters to have an overview of the potential outcomes*
- **G2:** *When a motion blending fails you can facilitate motion filters to simplify the input of motion blender and thus get better visualisation results*

5.1.11 Guidelines for using Scene composer

Scene components relies on a visual tracker to estimate the position of objects in the source frame.

- **G1:** *Make sure that source frames have sufficient information regarding the visualised-tracked object or hand (i.e. it is clearly visible)*
- **G2:** *When using source frames containing partial object and hand occlusions several experiments may be required*

- **G3:** *Don't use source frames where the position of the object can only be inferred through the position of the hand (non-occluded hand but occluded object).*

5.8 Improvements foreseen for the next reporting period

In the next reporting period we plan to generalise the presented approach and in particular:

Regarding motion blender, we intent to enhance the blending algorithms and create some pre-sets to enhance its usage in accordance to the guidelines.

Regarding motion annotator, we intent the integration of richer drawing formats that will allow the system to draw more artistically pleasant trajectories.

Regarding image filters we intent to extent the currently limited filter combination so as to provide solutions that apply several filters at the same time to a given input so as to produce a certain outcome. Furthermore, explore the advances on style transfer algorithms to provide even better visualizations.

Regarding manual annotator, we intent to extend the library of annotation to cover more use cases and application domains and if needed create domain specific libraries.

Regarding scene composer, the integration of 3D information to the static motion frame will allow us to open the way for using 3D data in the 2D visualization of motion in favour of scientific, analytics and visualization purposes. Regarding scientific purposes such visualizations of accuracy, repeatability and objectivity. In terms of analytics and visualization such visualization can enhance the capacity of extracting analytics form a scene and visualizing the analytics on the scene. Furthermore, in the future this could enhance the capacity of producing video visualizations and even isolate the actors of a movement so as to reproduce in another context such as for example in VR training.

6 Human Motion Analyser & Visualizer

6.1 System information

Human Motion Analyser & Visualizer is a software tool implemented in Unity 3D for analysing and visualizing human motion data. In this context, an analysis algorithm was created that receives as input a BVH file. The BVH file is parsed and the result is stored in an animation curve (a multidimensional array whose values represent a human's joint position in each frame). Using C# each joint's velocity is extracted and represented in Unity3D's graphical environment. The processing of results is done in Matlab, using a smoothing algorithm to eliminate noise and save them in a text file. The smoothed values are then imported in Unity, overriding the previous ones to create a more representative motion capture result. The following sub-section provide an extended overview of the functionality and results.

6.2 Velocity visualization

Using the aforementioned MoCap dataset as input, for each joint of the 3d human model a line was created to depict the resultant velocity of each such joint (see Figure 36). Every joint has three animation curves that depict its position in every axis (x, y, z) for all the animation time. Using that data two position vectors were extracted; the position of a joint in a certain frame (frame_pos) and the position of the same joint in the previous frame (prev_frame_pos). The magnitude M of the joint's resultant velocity was calculated based on the expression $\sqrt{...}$ and the direction D was found by calculating the velocity's deviation in each axis. All this was done using C# programming language in Unity both for calculating and visualization.



Figure 35. Visualisation of joint assignment (source: Mingei, 2019)[35]

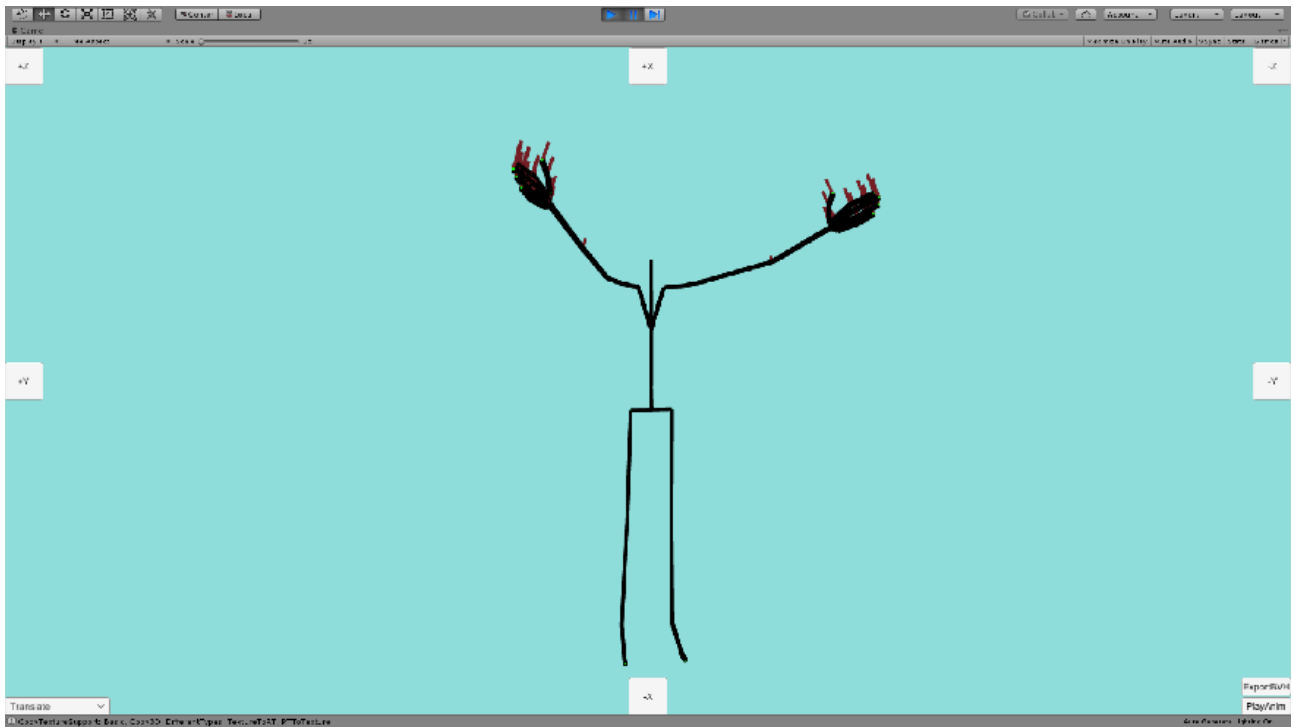


Figure 36. Motion capture results with velocity visualization [36]

The line visualization is done with unity's line renderer and an option is also given for visualizing the movement trail of a certain joint. The trail consists of circles created in 0,01 sec. intervals for the animation's whole duration. To pinpoint the location of this joint, `frame_pos` was used and refreshed every interval.

6.3 Dataset normalization

In order to achieve a more normalized dataset, a smoothing filter was utilized in Matlab³. The method used is the moving average smoothing algorithm. It is a low pass filter with filter coefficients equal to the reciprocal of the span. The filter took as parameters an array `A` containing all of a joint's velocities (stored in an array `animation_data`) for the duration of the animation clip and an integer `K` representing the span; the number of data points for calculating the smoothed value. While the filter originally accepted only odd integers as a parameter, certain changes were made to allow for even values as well. The changes are based on the coefficient neighbouring the filter's centre and the arithmetic mean of the dataset.

³ <https://www.mathworks.com/products/matlab.html>

Two methods using that smoothing filter were implemented and contrasted to find the one that produced better results. Both methods were used upon the same motion capture file with the same span parameter ($K = 10$). The parameters that played a vital role, in the decision of which of the two methods performed better, were radical deviation from the original movement and robustness. The results should depict gradual movement which doesn't differentiate too much from the starting data and should cope with erroneous input.

The first method applied the filter to the resultant velocity and overwrote the lines' visualization (see Figure 3). While the magnitude changed for each node, the direction remained the same (D). This method is more crude, producing results with more discerning differences in magnitude and zero change in direction. Movements that were caused by an action in only one axis, while the rest remained stationary, were much more overestimated by the filter and that caused some inconsistencies with the real life data since the direction was not adapted to the change in the movement's direction.

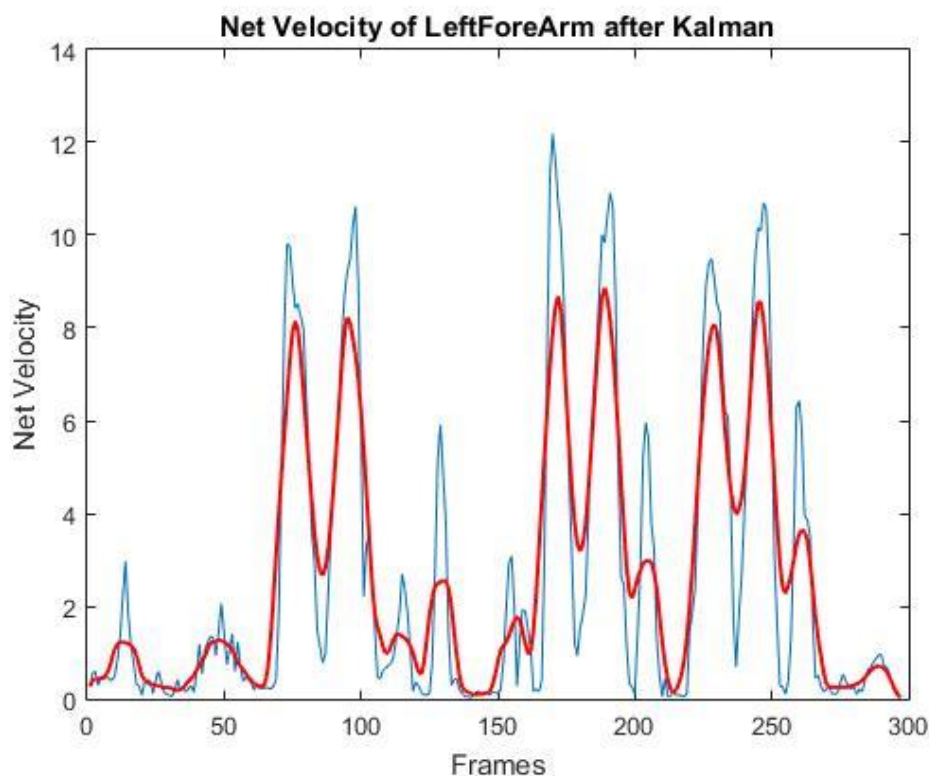


Figure 37. Kalman filter applied to net velocity [37]

The second method applied the filter to each of the velocity's axis separately and then produced the resultant velocity for each joint (see Figures 4-6). This method was much more impactful in the direction that the largest movement occurred, as it affected the vector's magnitude as well as the direction towards the most influencing axis. For each one of the figures seen below, it is easily observed that small change is mostly ignored by the system while larger change affects the direction as well as the movement on the coordinates that this movement occurred. This method is

much more accurate in representing the actual movement but sometimes underestimates the overall velocity if significant change occurs in two or more axis simultaneously.

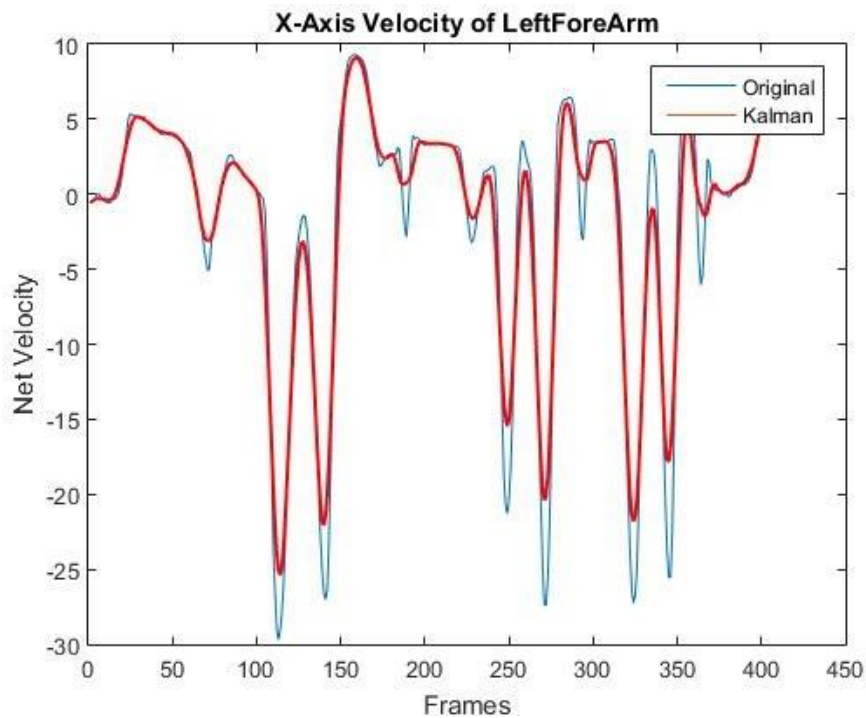


Figure 38. Kalman filter applied to velocity's x-axis [38]

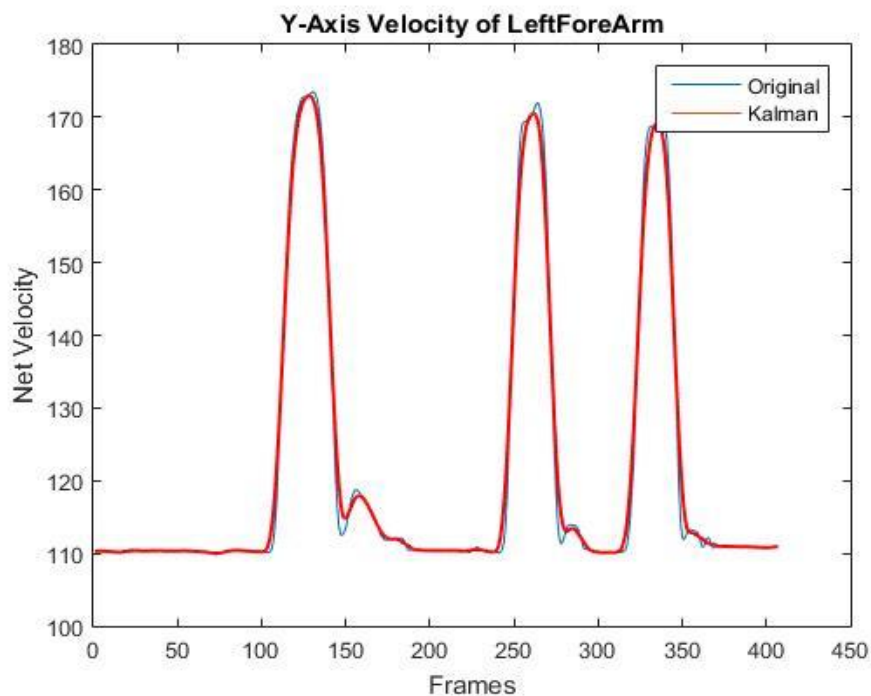


Figure 39. Kalman filter applied to velocity's y axis [39]

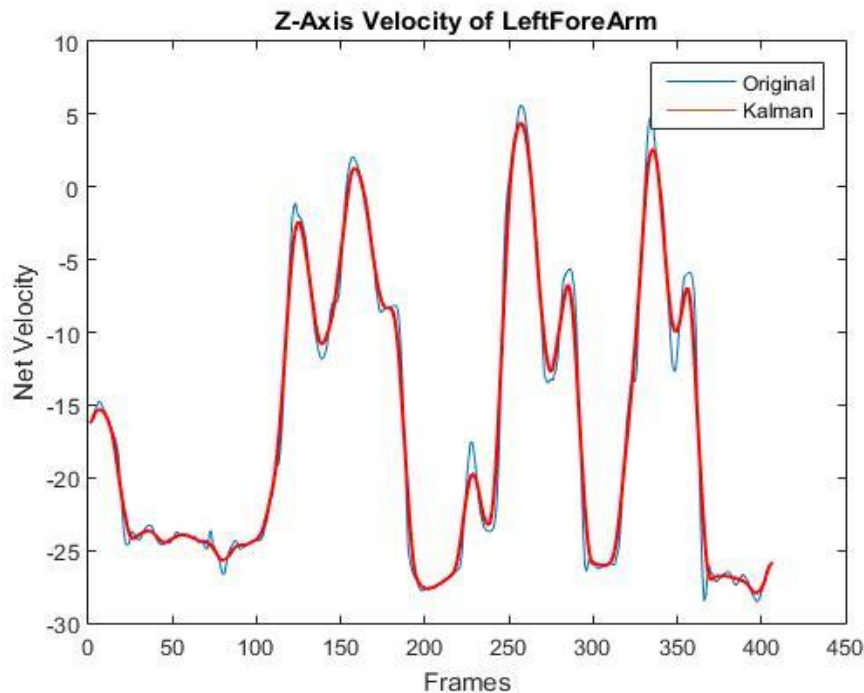


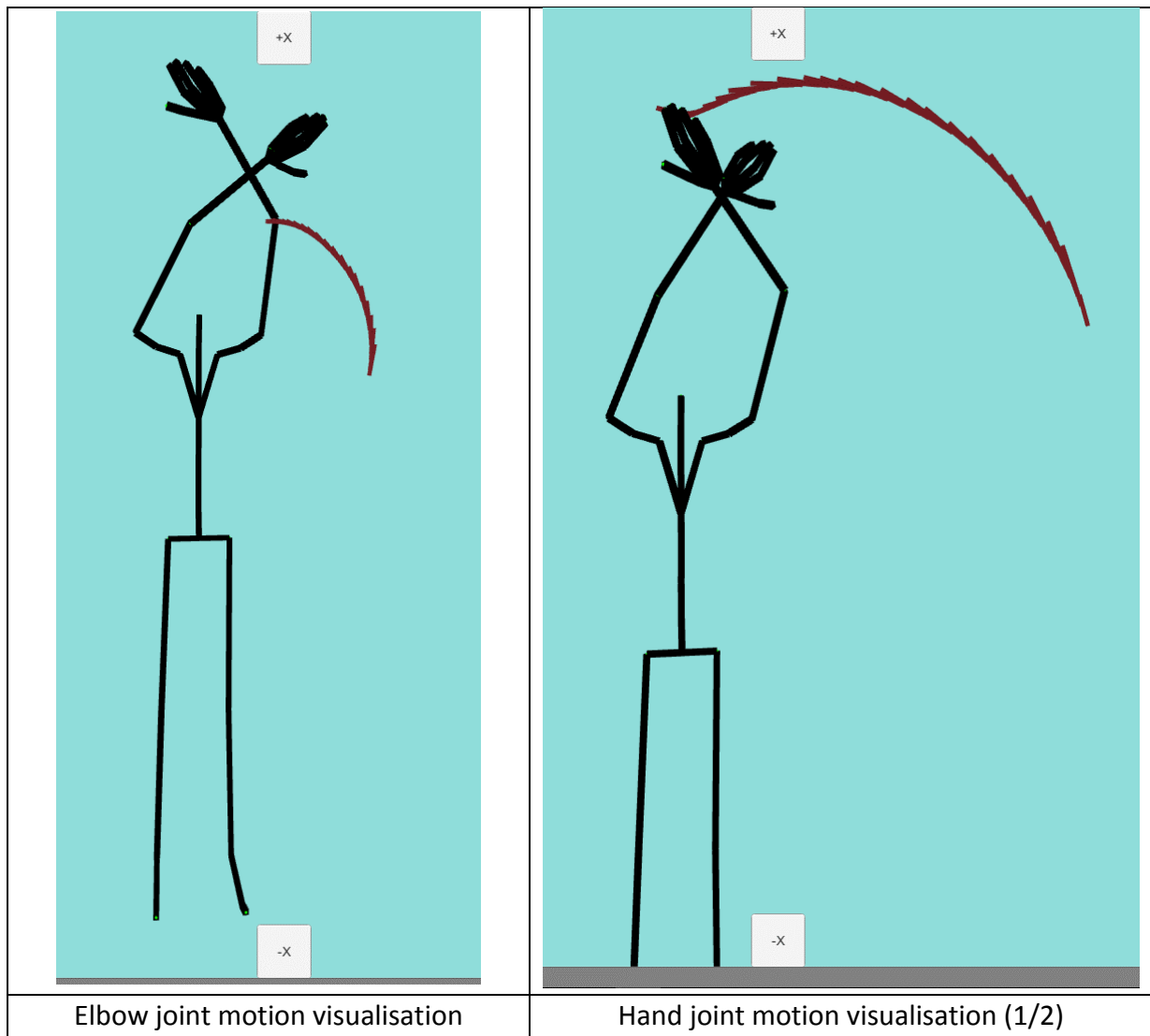
Figure 40. Kalman filter applied to velocity's z axis [40]

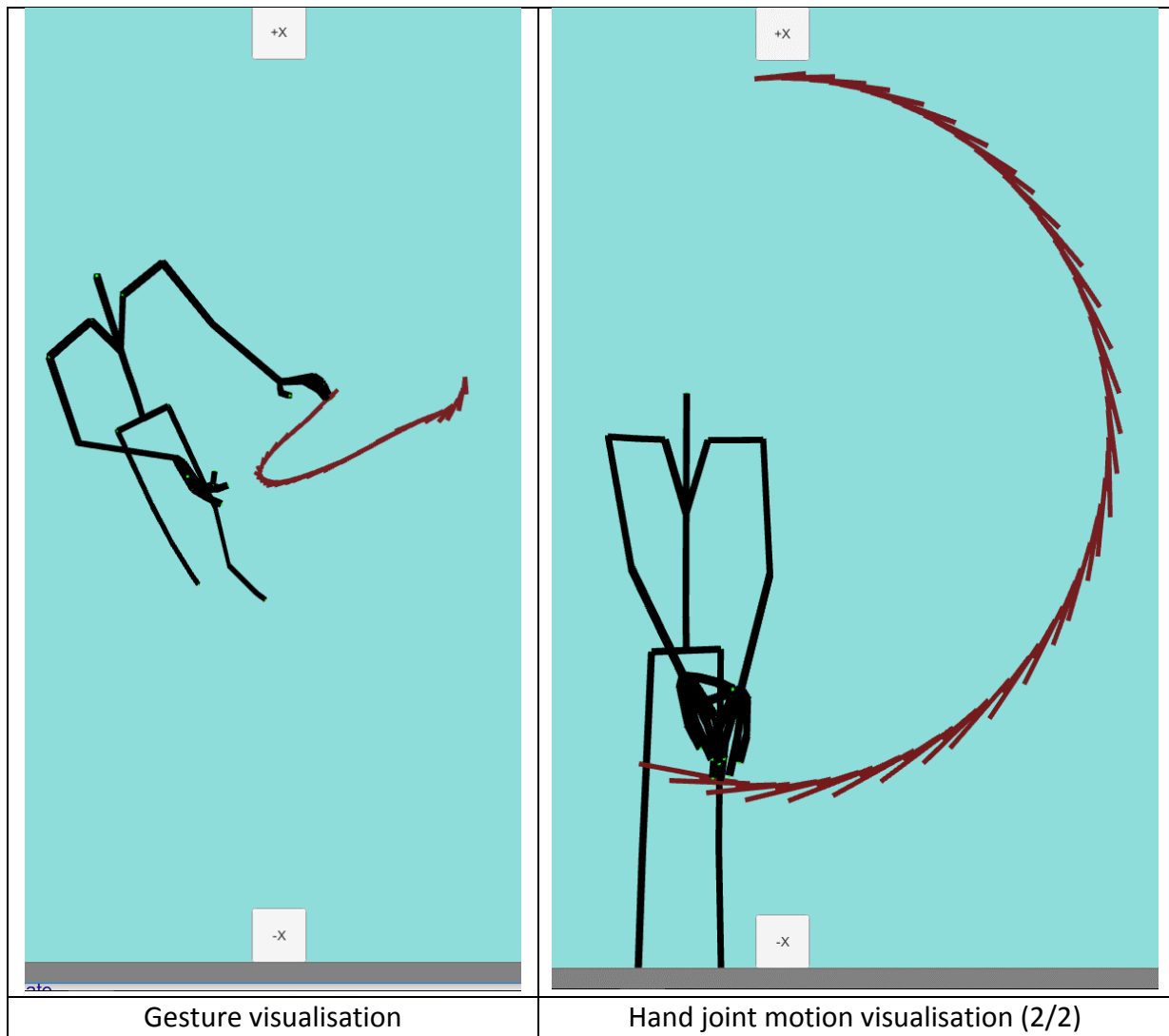
Many motion captures were used with the algorithm, each with different movements in all axis so that more precise results could be extracted. The data resulting from this Matlab process were saved in different .txt files and then they were read by Unity's C# code for visualization. All the position data are imported at the start of the program and stored in arrays, one position vector (coordinates in x, y, z axis) per line for all the duration of the animation clip.

6.4 Movement visualisation

6.4.1 Single joint trajectories visualisation

Human Motion Analyser & Visualizer offers the option for users to select the joint(s) that are visualized in order to produce analytics for a single joint. This is important in cases where joints have to be isolated such as for example in the process of extracting trajectories for visualization by the Human Motion Artistic Visualizer presented in Section 5. The following table presents some indicative single joint visualization examples.





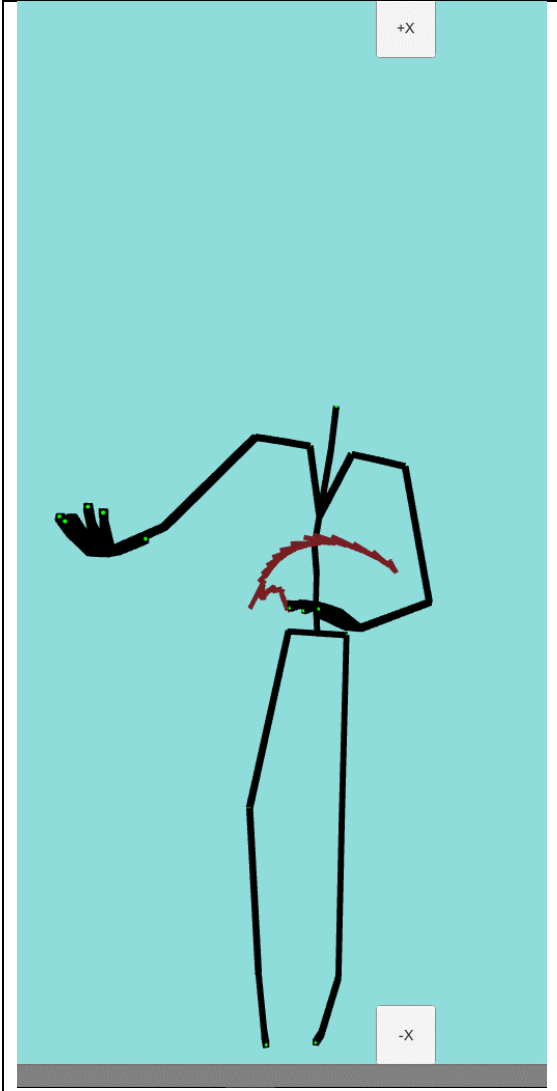
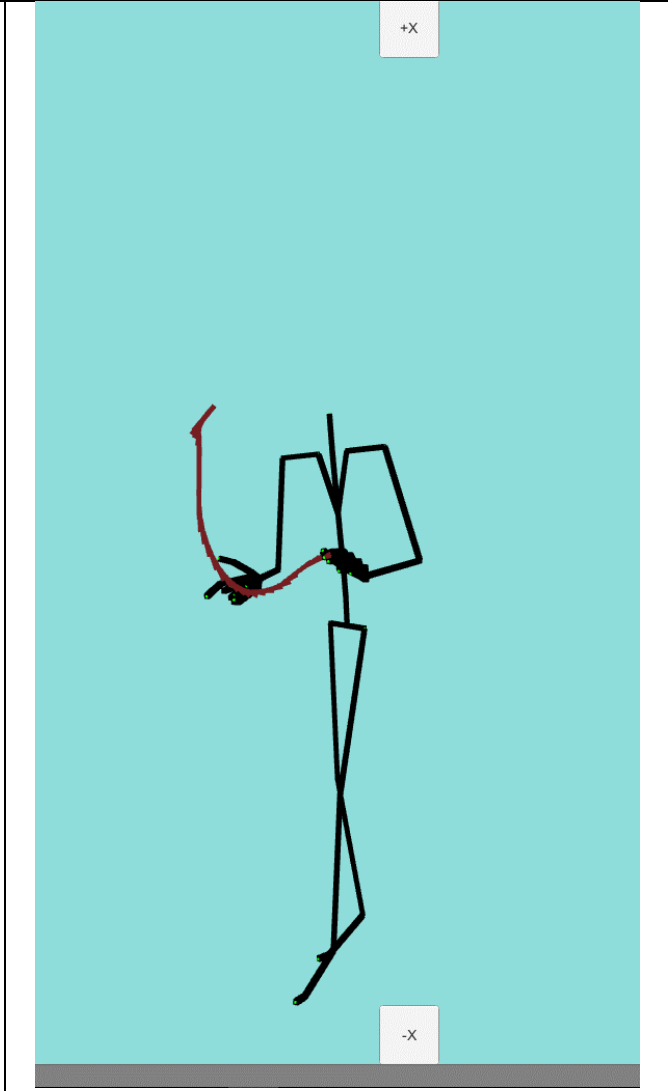
	
Gesture with acute finger movement (1/2)	Gesture with acute finger movement (2/2)

Table 2: Single joint trajectories visualization samples [62]

6.4.2 Multiple joints visualisation

Human Motion Analyser & Visualizer offers also the possibility to select multiple joints for visualisation such as for example all the joints of the right hand or all only the fingertips, etc. The following table present some multiple joints visualisation examples.

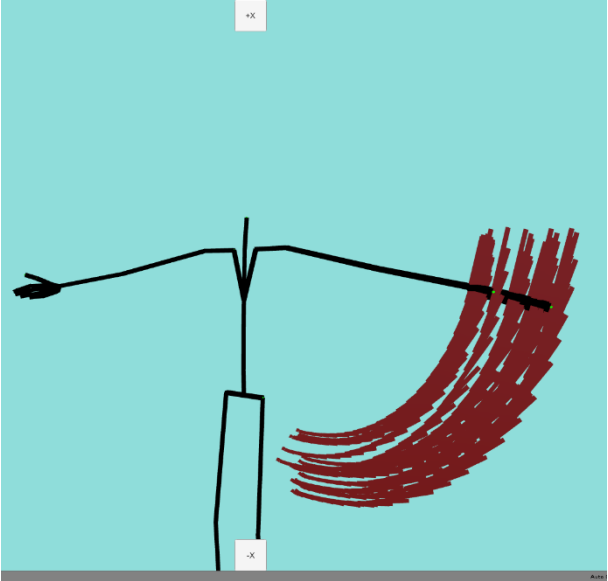
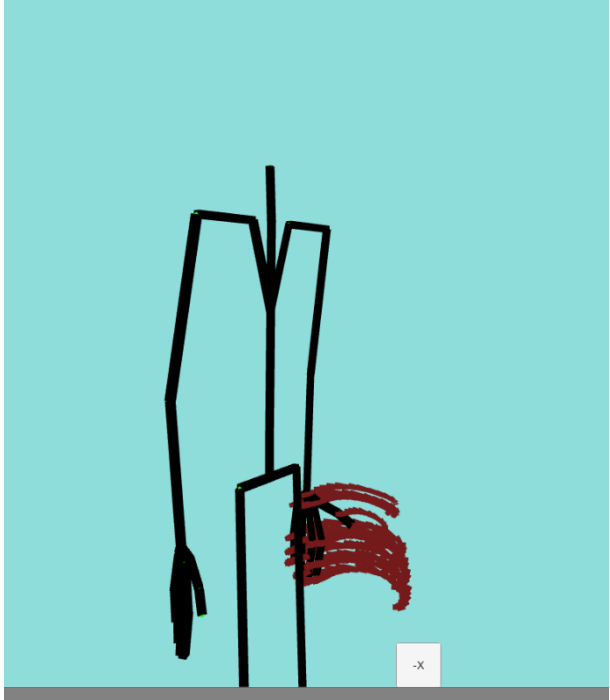
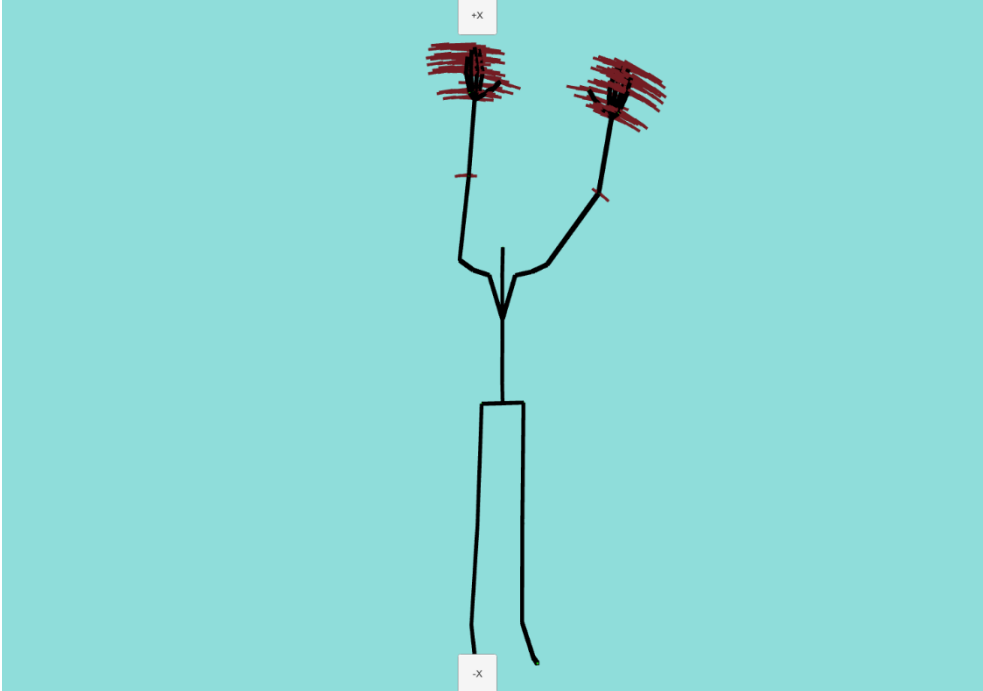
	
Multiple hand joints motion visualisation (broad gesture, left hand)	Multiple hand joints motion visualisation (narrow gesture, left hand)
	
Multiple hand joints motion visualisation (narrow gesture, both hands)	

Table 3: Multiple hand joints motion visualization samples [63]

7 Conclusions and Future Work

This deliverable presented the progress on gestures visualisation achieved during the first year of the project focusing on two directions. The first direction regards 3D visualisation and analytics and the section 2D synopsis and artistic annotation of motion.

In the next reporting period and towards the second version of the deliverable research will focus on producing insights on top of 3D visualisations and analysis of data and enhancing the 2D synopsis capacity of our tools. More specifically:

- Regarding motion blender, we intent to enhance the blending algorithms and create some pre-sets to enhance its usage in accordance to the guidelines.
- Regarding motion annotator, we intent the integration of richer drawing formats that will allow the system to draw more artistically pleasant trajectories.
- Regarding image filters, we intent to extent the currently limited filter combination so as to provide solutions that apply several filters at the same time to a given input so as to produce a certain outcome. Furthermore, explore the advances on style transfer algorithms to provide even better visualizations.
- Regarding manual annotator, we intent to extend the library of annotation to cover more use cases and application domains and if needed create domain specific libraries.
- Regarding scene composer, the integration of 3D information to the static motion frame will allow us to open the way for using 3D data in the 2D visualization of motion in favour of scientific, analytics and visualization purposes. Regarding scientific purposes such visualizations of accuracy, repeatability and objectivity. In terms of analytics, such visualization can enhance the capacity of extracting analytics form a scene and visualizing the analytics on the scene. Furthermore, in the future this could enhance the capacity of producing video visualizations and even isolate the actors of a movement so as to reproduce in another context such as for example in VR training.

8 ANNEX 1 MotiVo user manual

Create Project

The create new project functionality can be accessed by the start window of the application by selecting the file→create new project menu icon. The window that allows users to enter the details of the new project appears as a modal dialog (see **Figure 41**). In this dialog the project name, images file path, videos file path, BVH files path and trajectories file path are requested. When this information is provided the user can create a new project by selecting the save button. A file system browser dialog appears that allows users to select the file name and the location in the file system that the new project will be saved.

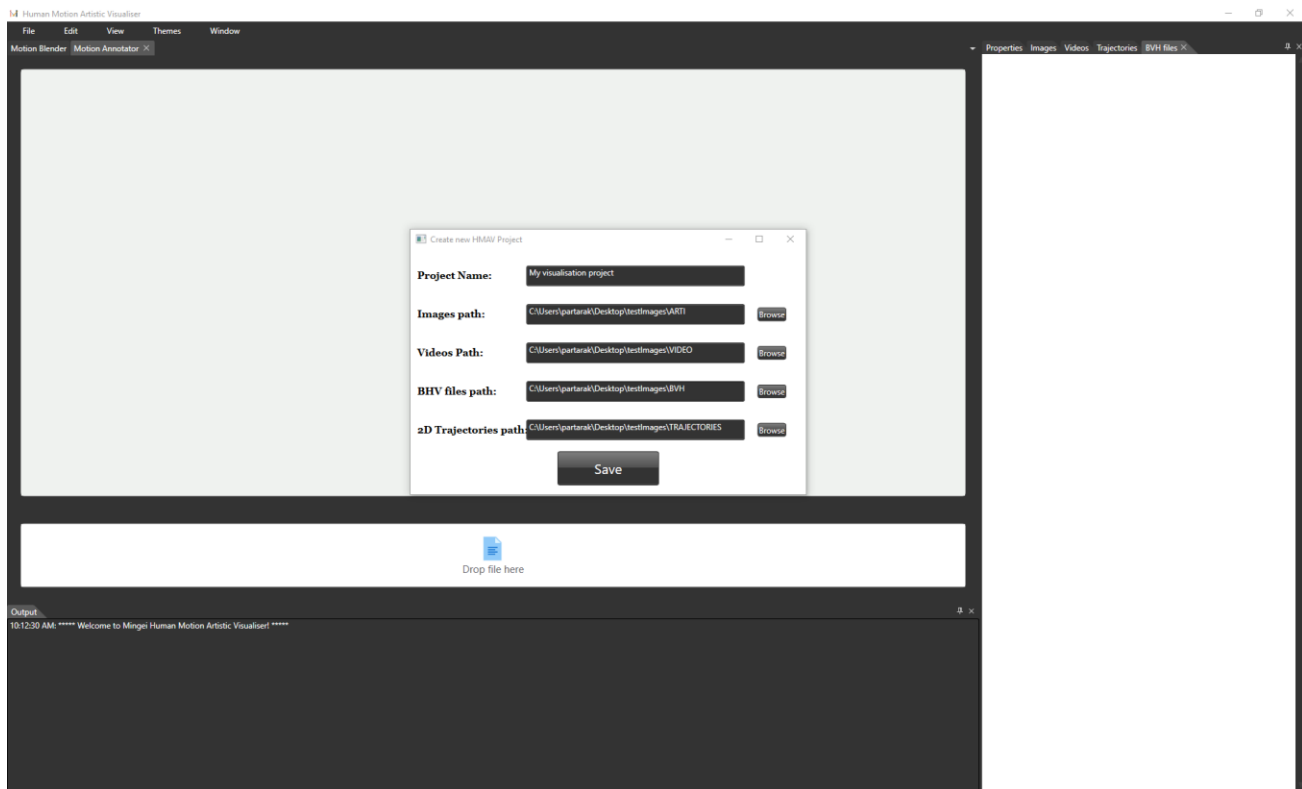


Figure 41. Create new project dialog [53]

Save Project

To save a MotiVo projects users should just locate the file menu and then select the save sub-menu item.

Load project

To load a new project users should access the select project file dialog accessed through the file→open project menu item. From there users should locate the “.hmv” file that represents their project and select the open button as shown in **Figure 42**.

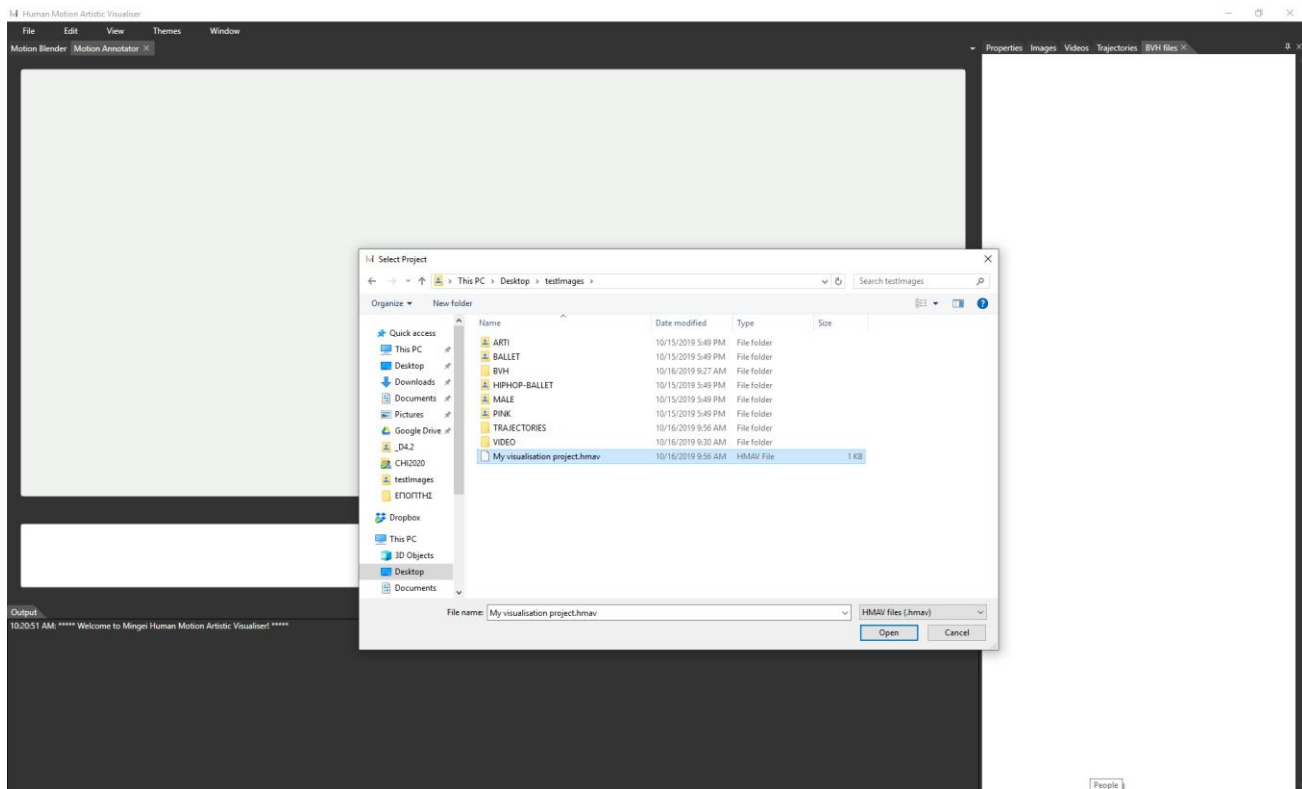


Figure 42. Load project dialog [54]

Select visualisation tool

The selection of a visualisation tool is performed by accessing the tools tab container and selecting the tab that corresponds to the preferred visualisation tool (see **Figure 43**)



Figure 43. Visualizations tools tab container [55]

Image based averaged motion visualisation

To perform an image based averaged motion visualisation users should first select the “Motion Blender” tool from the tab container. Then select the images control from the loaded project bar (right side of the main window). Then users just need to drag and drop images from the images panel of the HAMV to “Motion Blender” tool. Images appear and get a maximum weight by default to perform the averaged motion visualisation. An example of the outcomes of this process is shown in Figure 44.

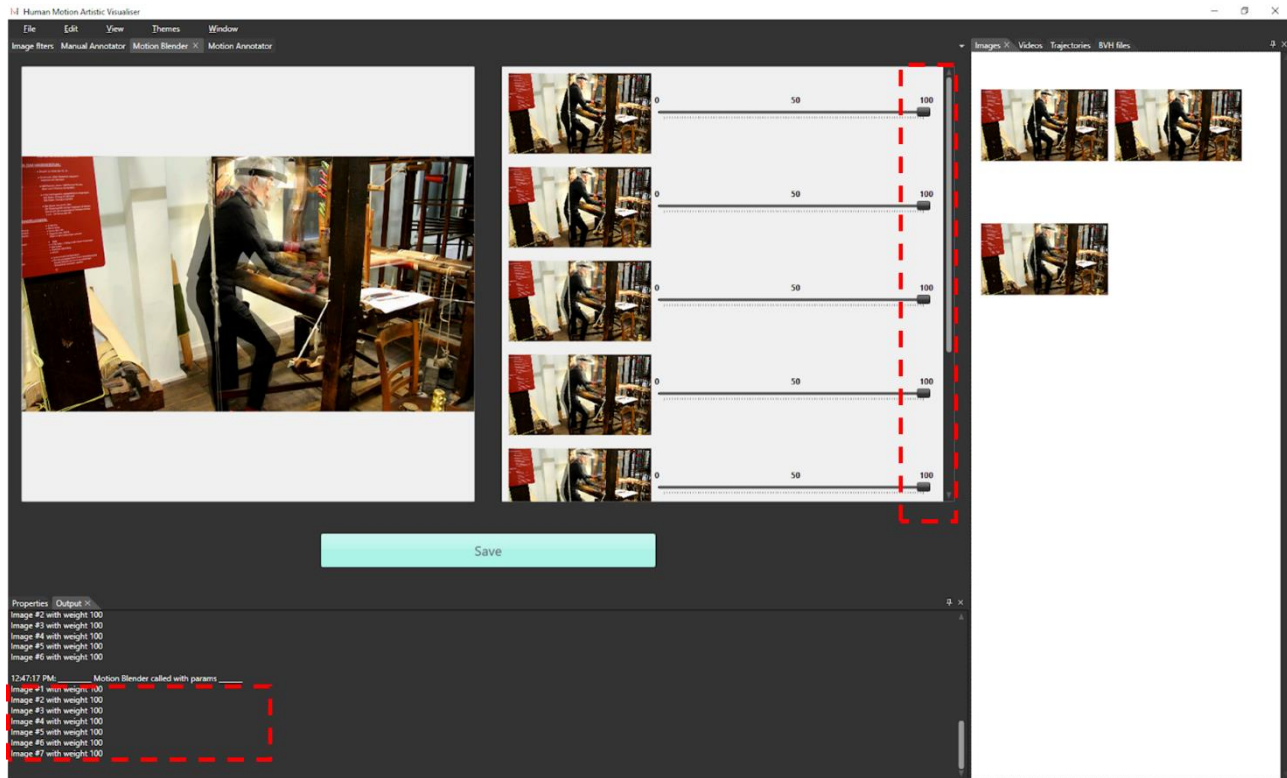


Figure 44. Averaged motion visualisation [56]

Image based weighted motion visualisation

The weighted motion visualisation can be performed by selecting through the user interface the weights for each of the dragged images. The selection happens with a scrollbar next to each image and the recalculation is happening automatically when each distinct manipulation of an image's scrollbar completes. An example of a weighted motion visualisation is shown in **Figure 45**.

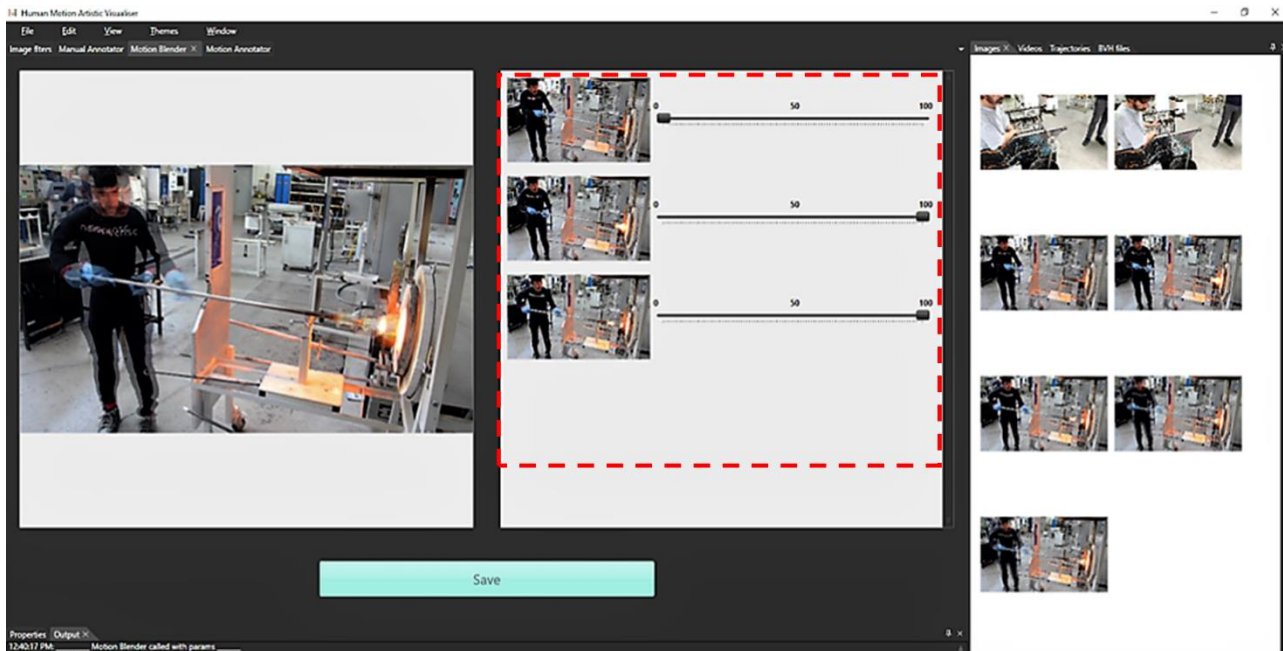


Figure 45. Weighted motion visualisation [57]

Artistic visualisation of trajectories within images

To perform an artistic visualization of trajectories within images users should first select the “Motion Annotator” tool from the tab container. Then select an image from the loaded project bar (right side of the main window). Then users just need to drag and drop an image from the images panel of the HAMV to “Motion Annotator” tool. Then, a trajectories file should be dragged in the trajectories container. Then the system automatically performs and displays the visualisation of trajectories as shown in **Figure 46**.

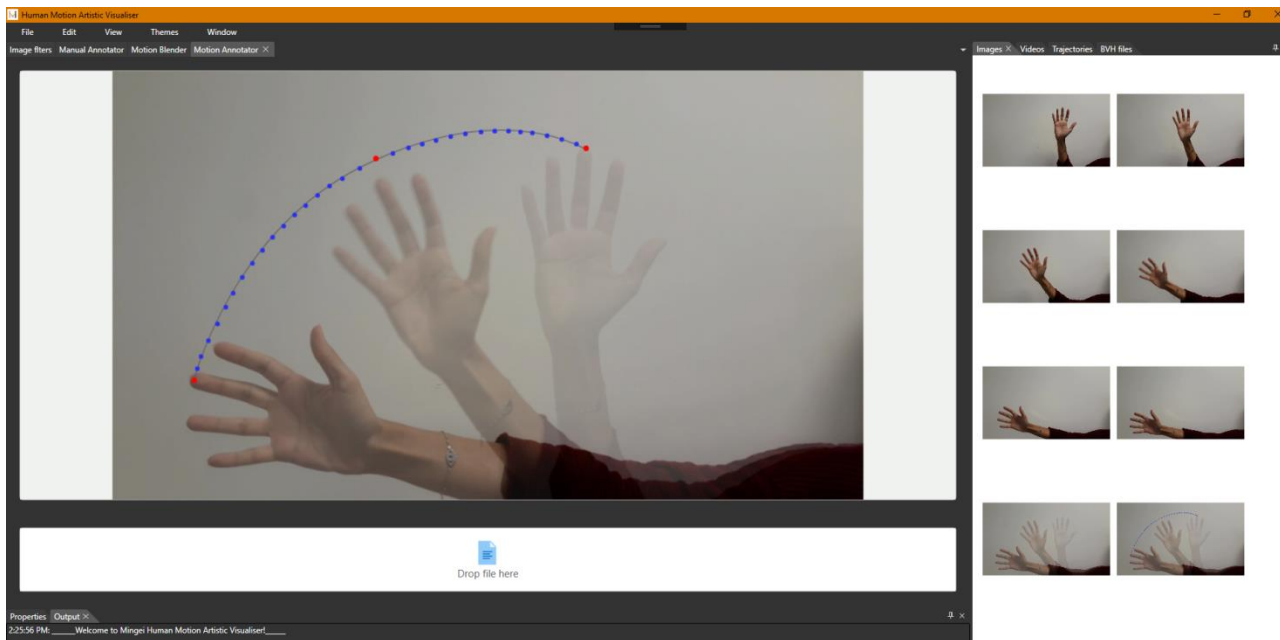


Figure 46. Visualisation of trajectories within an image [58]

Artistic visualisation of trajectories within video files

To perform Artistic visualisation of trajectories within a video file the user selects the appropriate tab corresponding to the artistic visualisation of trajectories within videos. Then, the user drags the video file to act as the background of the visualisation tool and drags the trajectories file source to act as source for the visualisation tool. Next, the user selects the type of visualisation from the drop-down menu with all the available visualisations and previews the visualisation result. Finally, the user presses the “visualise” button to produce and save the visualisation to the project.

This feature is under development and will be reported in the second version of this deliverable.

Edit visualised trajectories

To edit the visualised trajectories, the user previews visualisation points and manually edits their locations to improve visualisation (optional) by selecting and dragging them on the canvas. Furthermore, the user may apply filters to the trajectories to improve the visualisation results (optional) by selecting them from the drop-down menu of available filters.

This feature is under development and will be reported in the second version of this deliverable.

Manual artistic visualisation superimposed upon the video

To perform manual artistic visualisation superimposed upon the video file, the user selects the appropriate tab corresponding to the manual artistic visualisation superimposed upon the video and selects “start” and “stop frame” by double clicking on the timeline and then dragging the start and end points. Then, the user selects the type of visualisation from the visualization panel and drags it within the video to define the desired position. Next, the user selects the desired appearance effect from the effects panel for the selected visualisation and previews the visualisation by activating playback for this segment (pressing the “play” icon). Finally, The user produces the visualisation result when he is satisfied by the preview by selecting the “generate” button

This feature is under development and will be reported in the second version of this deliverable.

Manual artistic visualisation superimposed upon the image source

To perform a manual annotation superimposed upon an image source, users should first select the appropriate tab corresponding to the manual artistic visualisation superimposed upon an image source. Then the user is selecting the type of visualisation from the visualizations panels and drags the visualisation within the image to define the desired position. When all visualisation are places the user previews the visualisation and can proceed to saving is to the project assets by selecting the “generate” button (see **Figure 47** and **Figure 48**).

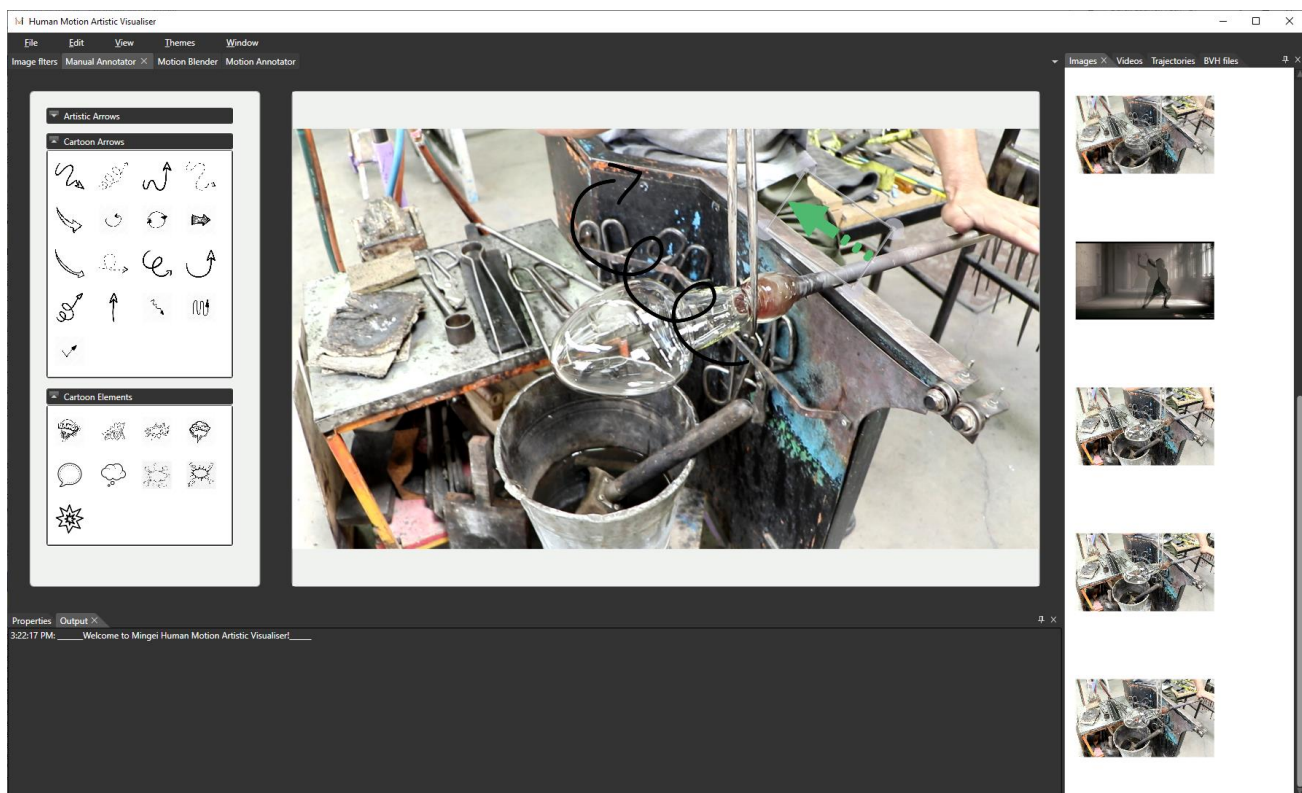


Figure 47. Manual artistic visualisation superimposed upon the image source (example 1/2, glass) [59]

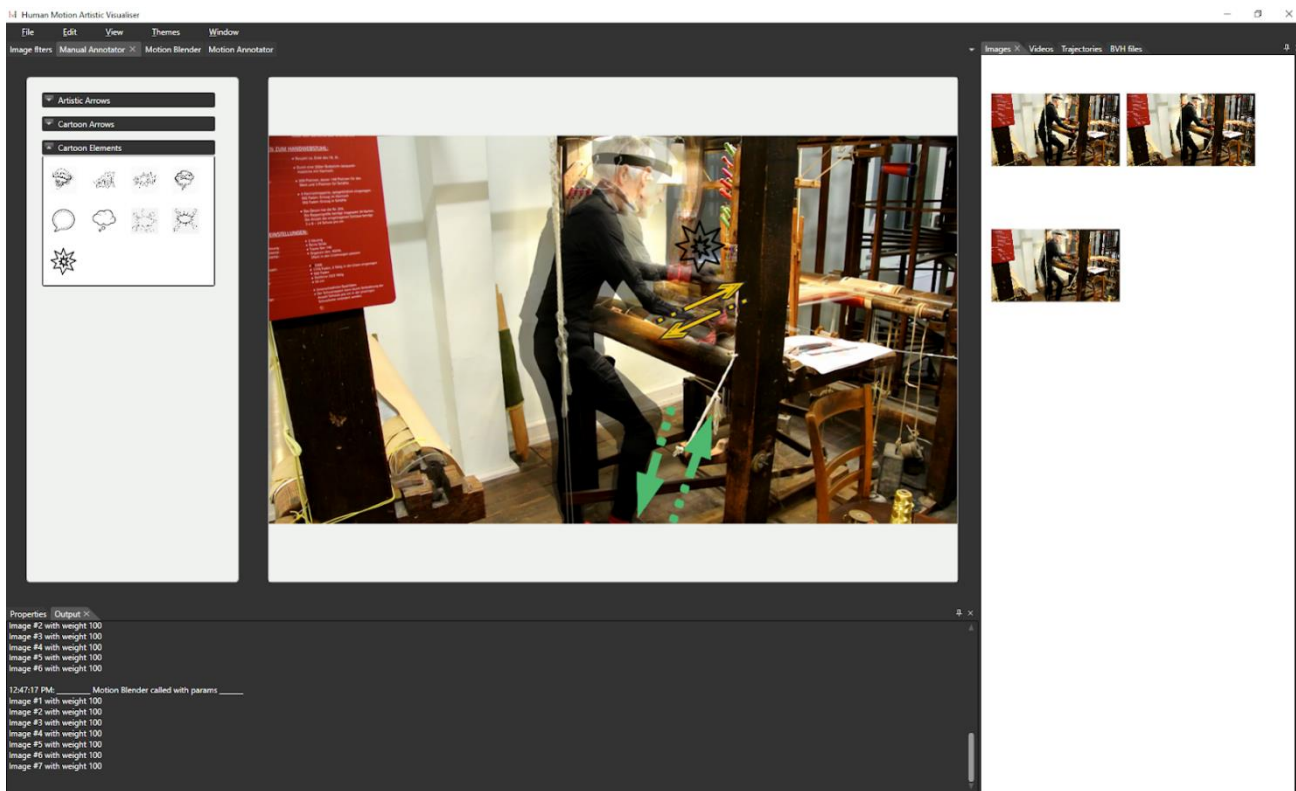


Figure 48. Manual artistic visualisation superimposed upon the image source (example 2/2, glass) [60]

Visualisation based on juxtaposed illustrations (cartoons)

The user selects the visualisation tool from the “tools” panels and loads the selection of images to be used as sources of the juxtaposed visualisations by dragging from the collection of project images to the tool. Then, the user edits each image (click to select image) and then selects illustration type by right clicking on “selection” and selecting from the “illustrations” menu. Finally, the user is manually inserting dialogs (optional) in each frame of the juxtaposed illustration using the “annotations” menu (right click on image → “annotations”) and then manually editing the appearance of each inserting annotation. The user previews the illustration results and saves the outcome.

This feature is under development and will be reported in the second version of this deliverable. Currently in this deliverable we are presenting the basic image filtering technology to be employed by this tools in the image filters sub-section (see experiments in 5.1.4)

Post-process 2D visualisation results

MotiVo supports pre and post processing of visualization results through the application of a number of specially developed image filters as described in depth in section 5.1.4. The application of these filter alter the appearance of an image source to imply or mimic an artistic concept. (see **Figure 49** sepia colouring filter).

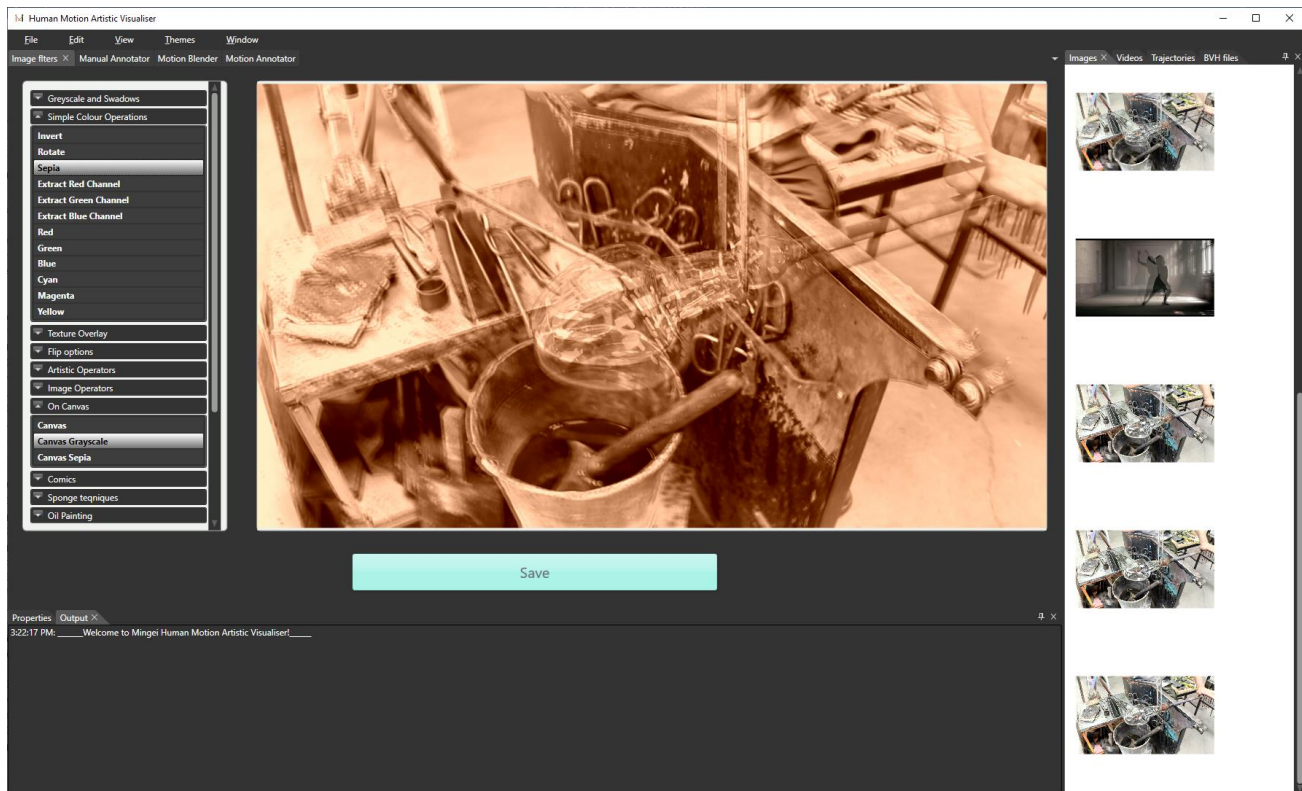


Figure 49. Application of post-processing filters [61]

Post-process 3D visualisation results

To post-process 3D visualisation results, the user locates a visualisation from the list of available visualisations in the project's visualisations window and selects to post-process the visualisation by right clicking on a visualisation and clicking the post-process menu item. Then, the user accesses the visualisation tool used for performing the initial visualisation and performs the actual post-processing using the “post-processing” tab of the visualisation tool (selection of the post processing tab and usage of tools, these tools vary based on the visualisation tool used for performing the initial visualisation). Finally, the user saves the altered visualisation by selecting the “save” button

This feature is under development and will be reported in the second version of this deliverable.

Currently in this deliverable we are presenting the basic scene composer functionality to be employed by this tool (see experiments in 5.1.5)

Export visualisation results in multiple output formats.

To export visualization results, the user locates the export functionality at the top bar (menu Project->export) of the HMAV and selects the sources to be exported from the list of project visualisations in the popup export panel (selection with checkboxes). Then, the user selects the export type from the dropdown menu of the available export formats and performs the export operation by pressing the “export” button.

This feature is under development and will be reported in the second version of this deliverable.

9 ANNEX 2 MotiVo usage example – The making of a glass carafe comic book

Mingei

The making of the Bontemps' carafe



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 822336.

<http://www.mingei-project.eu/>

Contributors

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Craft recording and MoCap

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Concept definition

The Glass Master

Jean-Pierre Mateus

“we can't tame this craft”



Jean-Pierre Mateus' biography, from Portugal to CERFAV

This narrative follows the biography of the glass master Jean-Pierre Mateus from his father story in Portugal to the actual life of Jean-Pierre at the CERFAV. The story begins with a Murano glass blower working in a glass factory in Alcobaça who rent a room at Jean-Pierre's grand-father place. Then, we follow Jean-Pierre's father who learned glass blowing from this Italian glass master and decided to move to Belgium to create a craft glass workshop. We then follow Jean-Pierre's life in glassblowing from his apprenticeship with his father to the creation of his own workshop in the south-west of France to his career as a teacher at the CERFAV. Following this European subjective glass journey, we will speak about craft knowledge transmission in Europe, the role of family in craft practices, the different categories of glass activities (from manufactures, to workshop to school), and the organisation of glass educative institution.

This narrative will help to understand, as Jean-Pierre said, how "we can't tame this craft".

A Murano glassblower in a Portuguese glass manufacture: craft knowledge transmission within the household

The story of the Mateus family within glass craft started in the 1940s in the city of Alcobaça in Portugal, when Jean-Pierre's grandfather welcomed a Murano glass-master into his house. At that time, in Alcobaça there was a glass factory specialized in the production of Murano-style chandelier. This Venetian glassblower came to this city to train the Portuguese glassmakers in the Murano glass know-how, in the context of subcontracting the Murano glass manufacturing around the world to be able to achieve their glass production and the reproduction of specific Murano glass objects. While this Murano glass-master was renting a room in Jean-Pierre's grandfather's house, Jean-Pierre's father used to go with him to the glass factory, because it was on the same route as school (5 km from the house). And one day, when he was 10, because Jean-Pierre's father school clothes were wet and he was afraid to be yelled at by his professor, he decided to dry his clothes in the glass factory. But when he entered the glass workshop, he remained hypnotized by the glass work and instead of drying his clothes in 5 minutes, he stayed all day in the glass workshop and didn't go to school. The teacher told Jean-Pierre's grandfather that his father didn't come to school, and so he asked his son to stop school and to start working. The Murano master decided to take care of Jean-Pierre's father and to become his master in glass training.

From Portugal to the North of France and Belgium: a family inside glassblowing

Jean-Pierre's father stayed 18 years working and learning with his master in the Alcobaça chandelier factory. But when he has 28 years old, with a wife and two kids, he decided to leave Portugal to have a better life. He travelled a lot and worked in several glass factories before stopping in the north of France, close to the border with Belgium, to open his own glass workshop as a craftsman, bringing his family with him. Jean-Pierre was thus born in France, unlike his older brother and sister. Jean-Pierre's father was the director of the Boussu glass factory in Belgium. And every Saturday, when Jean-Pierre's father taught glass

techniques to other Belgium glassblowers, the 4-year-old Jean-Pierre accompanied him. That is how he started glass craft. Jean-Pierre's older brother was his father's assistant, working also in Boussu, and his sister married another assistant of his father. Jean-Pierre's father worked in several glass workshops throughout his career: in Portugal, France, Belgium, Italy, England, Spain, the Netherlands. And each glass workshop he was working in was like a school to him where he always discovered a new way to work with glass. Each glass workshop developed its own glass techniques, and his father gained very strong skills in his European glass journey. When Jean-Pierre was 18, his father decided to go back to Portugal to start a new glass business. Jean-Pierre remembered the fight between his father and his master inside the Portuguese glass workshop where the old Murano master didn't understand the rich know-how of his students developed through his journey in different European glass places, which were not the same as he taught him years before. His father is 83 years old today, he still makes glassblowing in his glass workshop in Portugal and teaches other glassmakers his techniques he learned during his 58 years spent in glass craft.

Jean-Pierre Mateus journey within glass craft

The Belgium glassblower who Jean-Pierre met with his father when he was 4, liked to give him a blow-pipe and to teach him how to blow. But it was when he was 6 that his father started to teach him glass techniques properly in showing him how to gather glass from the furnace. Jean-Pierre remembered the small platform his father built for him in front of the furnace to be able to gather the glass. And slowly, within his father glass workshop, he started to have a small bench and small glass tools and started to create glass objects. As he calls himself, he was the *petit bousilleur* in his father glass workshop (the *bousillage* is a practice used in glass factory that consists of diverting a tiny part of the materials from the workshop and shape them with workplace materials as appropriate without the constraint of the mass production. The bousillage is often the place where innovation and creativity took place).

When Jean-Pierre was 18 and his father went back to Portugal, Jean-Pierre's brother-in-law (who was his father's apprentice) and Jean-Pierre's sister decided to open a glass workshop in the Landes (a region in the south-west of France). They asked Jean-Pierre to join them in this new business. At that time, because Jean-Pierre's brother-in-law was the assistant of Jean-Pierre's father, he was not able himself to create glass objects alone, whereas Jean-Pierre, even if he was younger, was more skilled to produce glass things alone due to his practice of *bousillage*. He followed them during one and a half year in this glass workshop, before returning to the north of France for his military service.

When he was 20, he decided to open his own glass workshop in the Lot (another region in the south-west of France), between Rocamadour and the Gouffre de Padirac. He bought a house and a workshop, and constructed all the furnaces himself to be able to produce his own glass. He then decided to specialize in *stretch glass*, a technique to realize glass animals in one minute, and *cased glass*, a technique which consists in the dipping of a primary glass object (gather) into a tank of coloured glass in order to superimpose a layer of contrasting colour. At this point, Jean-Pierre started to have his first own apprentice

and to transmit his knowledge. During the time he had his glass workshop, he trained 21 apprentices and received 10 to 15 interns each year worldwide. Changes in his personal life brought Jean-Pierre to sell his business and go back to work in a craft glass factory in Biot, near Nice. He spent a few years there, and eventually he became a teacher at the CERFAV (the European Research and Teaching Centre for Glass Craft) at Vannes-le-Châtel near Nancy in the Northeast of France.

From glass practice to glass teaching: the CERFAV

To Jean-Pierre, the difference between his apprentices in his own workshop and his students at the CERFAV is a matter of time. He spends more time teaching at the CERFAV than he was teaching his apprentices in his workshop. As a professor of glassblowing, he wants his students to be able to reproduce a gesture and to understand the different techniques available to create an object. For Jean-Pierre, it is important that the glass students understand that different techniques produce the same result, but through the way they approach it, it becomes different. So he wants his students to ask: which is the method we have to use? Why do we use this method and not another one? He wants them to understand that everything in glassblowing is a question of time in relation with the skill that the craftsman is able to manage when he wants to create a glass object. His pedagogy tries to let the student understand this relation between the time and skill as a way to realize that with one technique there are thousands of possibilities to work with glass and to create different glass objects. Therefore, his role as a teacher is to find a way to let the students adapt the gestures he teaches to their individual skills.

About Mingei



Mingei offers a method to digitally document, semantically represent, and actively support the preservation of Heritage Crafts (HCs). In this way, Mingei aspires to capture a comprehensive picture of the wide spectrum of tangible and intangible knowledge encompassed by this form of Cultural Heritage (CH).

A multidisciplinary approach is followed to digitally represent material heritage, human motion and action, socio-historic context, as well as experience and knowledge on craft practice and apprenticeship.

Towards the implementation of this vision, Mingei offers a craft representation protocol for the systematic acquisition of digital assets, the representation of knowledge, and the authoring of craft representations. The protocol is accompanied by tools for its implementation and guidelines for the simplification of the process and for the optimal of resources.

Intuitiveness of description and simplicity of use aim the capacity building of creative communities and cultural heritage institutions. Mingei is available as an online platform, which comprises a resource for the (a) creation of benefit for cultural institutions, content owners, and researchers, (b) support of craft training and education, and (c) promotion of thematic tourism relevant to HCs, as a way towards sustainable preservation of this form of CH.

The efficacy of this approach is demonstrated in three pilots whose diversity spans multiple craft dimensions, namely silk textile manufacturing, making of glass objects, and mastic cultivation.

The preservation common cultural elements and individual identities stemming provides a wider appreciation and a better understanding of cultural continuity and cultural pluralism in Europe. The main societal impact thus stems from *“collectively preserving our Heritage, by protecting culture and promoting cultural pluralism, [which] leads to more resilient and peaceful societies”* [*“The role of culture for resilience, peace and security”, UNESCO 2017.*](#)



HE OPENS THE DOOR OF THE FURNACE. BEFORE PUTTING THE BLOWPIPE INTO THE FIRE, HE CHECKS IF IT IS CLOGGED.



HE PUTS THE BLOWPIPE WITH THE GLASS INTO THE FURNACE.



HE HOLDS THE BLOWPIPE STRAIGHT WHILE THE GLASS IS HEATING UP.



HE ROTATES THE BLOWPIPE, CREATING A ROUND SHAPE TO THE GLASS.



HE CLOSSES THE FURNACE AND THEN REMOVES THE BLOWPIPE.





HE SITS AT HIS CHAIR AND WATERS HIS PAPER TOOL.



HE ROLLS THE BLOWPIPE WHILE HE IS WIPING THE GLASS WITH THE WET PAPER TOOL.



HE STANDS UP AND BLOWS INTO THE PIPE FOR 10 TO 15 SECONDS. AT THE SAME TIME HE ROLLS THE PIPE.



HE ROLLS BACK AND FORTH THE BLOWPIPE WHILE STANDING.

IT'S TIME FOR A SECOND TIME IN THE FURNACE.

AFTER THAT, HE ROLLS THE BLOWPIPE AND WHIPES THE GLASS WITH THE WET PAPER TOOL. ONCE AGAIN, HE BLOWS THROUGH THE BLOWPIPE AND THEN HE STRETCHES...



HE USES A METAL CARVED MOLD IN ORDER THE SHAPE AND TEXTURE OF THE GLASS TO MATCH ITS DESIGN.





HE IS WIPING THE GLASS WITH THE WET PAPER AS HE IS ROLLING THE PIPE. AT THE SAME TIME, HIS ASSISTANT BLOWS THROUGH THE PIPE AND INFLATES THE BUBBLE OF GLASS.



HE USES METAL JACKS TO SHAPE THE GLASS.



AFTER RE-HEATING THE GLASS, HE BLOWS THROUGH THE PIPE FOR A COUPLE OF TIMES.



HE CHECKS IF THE GLASS HAS THE APPROPRIATE SIZE ACCORDING TO THE PATTERN SHAPE.



HE BALANCES AND WIPES THE GLASS WITH THE WET PAPER WHILE HE IS ROLLING THE BLOWPIPE.



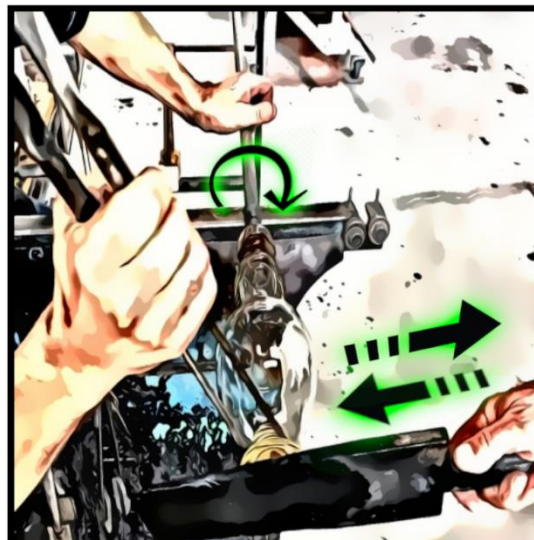
IT'S TIME FOR THE GLASS MASTER TO CREATE THE CARAFE BASE...
THE ASSISTANT TAKES OUT OF THE FURNACE A NEW MOLTEN BLOB OF
GLASS AND HE IS CHECKING THE EXACT POSITION THAT SHOULD BE PLACED.



HE PLACES THE MOLTEN GLASS ON THE INFLATED GLASS
AND CUTS IT WITH METAL SHEARS.



HE PUSHES THE MOLTEN GLASS ON THE INFLATED GLASS
USING THE WIDE SIDE OF THE JACKS.



HE WIPES THE GLASS WITH THE WET PAPER. AFTER THAT, HE USES A METAL
PALLET IN ORDER TO FLATTEN THE BASE OF THE CARAFE.

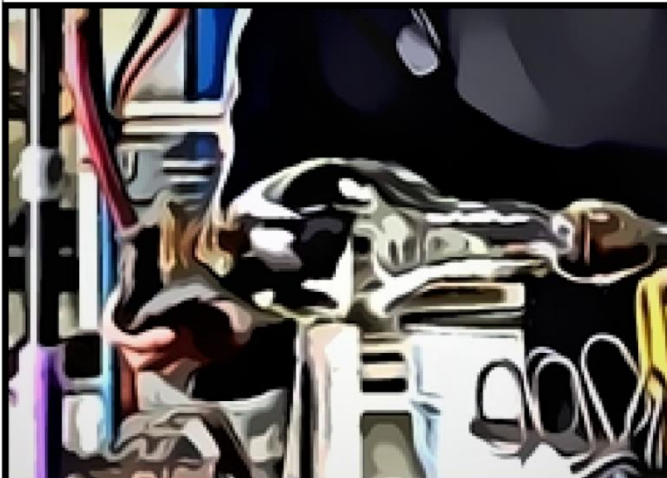




THE ASSISTANT BRINGS MORE MOLTEN GLASS FOR THE BASE OF THE CARAFE AND PLACES IT ON THE TOP OF THE PREVIOUS SHAPED GLASS.



HE SITS AT HIS CHAIR. WHILE HE IS ROLLING THE BLOWPIPE BACK AND FORTH, HE IS TRIMMING THE GLASS DESTINED FOR THE FOOT OF THE CARAFE, BY USING THE PALLET ONCE AGAIN. THEN, HE IS USING A METAL CLAPPER IN ORDER TO SQUEEZE THE BLOB OF GLASS AND FORM THE FOOT.



HE WIPES THE FOOT BASE USING THE WET PAPER TOOL.



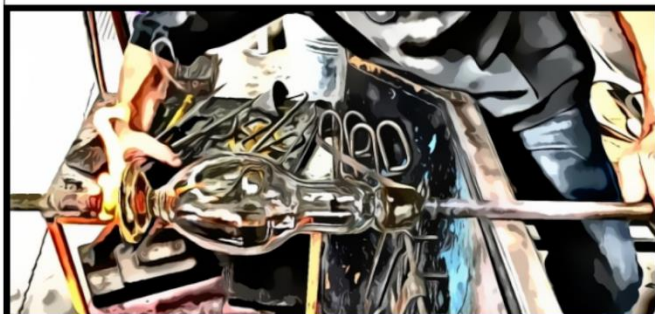
HE CHECKS THAT THE FOOT BASE HAS THE CORRECT SIZE ACCORDING TO HIS TOOL.



ON THE TOP OF A METAL MARVER, THE ASSISTANT ROLLS AND INCLINES A NEW SOFTENED GLASS THAT JUST CAME OUT OF THE FURNACE.



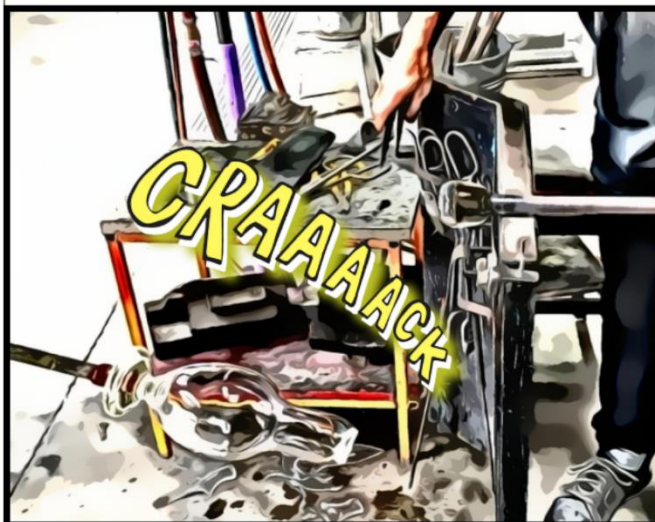
THE ASSISTANT PLACES THE HOT ANGLED GLASS ON THE FOOT OF THE CARAFE IN ORDER TO CREATE A CASP.



THE HOT ANGLED GLASS CREATES THE CASP ON THE FOOT, AS HE IS ROLLING THE BLOWPIPE.



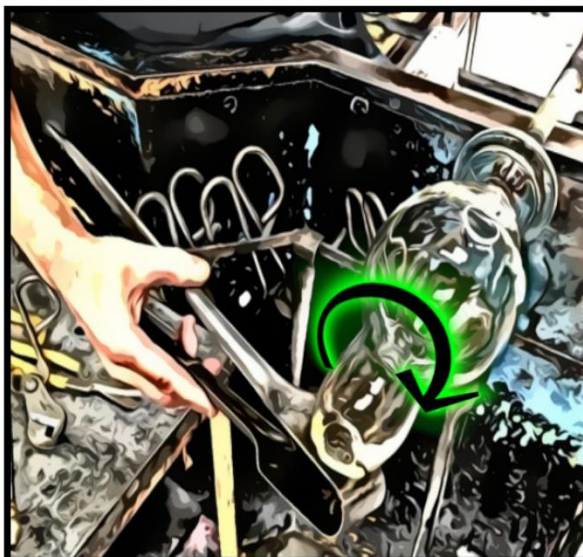
HE USES THE JACKS TO CUT THE TOP OF THE CARAFE.



IT'S TIME TO REHEAT THE GLASS... HE PUTS THE MOUTHPIECE OF THE CARAFE IN THE GLORY HOLE.



HE SMOOTHS THE LIP AT THE MOUTHPIECE OF THE CARAFE USING THE WIDE SIDE OF THE JACKS.

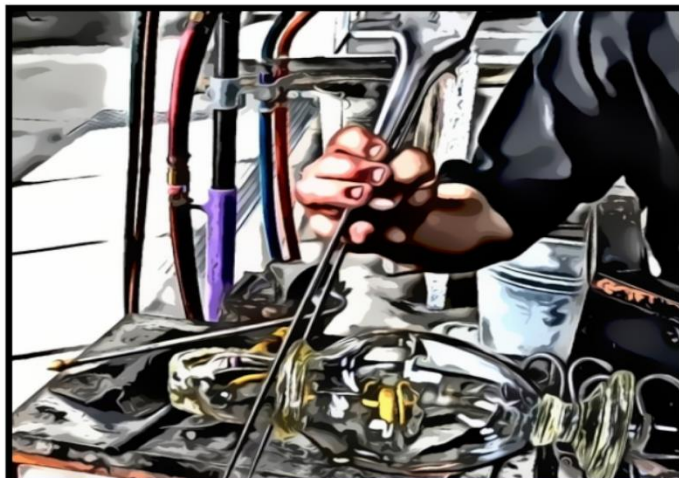




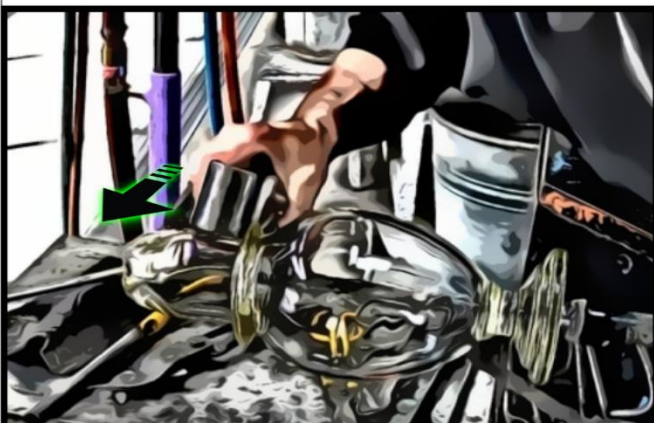
ONCE AGAIN, THE ASSISTANT SHAPES A HOT MOLTEN GLASS BY ROLLING IT ON THE MARVER AND CUTTING ITS EDGE.



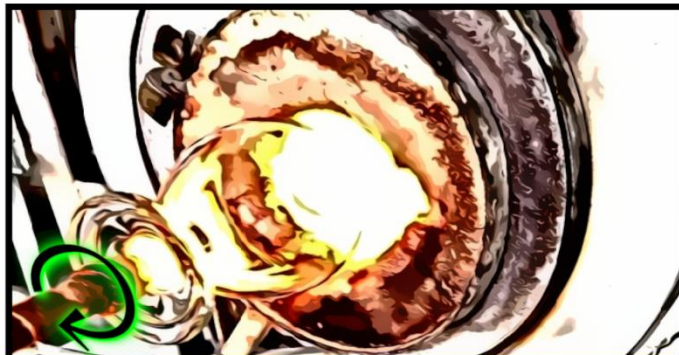
THE ASSISTANT PLACES THE MOLTEN GLASS AROUND THE OPEN MOUTHPIECE OF THE CARAFE IN ORDER TO CREATE DETAILS.



HE SHAPES THE DETAILS USING THE JACKS.



HE SMOOTHS AND SHAPES THE MOUTHPIECE OF THE CARAFE USING THE WIDE SIDE OF THE JACKS.



HE PUTS THE MOUTHPIECE OF THE CARAFE IN THE GLORY HOLE.



HE BLOWS THROUGH A SHAPING TOOL IN ORDER TO WIDEN THE MOUTHPIECE OF THE CARAFE.



HE USES THE JACKS TO FIX SOME DETAILS ON THE MOUTHPIECE.



HE PUTS THE MOUTHPIECE IN THE GLORY HOLE FOR THE SECOND TIME.



THE LIP OF THE MOUTHPIECE HAS SOFTENED BY THE FIRE SO HE IS USING THE SMALL JACKS TO SHAPE IT.



HE CUTS THE EDGE OF THE LIP USING THE METAL SHEARS.



HE WARMS THE MOUTHPIECE IN ORDER TO MAKE IT SOFT AGAIN AND FURTHER SHAPE IT.



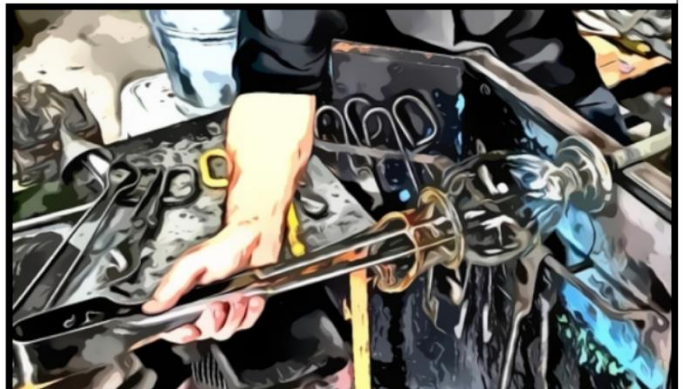
USING AN IRON BAR, HE SHAPES THE LIP OF THE MOUTHPIECE BY LIFTING IT UPWARDS.



HE USES THE JACKS TO WIDEN THE MOUTHPIECE BY OPENING THEM.



HE ROLLS THE IRON BAR ON THE LIP OF THE MOUTHPIECE SO AS TO SMOOTH IT.



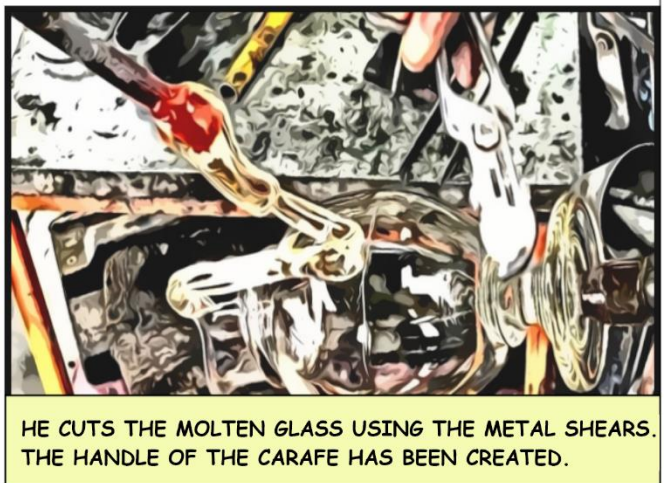
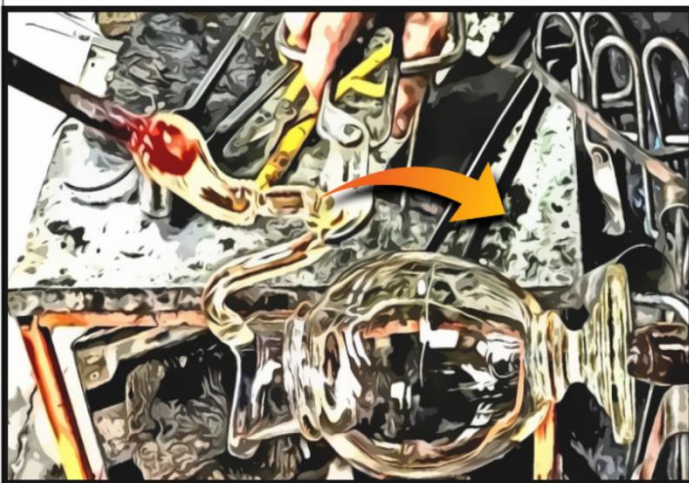
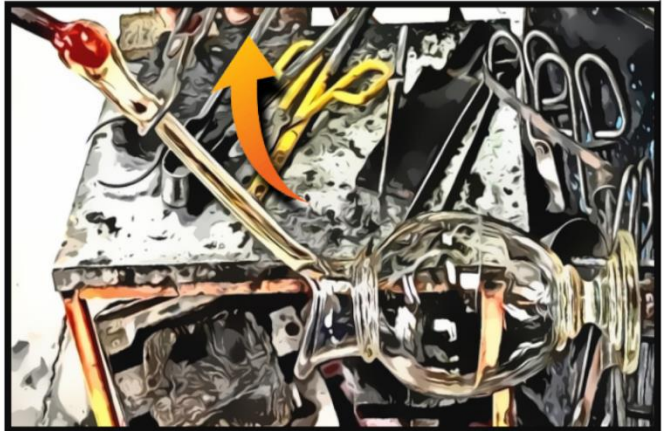
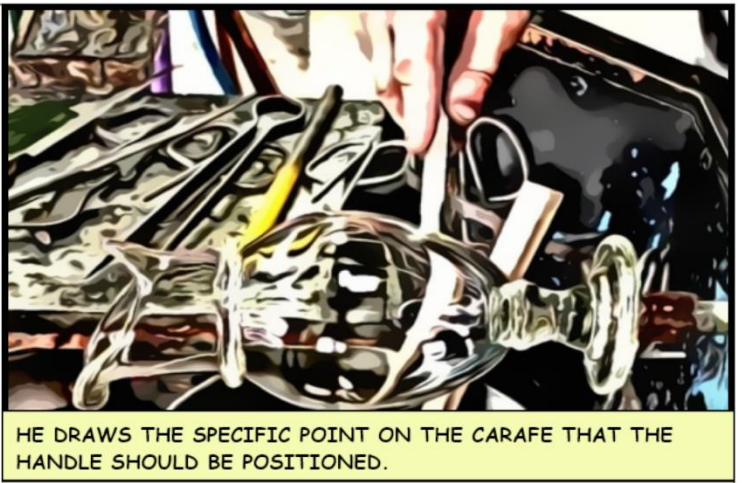
HE USES THE JACKS IN ORDER TO WIDEN THE MOUTHPIECE EVEN MORE.



HE TRIMS THE NECK OF THE CARAFE WITH THE METAL BATTLEDORE.

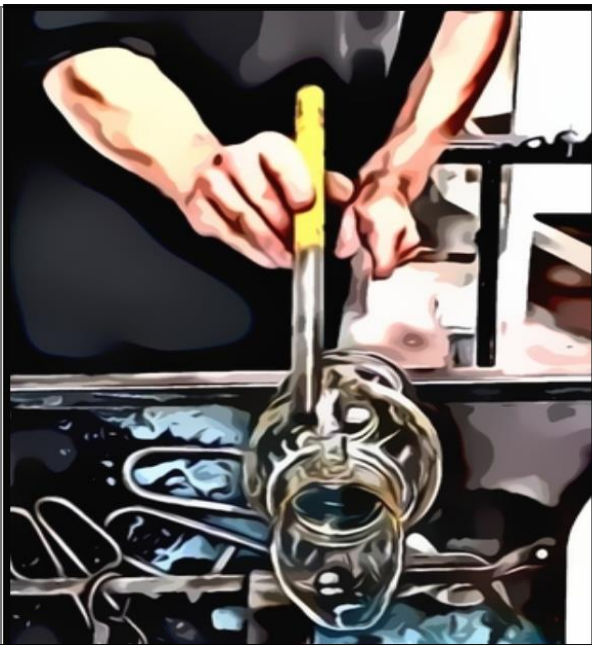


USING THE SMALL JACKS, HE SHAPES THE LIP IN MORE DETAIL. THEN, HE BURNS IT AGAIN.

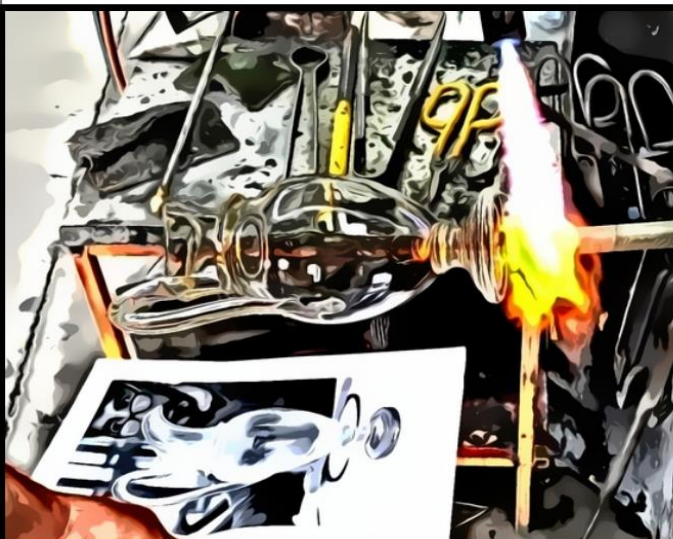


IN ORDER TO SHAPE THE HANDLE, HE USES AN IRON BAR AND ROLLS IT FROM THE TOP OF THE HANDLE TO ITS BOTTOM.





USING THE IRON BAR, HE FIXES THE LAST DETAILS ON THE HANDLE. AFTERWARDS, HE PUTS THE CARAFE IN THE GLORY HOLE.



BASED ON THE FINAL SHAPE OF THE CARAFE, HE IMPROVES THE CARAFE BY BURNING IT AND FIX THE LAST DETAILS.



LAST TIME IN THE OVEN..

THE FINAL RESULT.





Online Resources

- Mingei Online Platform: [Glass making schema](#)
- Mingei Online Platform: [Carafe making process](#)
- Mingei Project Webpage: <http://www.mingei-project.eu/>



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<http://www.mingei-project.eu/>

Mingei Consortium

Participant No.	Participant organisation name	Country	Logo
1 (Coordinator)	Foundation For Research And Technology Hellas (FORTH)	GREECE	
2	Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES)	FRANCE	
3	Consiglio Nazionale delle Ricerche - Istituto di Scienza e Tecnologie dell'Informazione "A. Faedo" (CNR)	ITALY	
4	MIRALab SARL (MIRALab)	SWITZERLAND	
5	WAAG society (WAAG)	NETHERLANDS	
6	Piraeus Bank Group Cultural Foundation (PIOP)	GREECE	
7	Imaginary SRL (IMA)	ITALY	
8	Conservatoire national des arts et métiers (CNAM)	FRANCE	
9	Haus der Seidenkultur (HdS)	GERMANY	

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