Mingei
Handbook

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The Mingei Handbook

Version 1.0

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Foreword - Who is this handbook for?

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

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

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

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

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

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

1. Introduction

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

1.1 What is craft?

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

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

Craft is performed by human persons. As such, they include historic, geographical, artistic, traditional, economic, and religious dimensions, relevant to the **context**. The anthropologic aspect is found in comprehensive definitions of craft, which denote a **social context** and link **craft evolution** with technological progress:

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

and underscore the relationship between craft and **artistic creation**:

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

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

1.2 What is the Mingei protocol and where does it come from?

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

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

The Mingei protocol stands as a product of over 30 years of research in the digital preservation of CH.

The **first generation** of digitisation projects focused on the digitisation of tangible heritage, first in 2D and more recently in 3D. During the FP6 Programme of the EC, the MINERVA digitisation programme and several other projects continued its legacy. In these approaches, digitisation meant the faithful representation of the material properties. Digitisation regards the "factual" occurrence of an object, as a material event, with measurable dimensions and material properties. Today there are still open challenges, such as multispectral and multimodal digitisation, as well as the digitisation of non-Lambertian materials, including transparent and translucent ones. The boost of technological capabilities obtained from this has facilitated the work of curators and Heritage Professionals, in documenting assets and made possible the development of online repositories of shared and semantically interlinked content. In the particular case of information carriers, such as historic documents, digitisation is regarded material part of the item. The digitisation of the "intangible" component reached up to OCR transcription, without accessing the semantics of the digital text.

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

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

- We treat the digitisation of craft products, by tangible heritage digitisation principles.
- We treat digitisation of the physical activity of the craftsperson, by intangible heritage digitisation principles.
- We treat the digitisation of knowledge on craft processes, by the generic formalisation of processes.
- We propose novel ways to represent contextual information, through the representation of socio-historical information as narratives.

1.3 Craft dimensions

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

In this context, we look at craft dimensions closer, to better understand the content we need to represent. In particular, we also follow the Tangible / Intangible distinction, but also look closely at the space and time where these two meet. We thus propose the following refinement, as illustrated in Figure 1.

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

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

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

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

Figure 1. Craft dimensions.

1.4 Overview

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

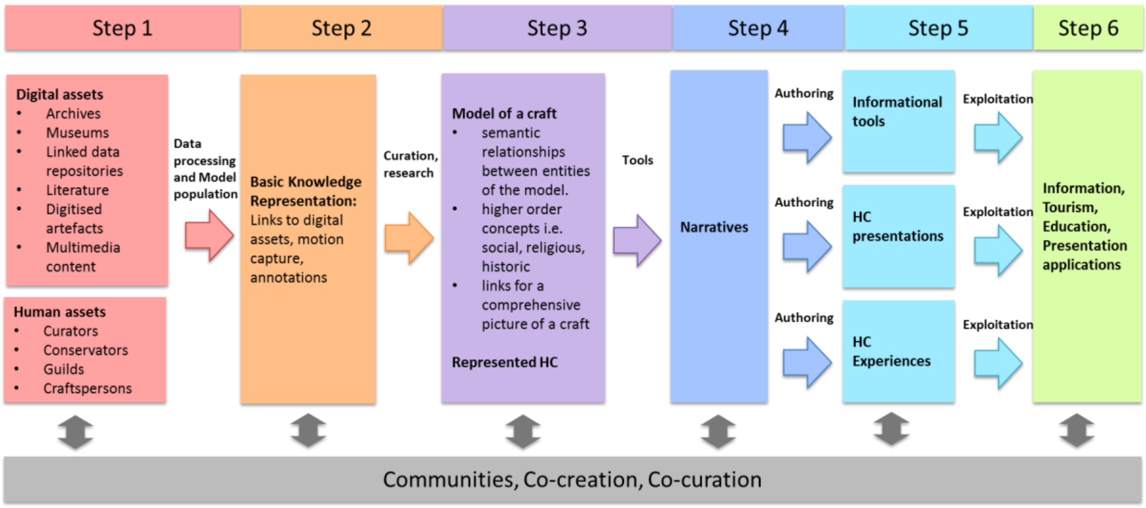


Figure 2. Illustration of protocol steps.

Executing the steps of the protocol linearly would mean that the entirety of digital assets would be acquired a priori. However, it is possible that knowledge acquired in the second step may refer to non-digitised items, which are only then identified, and may need to be digitised as new digital assets in the context of the first step. Moreover, additional, more sophisticated digitisations of an asset may be acquired later on, if judged so by CH professionals. Thus, although the flow of information is presented linearly in these steps, it is executed **iteratively** by revisiting earlier steps, as new insights are obtained, through knowledge collection, curation, and broadening of involved stakeholders. Thus, the protocol allows the iterative revisit of previous steps and the enhancement of their outcomes. The steps shown in Figure 2, illustrate the input required for each step and the result obtained when completing it.

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

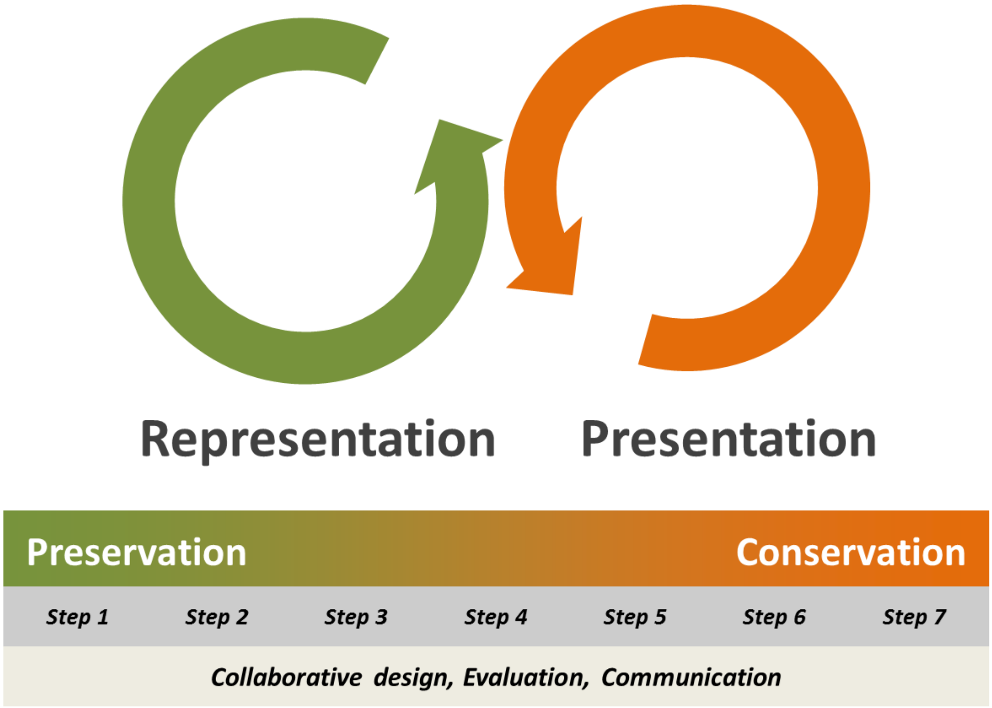


Figure 3. Craft representation and presentation are iterative processes in the Mingei protocol.

In the next sections, we describe Step 1, in Section 1 and Section 2. These sections refer to working with human resources and digitisation of tangible and intangible cultural assets, respectively. Step 2 is described in Section 3 and Section 4, as to the representation of crafting processes and contextualisation narratives, respectively. Section 7 regards Step 5 and Section 8 regards Step 6. The future of this handbook and invitations for the future development of this method are provided in Section 9.

2. Working with practitioners and communities

2.1 Orientation

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

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

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

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

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

More specific sources stem from curated material on expressions of the craft or similar expressions of that craft in other places and times. These can be museum guides, catalogues, magazines, essays, theses and studies. Photographs and illustrations in literature or photographic collections (museums, newspapers, information services, travel books), as well as videos (documentaries and ethnographic films), are useful for a prior understanding of the creation process.

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

2.1.1 What are the elements of interest?

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

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

Quantitative data regard the measurement of quantities relevant to craft practice such as the number of workers, production & economic figures (i.e., employment, creation of added value), social figures (i.e., population), and type of business or organization (financial, economic, professional, administrative and commercial).

Qualitative data for crafts refer to cultural, social, historical or religious significance, aesthetic qualities, originality, and the appearance and affordances of objects, processes or concepts. They are descriptive elements for the representation of objects, such as shape, technique, or even felt properties such as rigidness, smoothness, or texture. The collected knowledge should (at least) respond to address basic knowledge requirements stemming from this approach.

Relevant preparatory **guidelines** are:

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

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

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

We found that **spreadsheets** are of high practical value in this task, because notes, data, and links can be easily associated in a tabulated and indexed format. Multiple sheets of information facilitate thinking in multiple dimensions. In Figure 4, we show views of the spreadsheet we are using to collect knowledge on the Silk pilot.

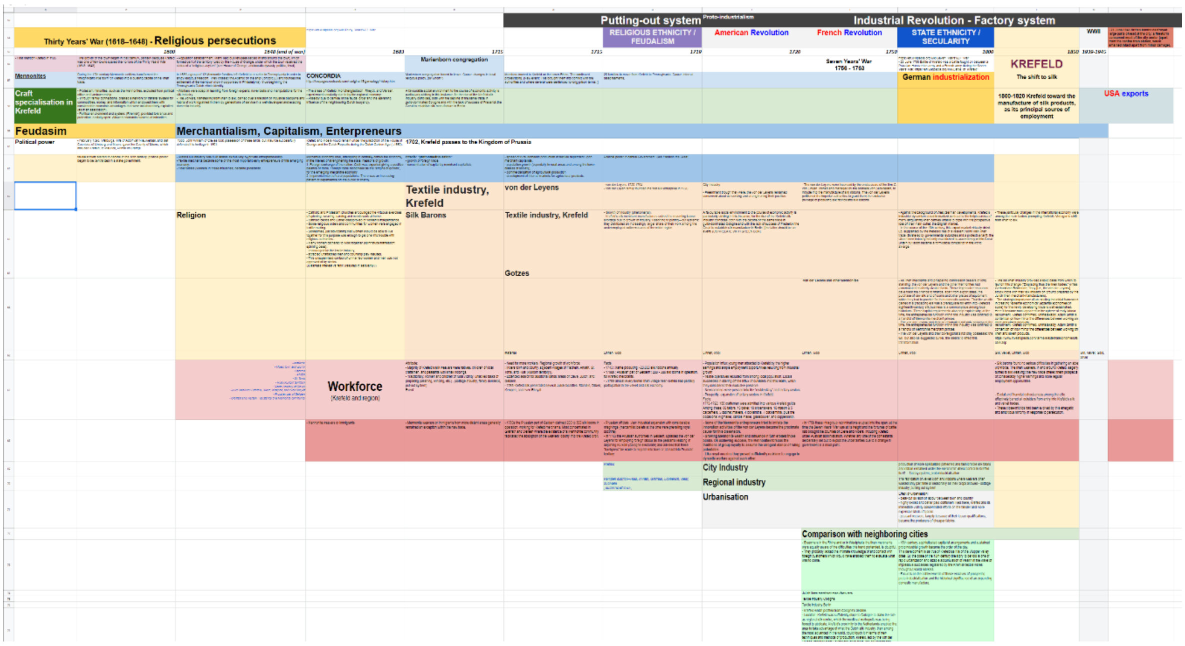


Figure 4. Note collection spreadsheet on the historical context of the textile industry in Krefeld, Germany.

2.1.2 Working with practitioners

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

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

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

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

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

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

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

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

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

The outputs of this step are:

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

In the remainder of this sub-section, we overview the principal topics that are directly relevant to the documentation of a craft. Their purpose is to serve as a guide toward the primary topics of investigation and, in this way, provide a point of departure for co-creation and ethnographic collaboration activities.

2.1.3 Working with communities

Communities are at the heart of safeguarding intangible cultural heritage The 2003 ICH Convention places communities at the centre of all its safeguarding activities and requires the prior and informed consent of the community or group concerned. Community involvement is required in the preparation and implementation of safeguarding programmes and must be willing to cooperate in the dissemination of best practices.

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

2.1.4 Craft practice

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

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

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

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

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

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

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

- Impact of global events on the craft.

Having in mind the affordances of the project budget, it is recommended that stakeholders in collaboration with technical partners are to determine and prioritise the digitisation modalities and targets. If the data to be collected are more than the capabilities of the digitisation project, then human resources are essential in conserving technical resources. By characterising assets as to their cultural significance and urgency due to endangerment, prioritisation can be provided for an initial, representative corpus of data, which can serve as a foundation for additional and ongoing digitisation efforts.

2.1.5 The craft digitisation team

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

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

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

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

2.2 Formalities

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

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

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

2.3.1 Legal issues, Authorisation

Upon establishment of communication, the **collaboration** with the CHI, association, or community is to be **specified** and made clear to all partners. An agreement on the use of Intellectual Property Rights regarding the produced digitisations, information, presentations, and knowledge is to be specified and agreed by the institutions. For this purpose, a Memorandum of Understanding or a Consortium Agreement is to be prepared by a collaboration of legal signatories of institutions and formally agreed upon. In this context, the DESCA consortium agreement can serve as a valuable template for the Consortium Agreement.

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

2.3.2 Ethics, Health, and Safety

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

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

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

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

2.3.3 Individual partner requirements

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

2.3.4 Institutional assets and material

Communication with a CHI, community, or association can involve a description of the **physical assets** and collections of these institutions. These are to be noted as they can provide an initial orientation of the relevant assets to the craft that will be identified as relevant for digitisation. The topic of **insurance** for artefacts that are to be handled or digitised should be brought up and planned if relevant, according to the conventional practices followed by content and asset owners. CHIs and craft communities often have **curated material**, already prepared in the form of literature, guides, brochures or even interactive multimedia presentations. Typically CHIs have a catalogue of their items and may digital collections, along with pertinent metadata. In initial communications, it is important to specify these assets, as potential assets for the knowledge collection of the digitisation project.

3. Digital assets

We consider as **physical assets** the objects and events, which we wish to have **recordings**. Examples of physical assets are a pot, the brush used to decorate it, the soil, clay, and paint utilised, the stool and the wheel of the potter (which, actually has a treadle too). In addition, we also consider as a physical asset the measurable physical events related to the transformation of soil into the artefact.

3.1 What is a digital asset?

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

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

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

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

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

The **most relevant digital data types** are Text, Photographs, and Video. Audio, 3D reconstruction, Human motion digitisation.

We classify digitisation targets into two classes.

Endurants are objects and sites recorded through photographs and textured 3D meshes. The digital assets are images and textured 3D meshes. The choice of scanning modality for the 3D capture of endurants depends on subject size, material, and type of environment. In Figure 5, the media objects for a photograph and a 3D reconstruction (right) are illustrated.

Figure 5. Illustration of two media objects digitizing an endurant entity.

Perdurants are practitioner postures and gestures. They are recorded through audio, video, and motion sensing. Motion data are acquired by motion sensors and video. They are time-series of 3D locations, each one recording the 3D motion of a point on the surface of the practitioner's body. The measurements are topologically organised in a skeletal tree, a hierarchical data structure that represents avatar joints and limbs and is rooted at the avatar's torso. Branches of this tree are called body members. A posture is the configuration of the skeletal tree at a moment in time. A gesture is a chronologically ordered sequence of postures. The pose, i.e., location and orientation, of a held object is represented relative to a designated body member and is encoded as a rigid transformation, i.e., 3D rotation and translation. In Figure 6 the media objects for two perdurants are illustrated. The left image shows a moment in a MoCap recording session and the middle image illustrates the obtained digital asset. The right image illustrates a media object obtained from markerless motion estimation in an archive documentary, its preview superimposing the estimated skeletal tree upon the original footage.

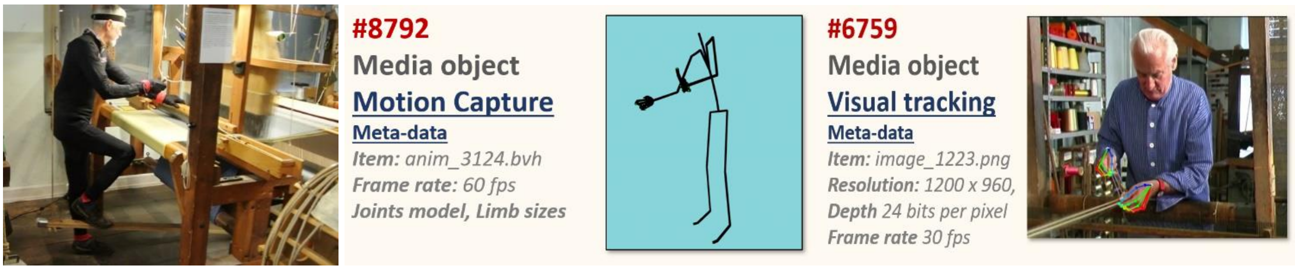


Figure 6. Illustration of media objects that digitize perdurants entities.

3.2 Digitisation of objects and workspaces

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

3.2.1 Photographic documentation

In the fields of archaeology, art history and museology, many recordings and examination methods are based on imaging techniques. One of the oldest but still heavily used non-destructive imaging approaches is photography. In the field of archaeology, for instance, photography has been incorporated into archaeological practice for at least a century, primarily because it is assumed to provide an 'objective' pictorial record. Today there are multiple types of photographic modalities used in a variety of domains from industrial inspection to forensics.

We recommend the comprehensive guide the Canadian Museum, Brosseau, K., Choquette, M., Renaud, L. (2006). Digitization Standards for the Canadian Museum of Civilization Corporation, as an excellent reference for photographic protocols, concerning the material and type of artefact. We present some important high

To simplify the understanding of the digitization process, it is important to classify what we are imaging.

Two-dimensional content: printed mater, manuscripts, visual depiction. A scanner or rectified photography is the recommended scanning modality for: Documents of text, visual art, and elements of printed matter, such as two-dimensional manuscripts or artefacts, black-and-white printed materials, printed materials with photographs and/or annotations, onionskin, rice paper, tracing paper, and newspapers (ink-dot printing). Photographic documents, photographs, and multiple photographs (photographic sets).

3D Artefact photography. Images of objects and artefacts are acquired by digital photography. The digitization process for such content essentially "flattens" three-dimensional physical objects into two-dimensional digital representations; therefore, additional issues arise when considering how best to create, display, and describe the digital surrogate.

A camera is only one component of a successful 3D digitization project; also needed is an environment suitable for photographing objects, including lighting, background, and materials to properly position the objects for capture: a professional-quality digital DSLR camera with a 50mm lens and shutter release cable, tripod or copy stand, lighting (2-3 mountable photo lights with stands, photo tent/cube for table top photography), black, neutral grey, or white background, colour and/or grayscale separation guide, cradles, paperweights, tape, image editing software.

Camera settings will vary depending on the setup being used and the object being photographed, but these settings can be used as a general starting point. Consult the camera manual to find out how to adjust these settings.

Table 1. Camera settings for artefact photography.

Setting	Recommendation	Comments
ISO	100-200	A lower ISO produces a smoother image with less digital noise.
Shutter Speed	1/25	This may require some experimentation depending on the setup being used. If the photos are too dark, a longer shutter speed may be needed. However, a longer shutter speed can cause blurring in the image, especially if a tripod is not being used.
Aperture	f8-f11	A smaller aperture gives a better depth of field in the image (objects both near and far are in focus).
White Balance	Auto	If saving images in RAW format, the white balance can be adjusted later.

File settings	10 to 16 megapixels; 48-bit RGB	The initial images should be captured at the highest size/quality possible for the camera.
File Type	RAW (Alternate: TIFF)	RAW files save the image exactly the way the camera's sensor "sees" it, and allow colour and white balance to be adjusted later.

Photographic techniques will vary depending on the setup and the item being photographed, but some general guidelines are listed below.

Basic technique:

- Mount the camera on a tripod and use a shutter release cable when taking photographs to avoid blurring.
- Avoid shadows in the images by using multiple lighting sources in various positions around the object.
- Position the object on or in front of a neutral background.
- Position the object as straight and/or level as possible.
- Include the colour or grayscale separation guide and scale in the image.
- Make sure the complete object is in the frame (except in the case of capturing specific details).
- Photograph the object from multiple angles (front, back, left, right, above, below, etc.) if there are details that cannot be viewed from a single angle.
- When shooting multiple angles, keep the object and the camera at the same distance/position.
- In general, avoid using the camera's digital "zoom" functionality, as this will lead to lower quality images. Physical zoom functions that physically move the lens are also acceptable.
- Capture any specific areas of interest, such as trademarks, signatures, seals, hallmarks, etc.

Other Recommendations:

- For smaller objects, a macro lens may be required.
- For clothing, place the objects on a mannequin if possible. If a mannequin is not available, lay the objects flat and photograph from above.
- If the item has multiple components or moving parts, photograph the object(s) multiple times in various states.
- For reflective objects, take care to ensure that the photographer and/or camera are not visible on the reflective surface of the object.

3.2.2 3D Documentation

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

We recommend the 3D ICONS Guidelines for a review of 3D scanning and processing guidelines. Moreover, important resources for 3D digitisation of CH are publicly availed by the non-profit organisation Cultural Heritage Imaging, including tools, technology, and training, for several digitisation methods used in the conservation and preservation of Tangible CH.

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

There is a range of products that employs these principles in **variations**, such as terrestrial and aerial photogrammetry. In addition, **combinations** of such principles are found in devices, such as the combination of trinocular stereo with structured light and IMU information in various types of handheld scanners. Recently, such applications are available for mobile devices leading to sufficient for many purposes and cost-efficient 3D digitisation solutions.

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

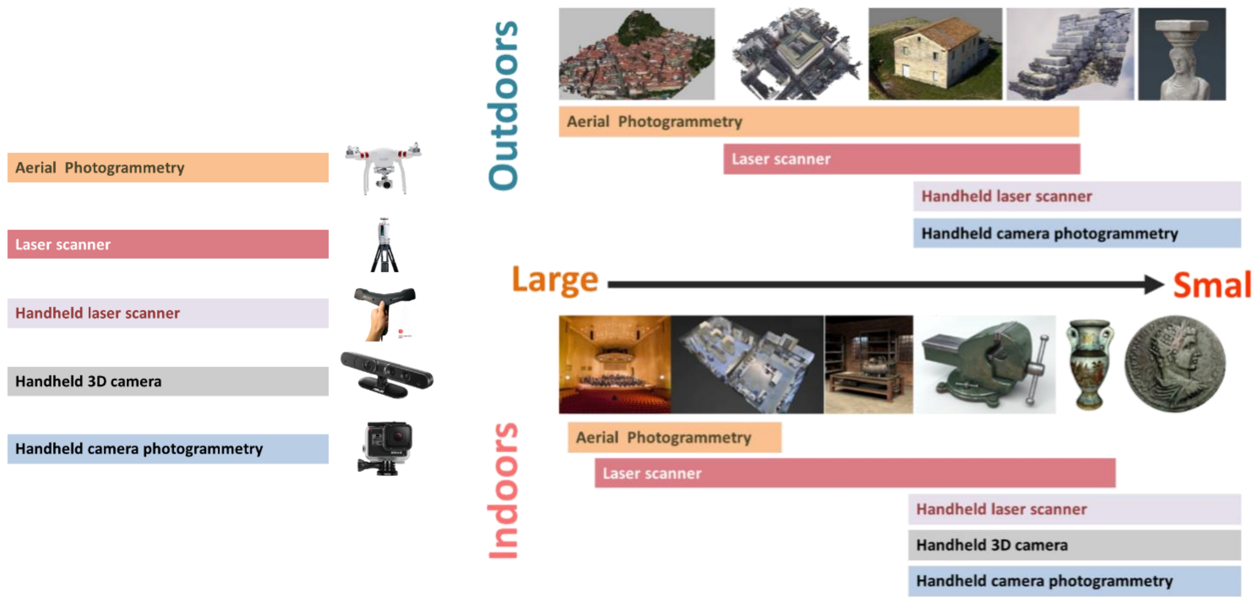


Figure 7. 3D scanning modalities and use cases in CH.

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

The **guidelines** are not as apt as for photographic documentation, for two reasons. The first is the recent development of some of these technologies. The second is the multiple modalities available for 3D digitisation.

Modalities vary in operational capabilities and environmental conditions, as well as **cost**. In some cases, the commission of the digitisation or rental of equipment may be more efficient.

The applicability of digitisation modalities is presented in the following table and figure.

Table 2. Applicable sensors per type and size of the environment.

	Indoors	Outdoors
Building complex	N/A	Drone, Camera
Large building	N/A	Drone, Camera
Multiple rooms	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Large room	LIDAR	N/A
Room	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Small room	LIDAR, 3Dcam, 3Dscan, Camera	N/A
Object, scene detail	3Dcam, 3Dscan, Camera	3Dscan, Camera

<u>Laser scanner</u>

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

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

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

Photogrammetry

For the digitisation of outdoor environments, the proliferation of Unmanned Aerial Vehicles (drones) has broadened the horizons of aerial surveillance and facilitated **aerial** photogrammetric reconstruction, providing vantage viewpoints that greatly simplify reconstruction. On the other hand, scene segments of interest may not be visible from aerial views, such as the scene locations below the eaves of buildings. Nevertheless, **terrestrial** views can be combined. This solution requires at least two scanning processes: one aerial and one or more terrestrial, depending on the complexity of the scene. In Figure 8, we demonstrate the reconstruction of the aerial and terrestrial views of a traditional village.

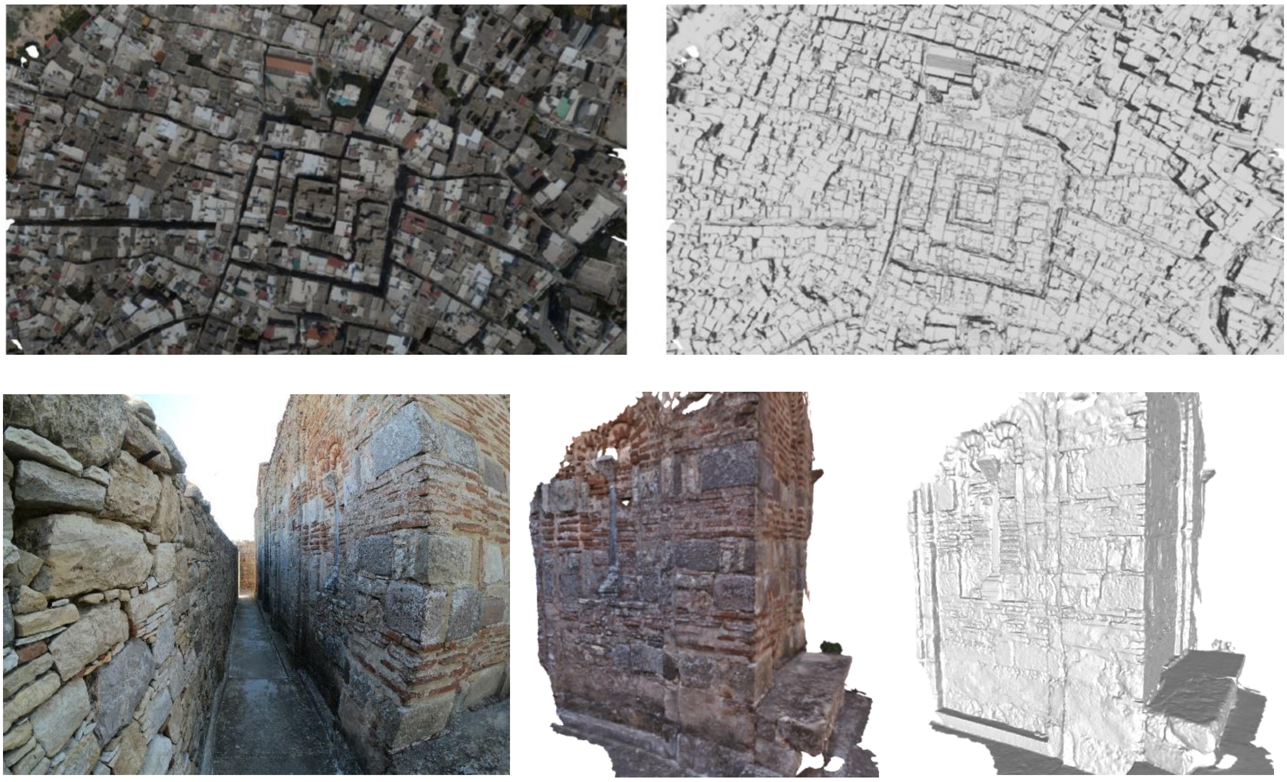


Figure 8. 3D photogrammetric reconstructions from aerial and terrestrial views.

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

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

However, if carefully set one can obtain detailed reconstructions of human size items. In Figure 9, we use photogrammetry to reconstruct a mannequin with traditional attire.

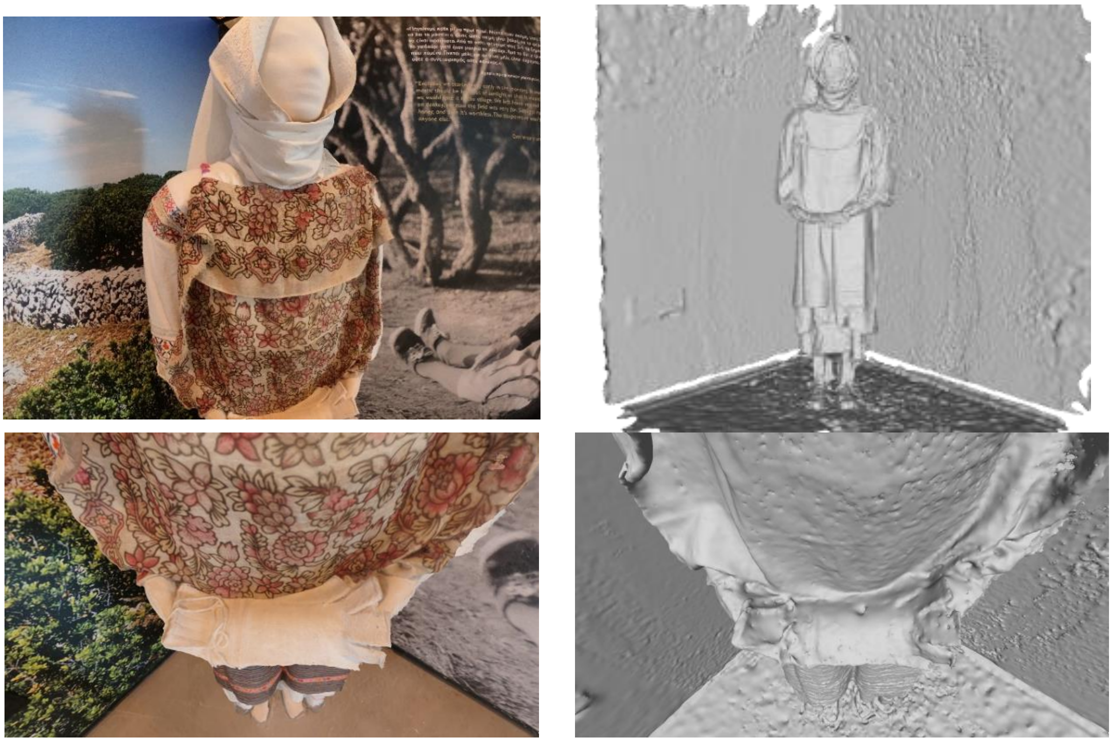


Figure 9. Original photograph (top left) and 3D photogrammetric reconstruction.

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

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

<u>Handheld scanners</u>

During the last 10 years, the proliferation of imperceptible, active illumination sensors (RGB-D cameras) has played a significant role in the development of new Computer Vision approaches and attracted new interest to older works in the domain of 3D surface reconstruction that was hindered by the limitations of binocular or multi-view stereo. Several products provide a fairly reliable solution for small objects. They are accommodated

In a **comparison with photogrammetry,** it falls short, particularly due to the limitations of sensor hardware. The most important limitation is the range within which it is reliable: 0.5m-1.5m. This distance in combination with the relatively low definition of the RGB camera produces less realistic textures. Moreover, the sensor is mainly designed for indoor use. To operate in the outdoors illumination insulation and engineering are required, i.e. low levels of (sun) light are required so that they do not overcome the intensity of the active illumination component. The digitisation modality is more resistant to lack of texture, due to the use of active illumination. The scanning modality is not sufficient for high-end 3D scanning it provides a photorealistic reconstruction of the room or desk-sized artefacts. However, it provides a reliable solution for a 3D overview of indoor spaces and artefacts.

The sensor is lightweight and handheld, though it requires a laptop or tablet attached because the sensor is available as a sensor and not bundled with an image-recording module. The scanning procedure is simpler than photogrammetric image acquisition because active illumination allows for a higher degree of affinity in the trajectory of the handheld sensor. In comparison with photogrammetry, it exhibits the advantage of simpler camera manipulation in cluttered environments. It thereby could comprise a handy and cost-efficient tool, for cases where a simple scan suffices the requirements of documentation. The reconstruction of a mannequin and an industrial machine is shown in Figure 10.

Figure 10. 3D reconstruction of a clothed mannequin and industrial machine.

3.3.3 Post-processing of 3D scans

3D post-processing is a procedure consisting of a sequence of processing steps that result in the direct improvement of acquired 3D data, and its transformation into visually enriched geometric representations.

- **Geometric reconstruction.** Geometric reconstruction is the essential processing step for the elaboration of a 3D representation of an artefact or monument following the capture of 3D digitisation. It includes the creation of a mesh for the scanned data the processing of this mesh, mesh cleaning, mesh simplification, and mesh retopologisation.
- **Visual enrichment of 3D models.** Several computer graphics techniques can be utilised for the visual enhancement of the 3D models produced from the geometric reconstruction processes. Visual enrichment techniques
- **Hypothetical reconstruction.** The hypothetical reconstruction of an architectural object or archaeological site to a previous state is a process primarily related to the field of historical studies. Nevertheless, some specific technical and methodological issues with 3D graphical representation of missing (or partially destroyed) heritage buildings are often integrated into 3D reconstruction approaches.

We focus on a situation where the aerial scan poorly reconstructs the space below the eaves, due to visibility constraints. To improve the reconstruction, we added images acquired from a terrestrial view, under the eave, where the UAV may not fly. In Figure 11, the improvement in the reconstruction of that area is shown; the left column shows the reconstruction of the aerial view and the right column the combined reconstruction.

Figure 11. Combination of aerial and terrestrial views.

The 3D model is available on the MOP and can be displayed online through a 3D view that we have developed for this case. In addition, we produce also a video of the reconstruction, which features an alternative-rendering approach (i.e. depth views, or views that show the mesh triangles).

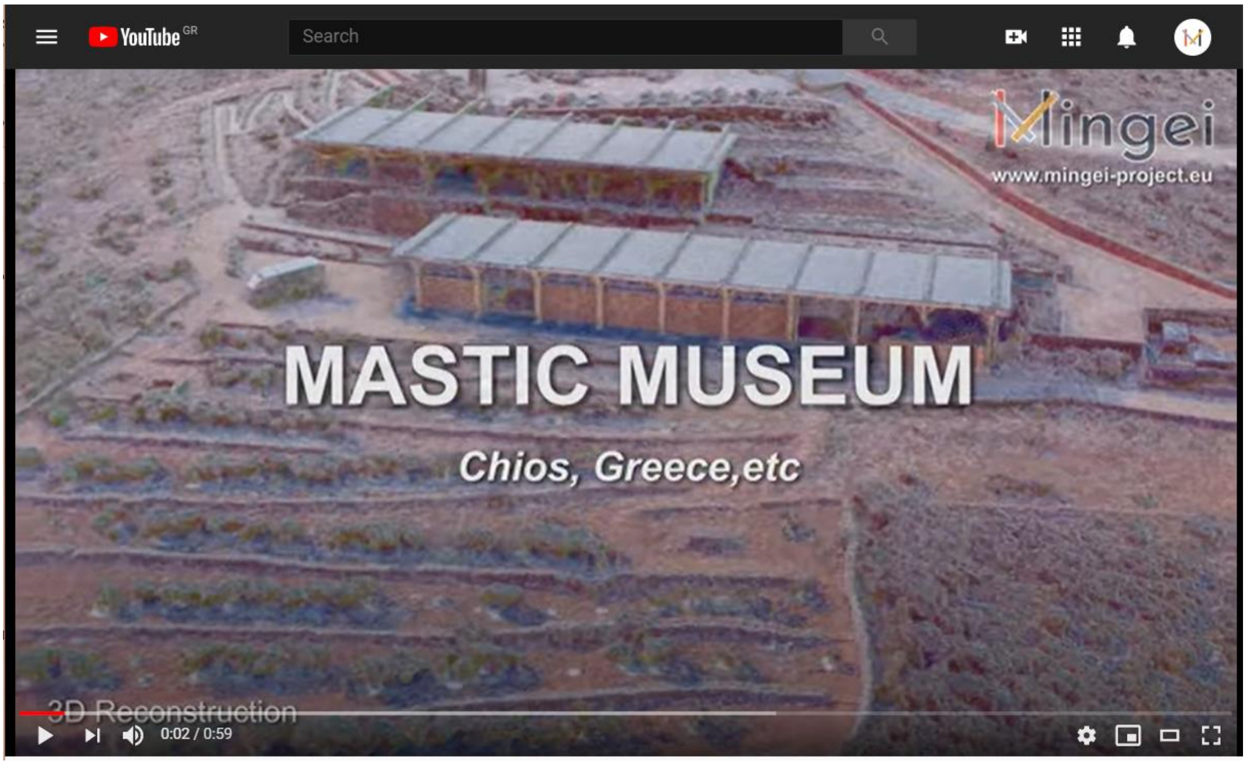


Figure 12. Video showing the 3D reconstruction of the Chios Mastic Museum of PIOP.

3.3.4 File formats

A 3D file format is used for storing information about 3D models. The basic purpose of a 3D file format is to store information about 3D models and in particular the geometry of a model, which describes its shape, and appearance. The basic contents of a 3D file format are:

- The **geometry** of the 3D model
- The **appearance** of the 3D model
- Scene information

There are three ways of encoding **surface geometry**:

- **Approximate mesh.** The surface of a 3D model is first covered with a mesh of polygons. This represents the surface geometry of the target model. Triangles approximate the smooth geometry of the surface. Hence, this is an approximate format. The approximation gets better as the triangles get smaller. However, the smaller the triangles, the larger the number of triangles you need to tile the surface, increasing the required computational resources.
- **Precise mesh.** When an approximate encoding of the 3D model is not enough precise file formats can be used. These formats use parametric surfaces called Non-Uniform Rational B-Spline patches (or NURBS). These surfaces look smooth on any scale and can replicate the surface geometry of a small part of a 3D model in exact detail. While the precise mesh is exact at any resolution, its rendering is slower and is avoided in applications where fast rendering is important.
- **Constructive solid geometry.** In this format, 3D shapes are built by performing Boolean operations (addition or subtraction) of primitive shapes like cubes, spheres etc. This file format is not relevant to scanned objects, for objects digitally created.

The second feature of the 3D file format is the **appearance** of the model. Colour and specularity are examples of related properties. Appearance describes surface properties such as material type, texture, and colour and determines the way that the model is rendered. Information about appearance can be encoded in two ways:

- **Texture mapping.** In texture mapping, every point in the 3D model's surface is mapped to a 2D image. Every surface point corresponds to a coordinate in this 2D image. The 2D image containing texture information needs to be stored within the same file or separately in a different file.
- **Face attributes.** Another way of storing texture information is to assign each face of the mesh a set of attributes. Common attributes include colour, texture and material type. A surface can have a specular component indicating the colour and intensity of true mirror reflections of light sources and other nearby surfaces. This approach is less relevant to scanning approaches and more relevant to the computer-aided design of objects.

Encoding **scene information** is a feature of a few 3D file formats. The scene describes the layout of the 3D model in terms of cameras, light sources, and other nearby 3D models. Some 3D encode information about lights.

The two most widely used formats for 3D digitisations are STL and OBJ. Comprehensive reviews of the numerous types of 3D file formats can be found in the EduTechWiki of the University of Geneva on 3D file formats and Wikipedia on 3D graphics file formats.

STL. STL (STereoLithography) is important in the domains of 3D printing, rapid prototyping, and computer-aided manufacturing. The corresponding file extension is.STL. STL encodes the surface geometry of a 3D model approximately using a triangular mesh. STL ignores appearance and scene information. It is one of the simplest and leanest 3D file formats.

OBJ. The OBJ file format is widely used in 3D graphics and is associated with the file extension OBJ. The OBJ file format supports both approximate and precise encoding of surface geometry. For approximate encoding, the surface mesh is not restricted to triangular facets, but polygons can be used. For precise encoding, it uses smooth curves and surfaces such as NURBS. The OBJ format can encode colour and texture information. This information is stored in a separate file with the extension.MTL (Material Template Library).

GLB is the binary file format representation of 3D models saved in the GL Transmission Format (glTF). Information about 3D models such as node hierarchy, cameras, materials, animations and meshes in binary format. This binary format stores the glTF asset (JSON, .bin and images) in a binary blob. It also avoids the issue of an increase in file size which happens in the case of glTF. GLB file format results in compact file sizes, fast loading, complete 3D scene representation, and extensibility for further development. The format uses model/gltf-binary as MIME type.

We recommend the latter GLB format because of its advantage to encode all reconstruction in a single file.

3.4 Digitisation of human motion

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

3.4.1 Motion recordings

Digitisation of human motion has been achieved by several methods, which can be classified based on the requirement that requires human subjects to **wear markers or not**.

Motion Capture (or MoCap) technologies measure the movement of subjects in three dimensions, based on wearable markers whose location in 3D is estimated by corresponding sensors. As such, the resulting data are not necessarily intuitive to visualize without some post-processing. Two main technologies are used, optical-based MoCap, and inertial measurement units (IMU) MoCap. Unlike normal video, MoCap directly extracts position information of human motion. The results encapsulate human motion in 3D with great detail and therefore show a complete representation of the recorded motion.

Visual Tracking methods use camera-type visual sensors to record the subject. These sensors are typically video cameras (RGB sensor), possibly with the addition of a depth camera (RGBD sensor). Motion is estimated in 3D by the processing of the visual stream, segmentation of the motion silhouette from the rest of the imaged scene, and fitting in a 3D mathematic model into this silhouette. 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. The methods have been the epicentre of many works in Computer Vision considerable progress has already been achieved in the last decade. Visual tracking is of particular importance to the documentation of CH because it means that a 3D representation of motion can be obtained from documentaries and archive footage.

Marker-based systems have multiple cameras that encircle a specific volume. Retroreflective (i.e. has minimum scattering reflection) spherical markers are placed on the subject at the set pattern. The cameras emit IR light that is being reflected directly back to its source with virtually no scattering by the markers. A variant of that approach is the use of active LED markers that emit IR light instead of reflecting it. Each camera generates 2D images where the markers appear as white dots and everything else is black. Those images are triangulated and a complete volume is generated that shows the motion in three dimensions. The marker-based system provides a complete 3D area where only the marked objects are tracked while ignoring the rest of the scenery. With enough cameras and an appropriate setup, it is possible to have an unobstructed view of a large area. Another benefit is that the system records only the markers, therefore background items are not included in the final recording, making the output efficient. However, marker-based systems require more post-processing to extract joint angles from the cluster of markers, and they are not portable by their nature. Though they can be used for many different purposes, they need a structured environment. In general, optical-based systems are affected by their environment. Sources of IR light (sun, heating bodies, even a lot of people in a small room) can cause the sensors to record incorrect data, space limitations can limit the field of view, and equipment that needs to be in contact with the user (tools, instruments etc.) can create obstructions.

The IMU MoCap systems are a bit different in the sense that they do not measure displacement but acceleration. Each IMU is comprised of an accelerometer, a magnetometer, and a gyroscope that provide measurements in three dimensions concerning the earth's magnetic field. The output of one IMU is relative to a global coordinate frame. The biggest benefit of this method is that there is no need to generate a reference signal, such as the IR light in optical-based systems. However, this is of limited use when there is interest in the relative position between two body segments. To identify relative position and orientation, the person needs to wear several IMUs (either by using straps or embedded in specialized clothing) on different segments of the body. Since more than one IMUs is used, the measurements can be transformed to show the relative acceleration between each unit and therefore the relative position of each sensor can be found by integration. In general, IMU systems are very accurate with little noise. However, they are sensitive to magnetic noise. Sources of magnetic noise can be electrical appliances, metal furniture, and metallic structures within a building. There are commercially available suits that have embedded several IMUs to be worn by the subjects and their output is very streamlined without the need for significant post-processing of the data.

However, the drawback is that IMU suits can be used to record only the motions of people who can wear them, unlike marker-based systems which can track the motions of drones, robots, individuals with amputations etc.

To sum up, IMU-based suits are portable but have high specificity. However, electromagnetic disturbances can cause a high error in the azimuth angle (Perpendicular to the north-south pole of the earth's magnetic field), for as long as the magnetic distortion is present. Regardless of the technology used to acquire those recordings, the resulting data are always a chain of coordinate frames and the difference in position and orientation between them. In the context of this project, MoCap recordings can be used to preserve and recreate the motions of the craft.

3.4.2 Motion Capture for crafts

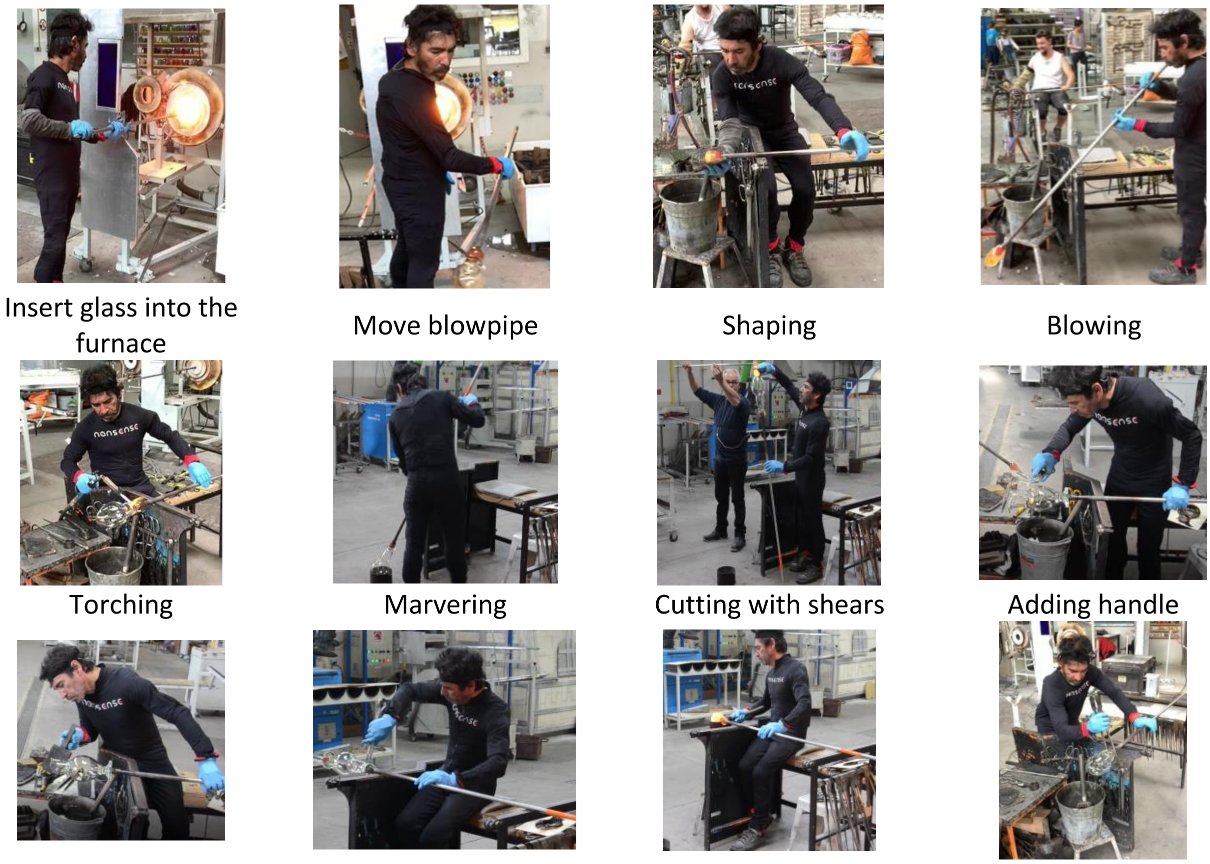
We recommend IMU MoCap for the cluttered spaces of craft workshops. The recordings for three crafts are shown in Figure 13, Figure 14, and Figure 15. It is recommended that recordings take place while noting the action performed, something that will ease their characterisation later on.

Figure 13. Recordings of mastic cultivation.

Punch card perforation | Beam wrapping | Beam preparation

Small loom | Medium loom | Large loom

Figure 14. Recordings of textile manufacturing.



Insert glass into the furnace | Move blowpipe | Shaping | Blowing

Torching | Marvering | Cutting with shears | Adding handle

Shaping with paddle | Shaping with jacks | Shaping with block | Shaping with tweezers

Figure 15. Recordings of glasswork.

3.5 Annotations

Though significant tools exist for the representation of verbal semantics, the topic of associating visual data with semantics, or semiotics, has been less explored. In verbal content, words and phrases correspond to semantics. In static visual data, some spatial regions are associated with specific meanings, such as a sign. Similarly, dynamic visual data contain scenes of interest, because of the occurrence of an action. The demarcation of parts of an object, a process or an event (sometimes called parsing or articulation), contributes to the understanding of an object or activity. This way, parts of an object such as an ornament, or parts of a scene such as a gesture can be isolated, represented, and studied.

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

3.5.1 Static scenes

An Annotation Editor for 3D models was developed to cover the requirements of associating parts of 3D digitisations. This requirement stems from the need to provide location-specific information on points and regions of an object or site, such for example a workshop. In objects, we may wish to indicate which piece of a carafe is the handle or indicate a motif or symbol upon a piece of pottery. The Annotation editor

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

The Annotation Editor provides a user-friendly annotation user interface for the spatial mark-up of 3D models. Feature (a) above is demonstrated in Figure 16. In the figure, the photogrammetric reconstruction of a marble sculpted temple is shown, through the 3D GUI of the Annotation Editor. In the example, the user wishes to annotate an approximately circular piece of the ornament, which symbolises a flower. By navigating in 3D, the user can find a view which facilitates convenient observation of the target. The user circles roughly the region around the ornament and the 3D & RGB content are utilised to accurately segment the target (intuitively, it is the opposite of the "magic wand" tool, in image processing programs). This simplified greatly the interaction of the use, particularly in the 3D case. The component is described in Mingei-D4.2.

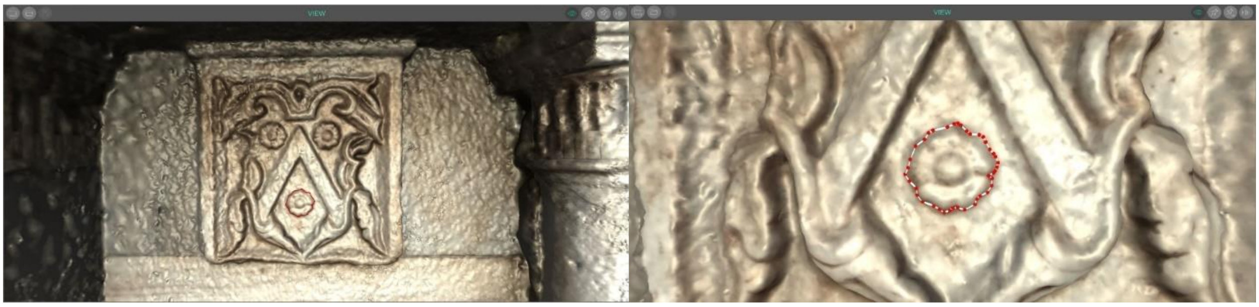


Figure 16. Region-based annotation of a 3D reconstruction.

3.5.2 Dynamic scenes

Animation Studio is the tool that we utilise to associate fragments of digital assets to craft actions and gestures, to associate them with their corresponding semantic description. Animation Studio is an application to **visualise**, **edit**, and **annotate** 3D animation files, obtained by motion capture or visual tracking. In the case of visual tracking, temporally corresponding video can be also edited. The application allows the user to isolate animation segments and associated videos, for further annotation. The application allows the synthesis of composite animation files and videos from such segments. The tool allows the synthesis of composite animation and video files from isolated segments. In Figure 16, it is shown to be used in the isolation of a weaver pushing his foot on the treadle of a loom.

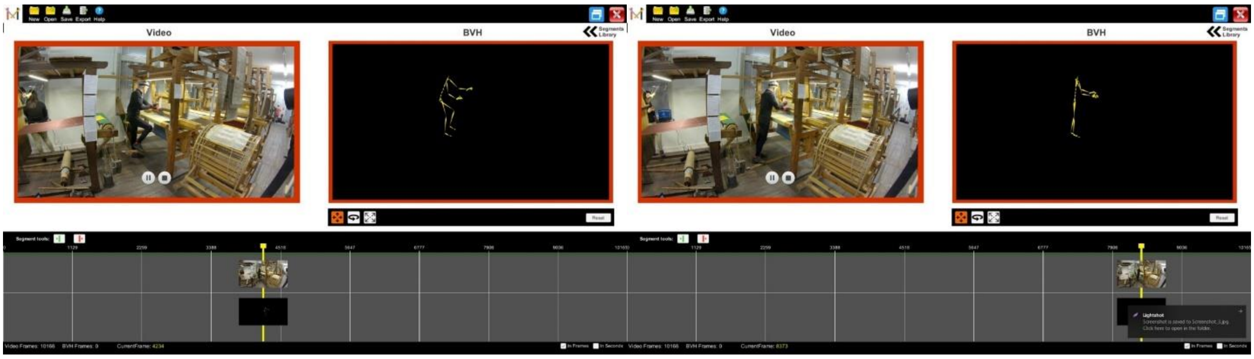


Figure 17. Animation Studio is used to isolate segments of 3D and video animations.

The BVH format is initially used by the application. All major video file formats are supported. Animation Studio features a BVH parser and exporter, based on the BVH specification, written and optimized for Unity. The animation data are parsed, split into per-joint per-channel animation curves, and compiled into an animation clip. Regarding visualization of the skeleton defined in the BVH file, a simple skeleton is generated, using spheres for joints and cuboids for bones, providing a lightweight implementation. Additionally, controls are provided for viewport transformations, such as 3D rotations, zoom in-out, change of viewpoint etc.

Users can split BVH files into parts (usually defining a specific motion) and then export those parts as new BVH files. Users can play individually the selected split part and modify the attributes (description, start frame and end frame) of a split part. In addition, provides the capability to move split parts up or down within the list to change the order they are played or exported. Users can add a new split part or remove an existing one.

Animation Studio provides a timeline to navigate through the animation and the video. Users can define a new split part in this timeline. The UI provides controls to play/pause the video and displays timing in frames or seconds.

3.6 MOP implementation

New digital assets that are not Web resources, i.e. new media objects, are made by uploading them to the MOP repository, associating them with new URLs, and assigning them to the Web server of the MOP. They are identified by an IRI and served by the MOP Web server via the HTTP protocol. No operation is required for resources already online. When data collection is complete, all media objects are seamlessly treated and their storage location is transparent to the user.

The instantiation of media objects is enabled using forms that simplify asset linking and the entry of metadata. In Figure 18, the user task is illustrated. The images show a media object instantiation form, for a 3D reconstruction. The asset is comprised of multiple files, representing the geometry and visual appearance of the digitised structure. The form enables the entry of the URL, its appellation, and potential relations to existing knowledge entities, such as a place, a person, or an event.

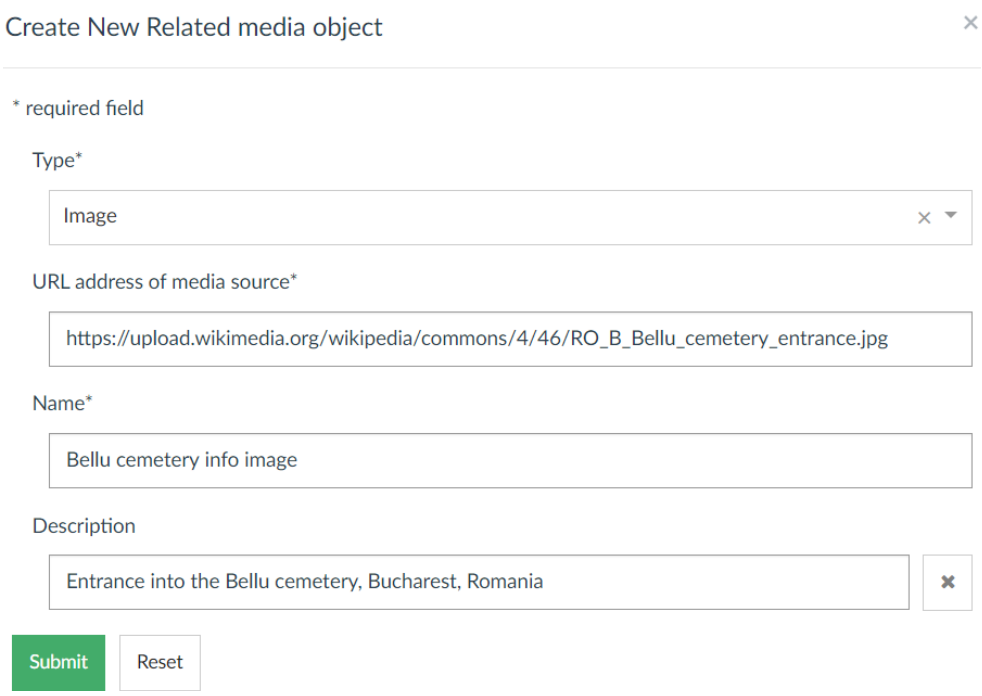


Figure 18. Linking a digital asset to the MOP.

4. Knowledge elements

In this step, basic craft knowledge elements are formed. Knowledge elements include curated information about an element of knowledge and links to digital assets that record it. Knowledge elements are instantiated through **knowledge statements**. Relations between knowledge elements are established to signify meaning in terms of narratives or crafting processes, in the next steps.

4.1 Conceptualisation

Knowledge elements and relations between them belong to classes. In Mingei, these classes are defined in the Mingei ontology in detail. The basic knowledge elements utilised are Materials, Objects, Places, Persons, Groups, and Events.

Figure 19 illustrates the relation between a knowledge element and a digital asset. More specifically, a person is linked to the encapsulating media object, which contains the asset (an image) along with technical meta-data for its appropriate presentation.

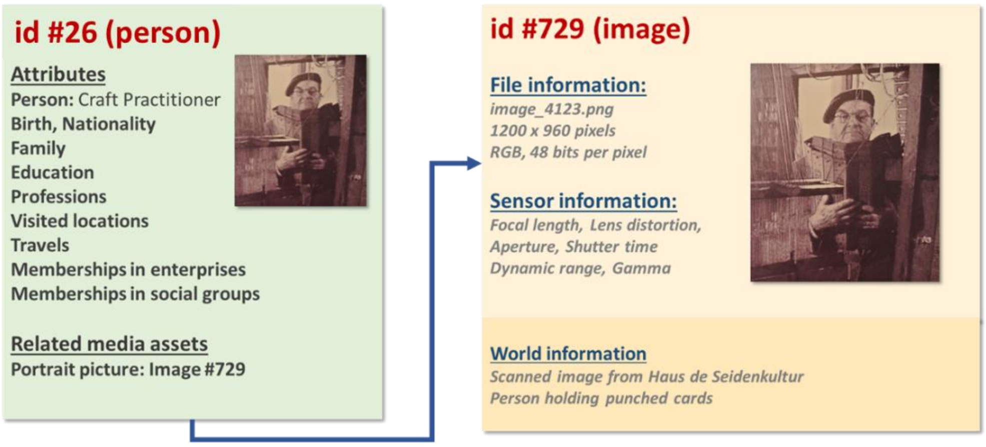


Figure 19. Relating a representation of a 'Person' to a 'Media Object'.

Forming a knowledge element requires a comprehensive understanding of the assets and their digital representation (digital asset). This process is a basic **digital curation** process. Digital assets are represented in the knowledge base through knowledge elements, which associate digitisation data with the result of a curation process that yields metadata, annotations, and descriptions. Intuitively, a knowledge element is what we would read about the artefact in the museum guide about it.

In Mingei we add the concept of Event in our representation, following the principles of the CIDOC-CRM. The generality and plasticity of the event as a concept provide the ability to represent a wide variety of topics and relate diverse notions and knowledge entities. Figure 20 illustrates how events can be conceptualised to represent two events relative to a crafted artefact. On the left, events relate a sculpture to its creator. On the right, an event is used to represent the crafting of a glass body. We distinguish between the two as **contextualisation** (left) and **crafting** (right) events.

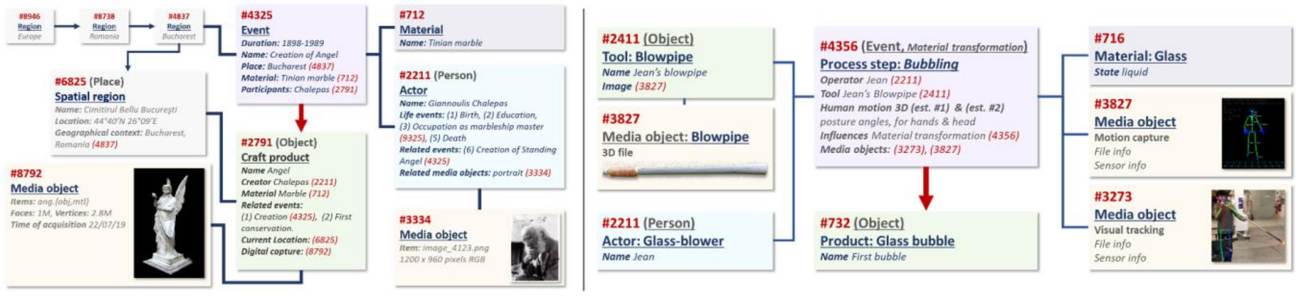


Figure 20. Relations between objects, persons, places, and events.

The visual appearance of artefacts may bear signifiers (i.e. symbols or imagery) that refer to historic or legendary events. In Figure 21, we show an example. The historic figure of Charlemagne is illustrated as a person. Events related to this person are several military campaigns. Using the mereological representation of events, a broad event, such as the "Italian Campaigns", can contain links to individual campaigns and individual battles per campaign. Among these events, we are interested in the acquisition of a Persian elephant, a story that made its way into oral tradition and gave rise to a folk motif found in garments and textiles even today. You can read the story on MOP at [this link](). By relating the historic event to the digitisation of the motif we can associate the narrative with the picture and in turn with the artefacts that bear it.

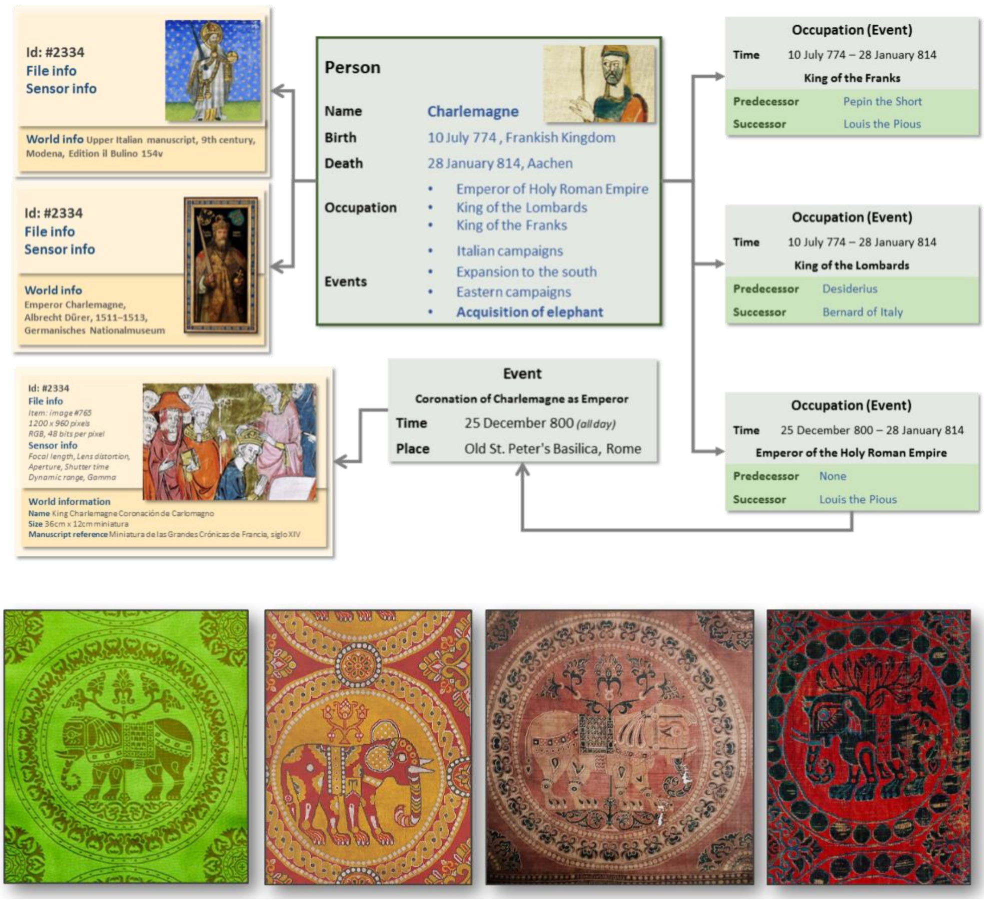


Figure 21. Illustration of knowledge elements related to Charlemagne (top) and motifs found in traditional textiles (bottom).

4.2 Materials

Materials are documented by name and can be classified into minerals, fauna, and flora. In the MOP, users can add materials at will to their workspace and projects. However, it ought to be noted that several materials are subject to legislation, and in Europe, the following two regulations apply:

- Regulation 1151/2012 on quality schemes for agricultural products and foodstuffs *provides a clear framework for the protection of designation of origin and geographical indication*. Mingei serves this goal through digital certificates of craft products.
- Regulation 1007/2011 on textile fibre names and the marketing of the fibre composition of textile products is adhered to by the vocabularies of Mingei.

The MOP provides a UI component for the entry by name of materials, which also provides linkage to definitions of materials by the thesauri of Getty and UNESCO. Links to definitions by National Aggregators can be also added. In Figure 22, the MOP UI is shown for the entry of silk into the collection of materials. The SKOS information is the entry in the Getty thesaurus.

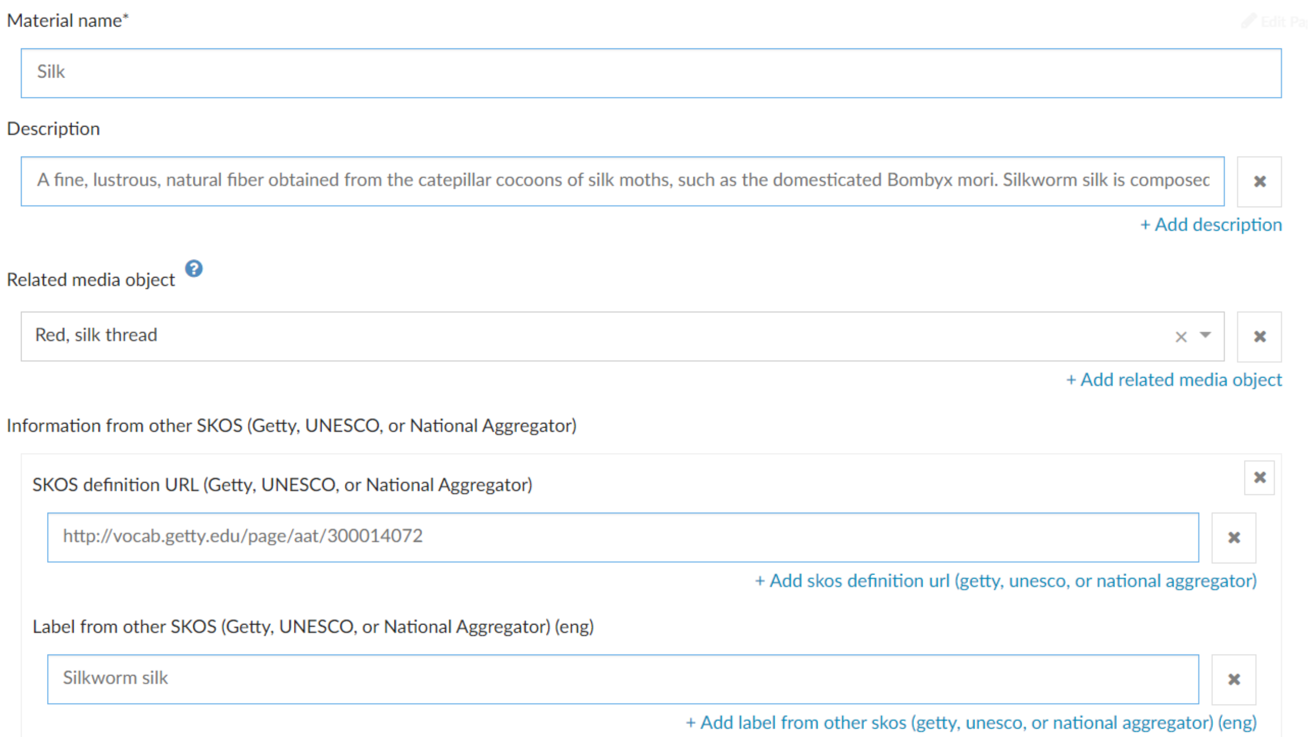


Figure 22. MOP UI for material definition.

4.3 Objects

Objects are composed of materials and cover a broad range of "things". They are primarily used to represent craft artefacts, tools, and machinery. The Mingei ontology and the MOP by default provide links for the creation and, if non-existing anymore, the destruction of an object. Through these events, the creator(s), location, and date can be associated, as shown in Figure 20. Moreover, an object may be linked with an arbitrary number of digital assets, such as media objects. In Figure 23, we illustrate the relations between a silk artefact and three media objects, two images of the object and one image of its sketch.

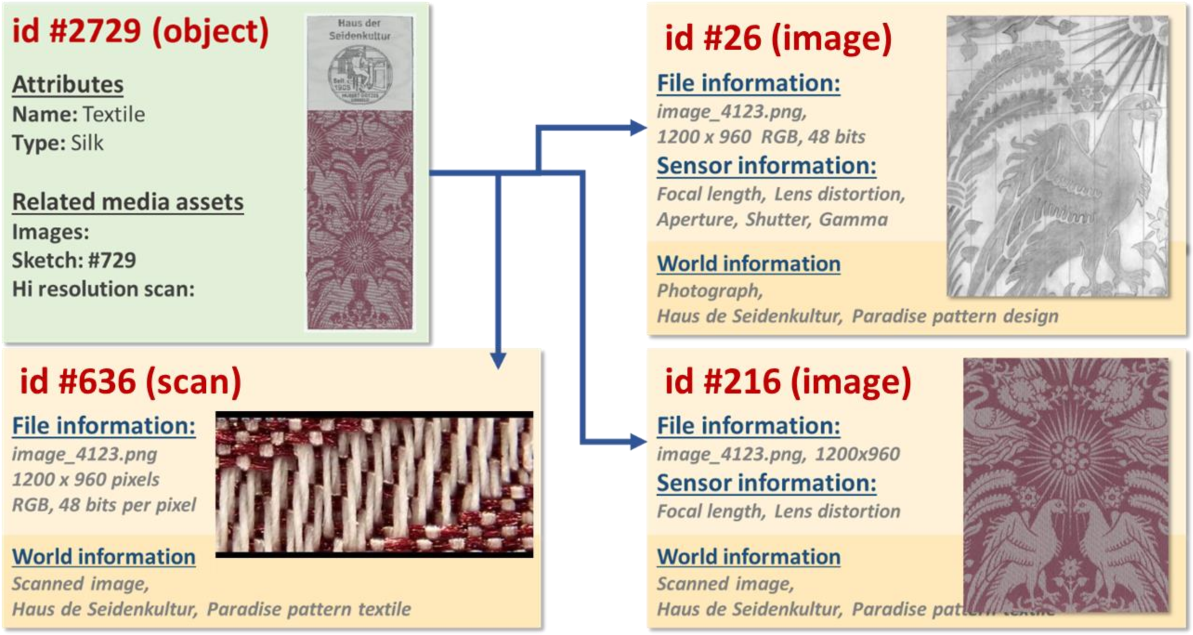


Figure 23. Object knowledge element (a silk page marker) and linked medial objects.

4.4 Places

Locations on the Earth are defined as points which have 2 coordinates, latitude and longitude. Regions are polygonal representations upon the surface of the Earth. We call both “places”. A semantic property of a place is whether there is, or was, a name associated with it. For named geographical locations, we use a database of location names (GeoNames). The coordinates and further semantics, such as hierarchies of city, region, and state inclusion, are also available through this resource. The MOP will automatically retrieve the coordinates from location names registered in GeoNames.

A more refined representation of locations may require addresses or even arbitrary user-defined locations on Earth that are not included in the database. The coordinates of these locations are provided through direct input of GPS coordinates.

A common modelling simplification in database names is that the entire region (e.g. a city) is associated with a single point location. This may be sufficient for some cases, but an overly coarse approximation in other cases. For this reason, place knowledge elements may link to an arbitrary number of locations. In Figure 24, the instantiation of a knowledge element for a village in Greece is shown.

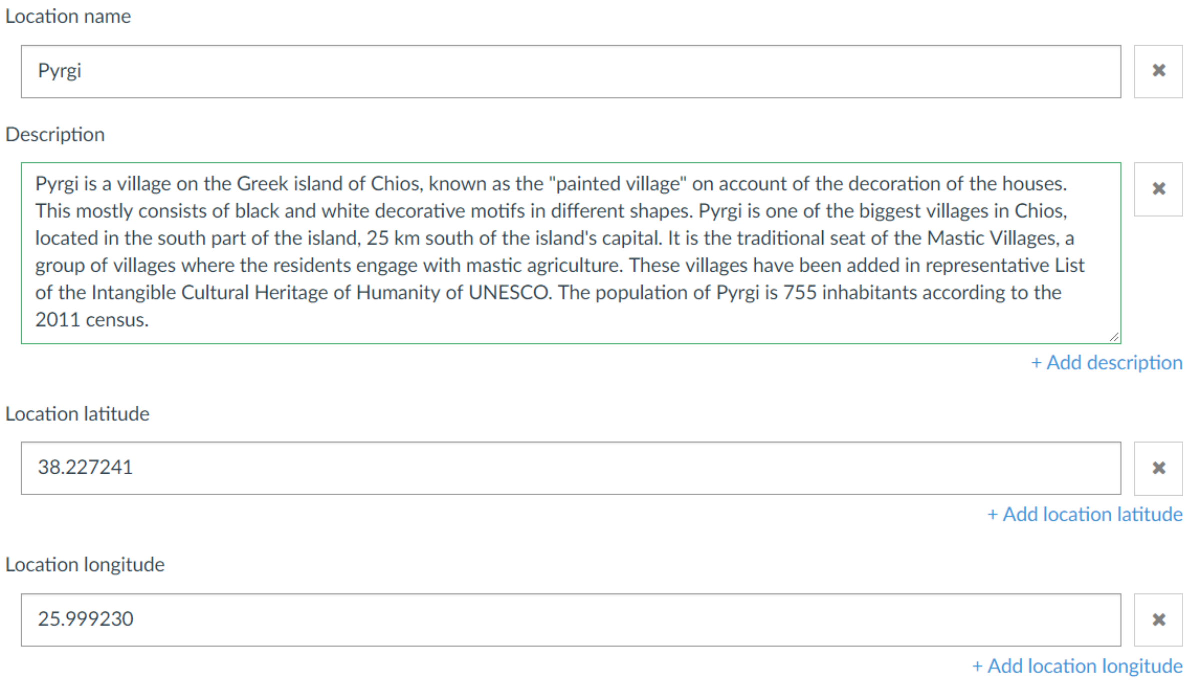


Figure 24. The MOP UI for the instantiation of place knowledge elements.

4.5 Persons and groups

Knowledge collection on the life of persons can lead to very broad representational requirements, depending on the profession and life of a person. Of relevance is also the participation of persons in communities, guilds, and social or artistic movements.

In this step, we record and represent basic information on the life and times of a **person**, such as occupation, places of visits, time and place of life and death, and **key events** relevant to the topic of study, such as education, professional activity, collaborations with other persons and so on. The case is the same for **social groups**. At this step, groups are represented agnostically as to their type. As in the case of persons, **key events** are associated with social groups. Such events can be the foundation of a company, the meeting and collaboration of two artists that triggered a movement, the passing of a law that establishes the monopoly of silk ribbon production to the industry of one city, or a law that exempts the producers of some rare agricultural product from military service or tax. The MOP UI for the instantiation of persons is shown in Figure 25.

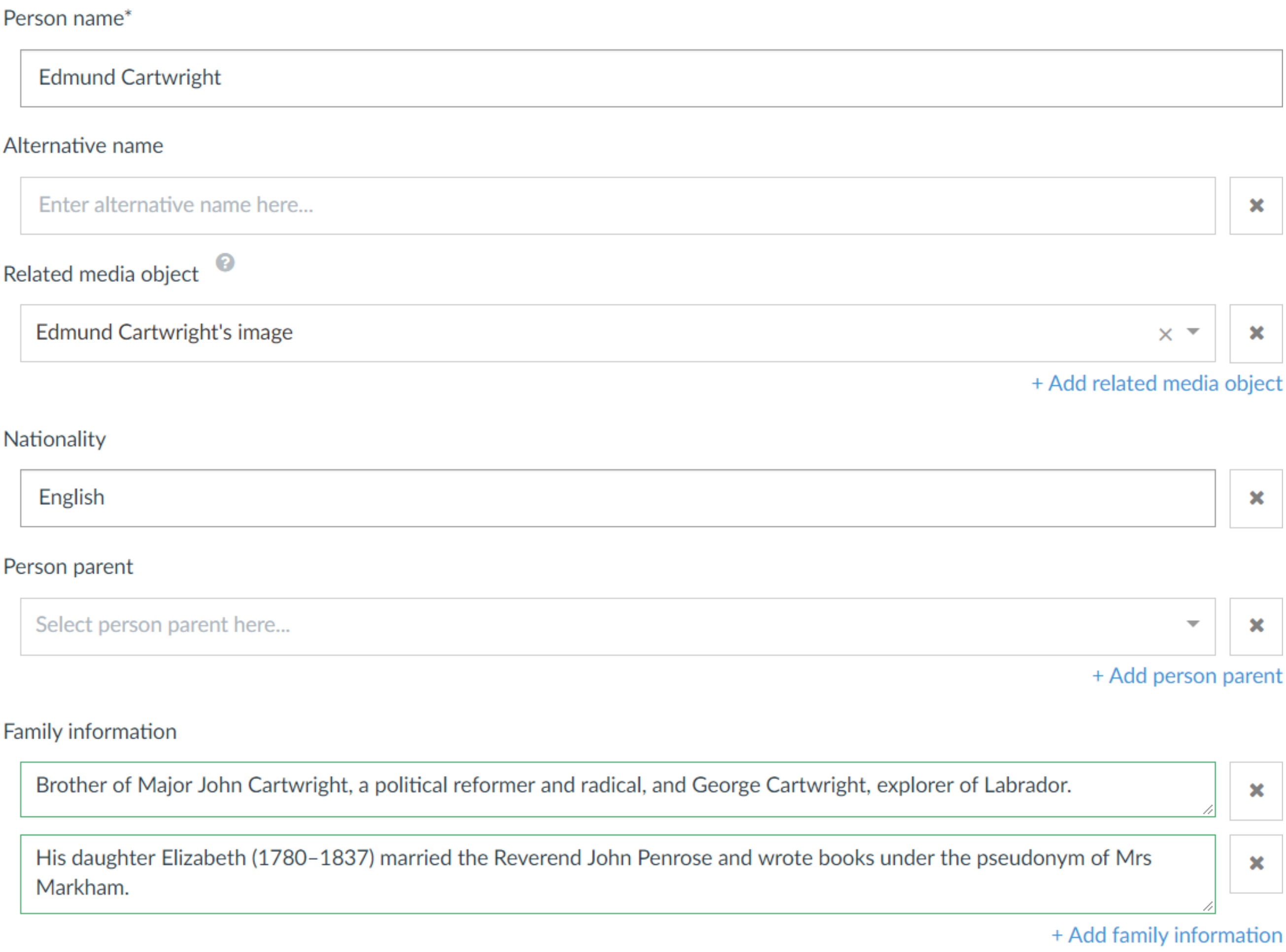


Figure 25. The MOP UI for the instantiation of person knowledge elements.

4.7 Events

Events are basic elements of stories and processes. The principal property of the event is a time interval. Events also link to:

- Places
- Participants
- Objects

The representation of events links them with other knowledge elements corresponding to the above. We illustrate these associations with lines that interconnect them with knowledge elements, in our illustrations.

Events to occur in time intervals delimited by an ordered pair of points in time. Depending on the required granularity of representation, some events may be considered to have a zero-time length although they have a very brief duration.

Events can be linked to various authored data entries related to the Event from the repository, such as Persons, Places, and Media Objects. It can also be linked to other events that occurred in that period or that had an impact on it, to further expand its historical or social context. An event may include other events as parts, enabling hierarchical decompositions of events into simpler ones. We employ three types of temporal associations between events:

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

The Event instantiation UI is shown in Figure 26.

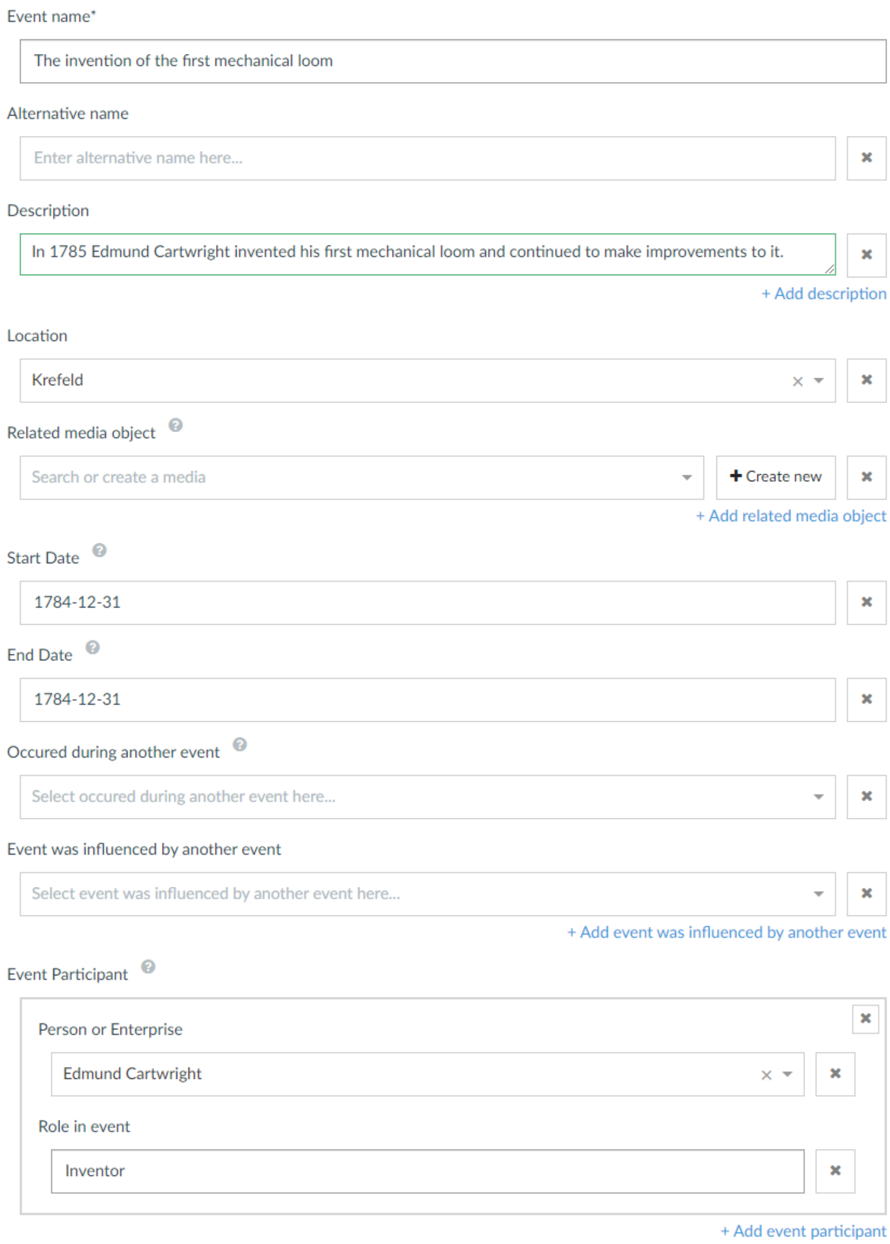


Figure 26. Event authoring – "The invention of the first mechanical loom".

In the following two subsections, we provide illustrative examples of the rationale for authoring contextualisation and crafting events.

4.7.1 Contextualisation events

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

In Figure 27, we illustrate with yellowish hues digital assets. To document the event, we need the basic knowledge elements about the place of the event, the date and time and the participants. These are illustrated below, as the records for H. Gotzes, G. Diepers, and an address at Krefeld, Germany. We underscore the description of the building, which goes from generic (building) to more craft-specific (workshop). The location is a knowledge element that happens to be referred to by other entities, besides the studied event, such as the construction of the building or its renovation (shown only for illustration). The figure also illustrates the use of the geographical database of GeoNames. Given the association of this location with Krefeld, it is possible to reason that this location is in Germany and Europe.

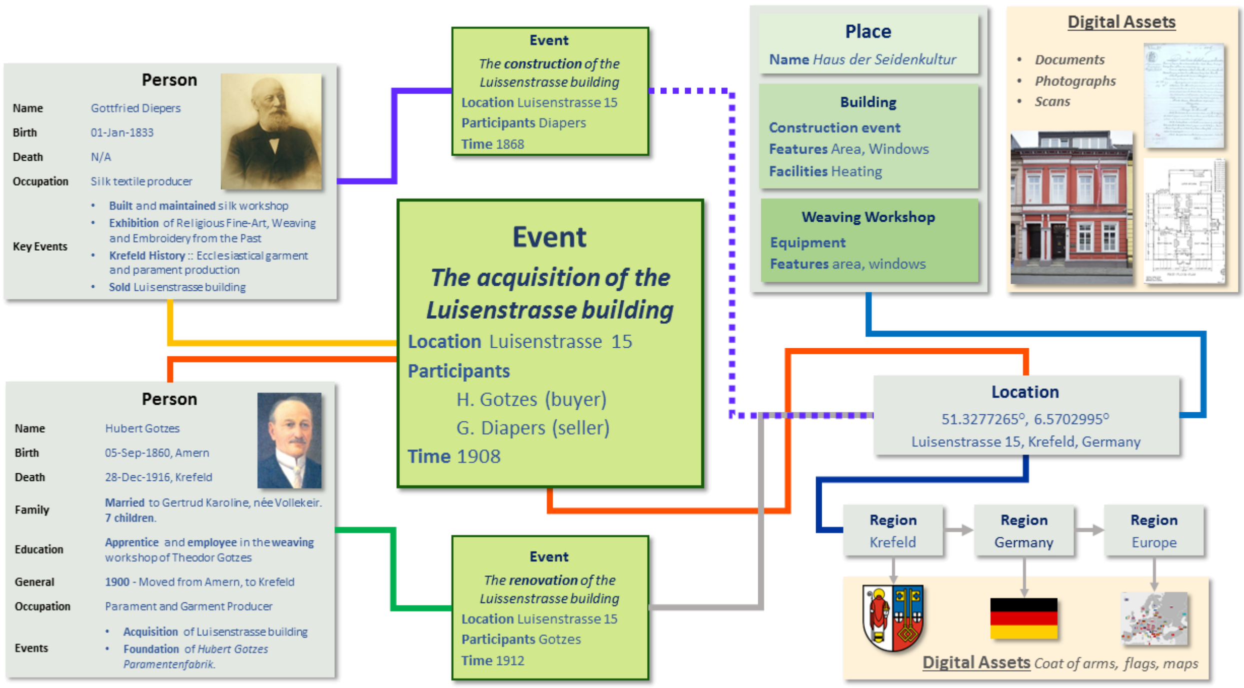


Figure 27. Illustration of the representation of a contextualisation event.

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

4.7.2 Crafting events

The second example is illustrated in Figure 28 and comes from glassblowing. The term "bubbling" refers to a glass-forming technique, where the practitioner insufflates air into a gathering of molten glass with the aid of a blowpipe to create a glass bubble. In the illustration, the representation of the event is linked to the required knowledge elements. The association of digital assets with knowledge elements exemplifies objects and actions. In our knowledge base, the blowpipe tool is associated with two usage postures: standing (free blowing) and sitting (using stabilizing supports). These postures and performances are documented by (i) a semantic description and (ii) digital assets that exemplify the posture and the action. In the example, the first case is linked to three digital assets.

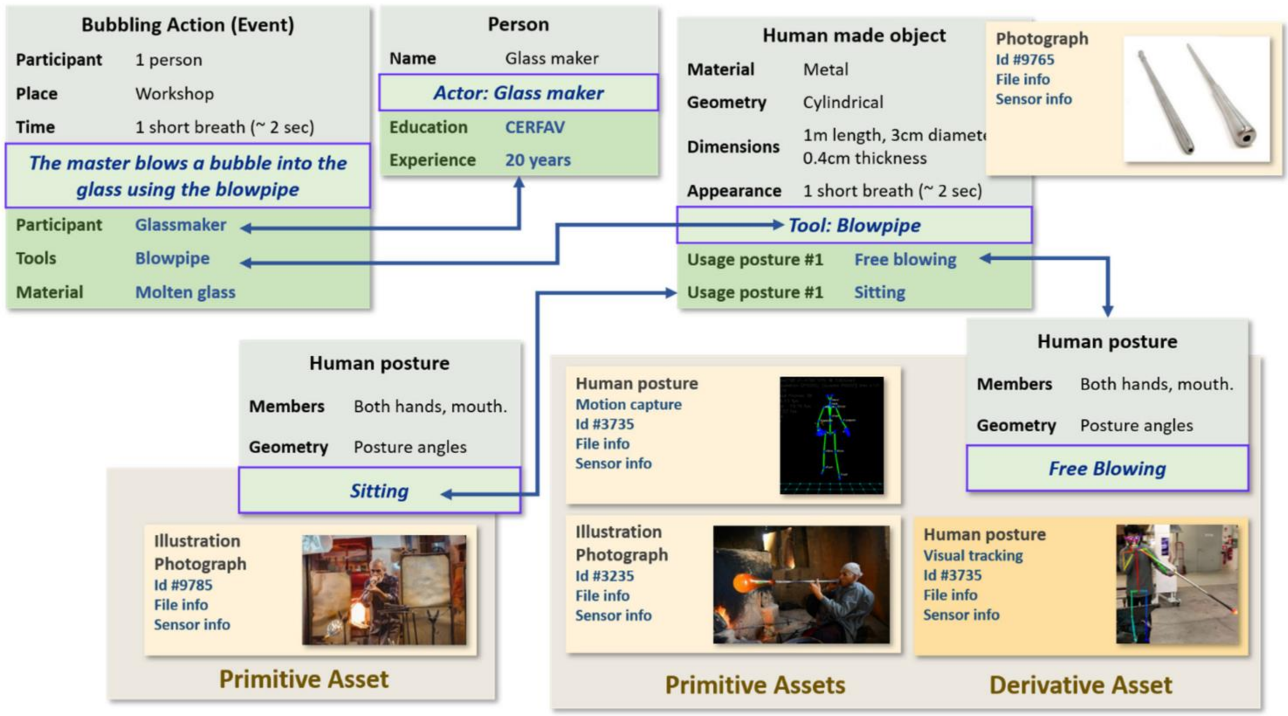


Figure 28. . Illustration of the representation of a crafting event.

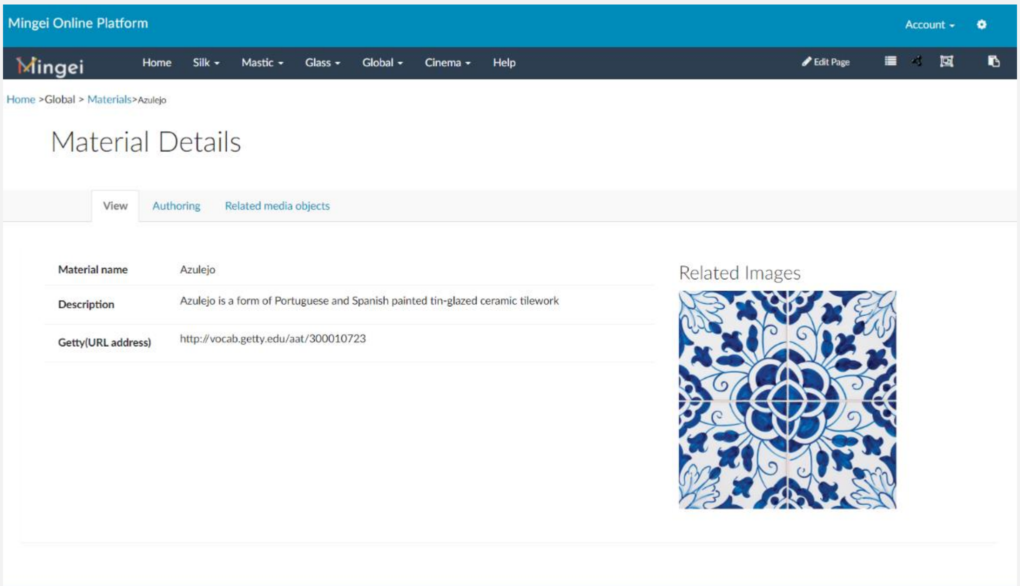
4.8 MOP tutorial – Basic knowledge element instantiation

Recall the "hand-on" example of the previous instalment of instructions ("How to create a Europeana compliant digital asset"). It is regarded as an example in the "Global" context and, in particular, a wonderful mural made of azulejo tiles. It can be found under "Global->Objects-> Panel of glazed tiles by Jorge Colaço (1922)"

Recall that the documentation of the objects that we achieved was lacking the Creator and the Material. In the following two subsections, we will create the pertinent entries. In the third, we will link them to the object to complete its documentation.

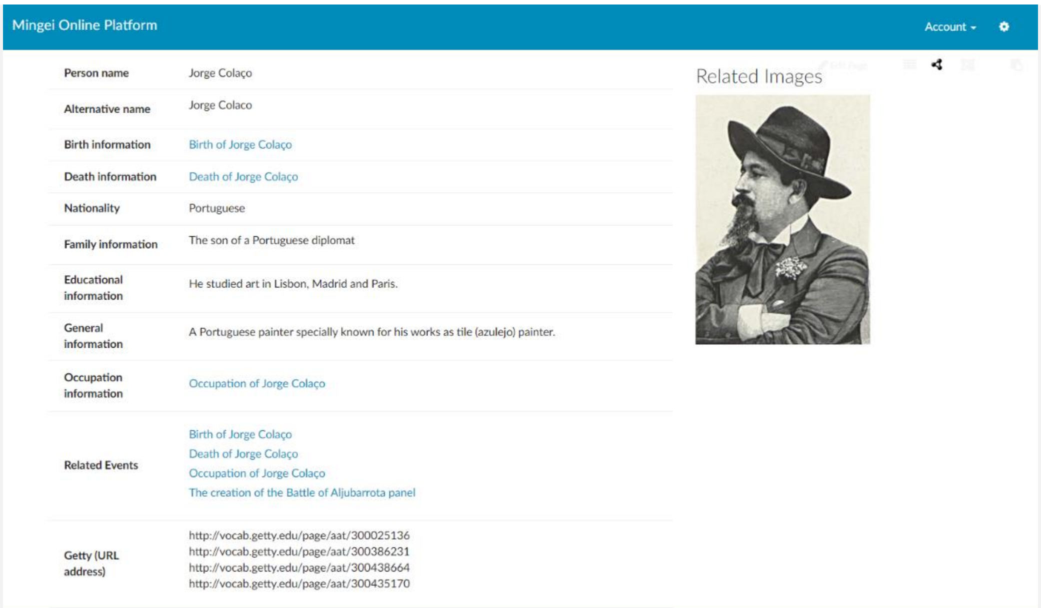
1. How to add a new material

We visit the "Global->Materials" and "Add a new" material. We name it Azulejo and add a description, create a new media object (an image) using an image we found on the Web, and add the Getty link for this material, which is http://vocab.getty.edu/aat/300010723.



2. How to add a new person

- Use the Global->Person menu, to visit the list of existing persons.
- Add new person
- I enter the name, nationality, educational information, and general information in the respective fields as plain text.
- We then create a new media object using the Wikipedia URL of his image https://upload.wikimedia.org/wikipedia/commons/8/8a/Jorge_Colla%C3%A7o_-_Brasil-Portugal_%2816Mai1908%29.png
- Then we add the birth and death information (the latter only if applicable). Notice that birth and death are events and they will require a location (if known); you can add a description note if you wish. For both the birth and the death of this person:
    - Add the date, using the mini-calendar
    - Add the place. If the place is not already known to the system, I use the Create new button and use the GeoNames URL for that location, i.e. http://www.geonames.org/2530335/tangier.html
- We do the same for the occupation, which is also an event, but I have to add a role. In this, I added azulejo painter (albeit we know that he did other works too, but this is a simple example).
    - Since we do not know the exact dates of his occupation I approximate, estimating that he was a professional at 22 y/o and worked until his last day.
    - To better document his occupation, I enter the relevant entries under painter I found in the Getty thesaurus. These are painters, panel painters, façade painters, and enamel painters, which are the closest I could find as "azulejo painter" was not available.



3. How to attribute the creation of the object to the artist

We now revisit the object and enter Authoring mode.

- In the Material field, we select Azulejo which now appears in the pop-up menu. I can add multiple materials if I wish.
- In the Creator name, there are many options so I use the autocomplete feature to narrow them down. We enter 'Jor' and narrow down the options to select Jorge Colaço.

4. How to contextualise the object

Step 1

- First, we create an "auxiliary" Event, visiting "Global-> Events" and adding a new event which we call "The creation of the Battle of Aljubarrota panel".
- As a participant in the event, we wish to add the creator. I select the appropriate name of the Event participant and comment on his role in that event using the term Creator. We can add more people if we wish.
- As we have registered Lisbon before, it is already available in the Location pop up menu.
- For the moment we do not complete the "Global event was influenced by another event"

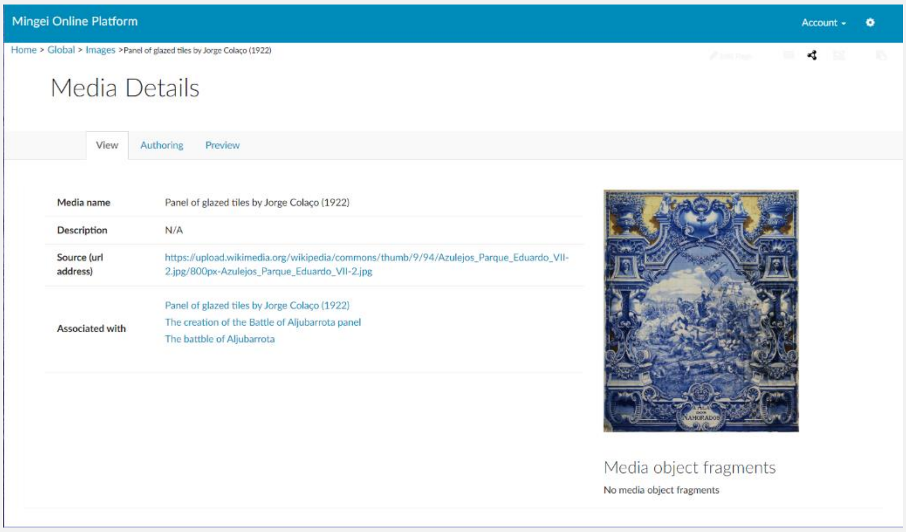
Step 2

We create another event called "The battle of Aljubarrota".

To document the event, we have to create Enterprises for the belligerents (Kingdom of Portugal and Crown of Castile). Enterprises are useful to represent social groups, companies, political parties etc. You can associate events of Establishment, Dissolution, change of ownership (or King), joins and departures from the organization etc.

Step 3

We can then go back to the event “The creation of the Battle of Aljubarrota panel” and in “Global event was influenced by another event”, select “The battle of Aljubarrota”. We can also go back to the media object and add in its associations with the same event.



5. Why are we doing this?

To be able to organise content and be able to show and publish it in multiple ways without significant effort.

Notice that you can build stories made out of real or imaginary events. This way you can have searchable and explorable content that can be compiled in presentations or shown interactively.

5. Context

Context representation is based on stories that are built from events and knowledge references, to represent social, technological, economical, or cultural changes, which relate to the representation of a craft instance. Stories that are of direct relevance to craft representation are historical events that have influenced the history and economy of social groups, technological advances, and artistic movements.

5.1 The fabula

The term *fabula* has been introduced in Narratology to denote the series of happenings, in chronological order, that together makes up a narrative. A fabula is an abstraction that represents a set of facts that have happened in the world and which entertains a contextual topic **in chronological order**. More precisely, a fabula is *a set of coherent phenomena or cultural manifestations occurring in time and space.* Fabulae represents the history of what has already happened and is comprised of events. These facts are **connected** in a way that makes them a **story**. The fabula is conceptual. By telling or writing it, we are only reciting narratives of “what happened”, by whom, where, which way, etc. This fabula may encode causal relations, as to why something happened. All these existed in reality as part of the fabula, but the fabula is gone forever, all we have are narrations and documents that we use to reconstruct the fabula. As Umberto Eco quotes, “*Stat rosa pristina nomine, nomina nuda tenemus* (The primigenial rose exists only in the name, we possess only bare names).

In more practical terms, fabulae is the grounding data structure for the representation of stories. In the next step, we will see that a story, or otherwise a narrative, may have multiple narrations that differ in the events they present or the of their presentation (e.g. a flashback). The relations between the events of a fabula may be either:

- Mereological, denoting relations between parts and wholes, or
- Causal, relating events that in normal discourse are predicated to have a cause-effect relation in the author’s opinion.

5.2 Authoring Fabulae

In the MOP, basic data entries are transformed into a fabula as a series of events in a chronological; form as schematically shown in Figure 29.

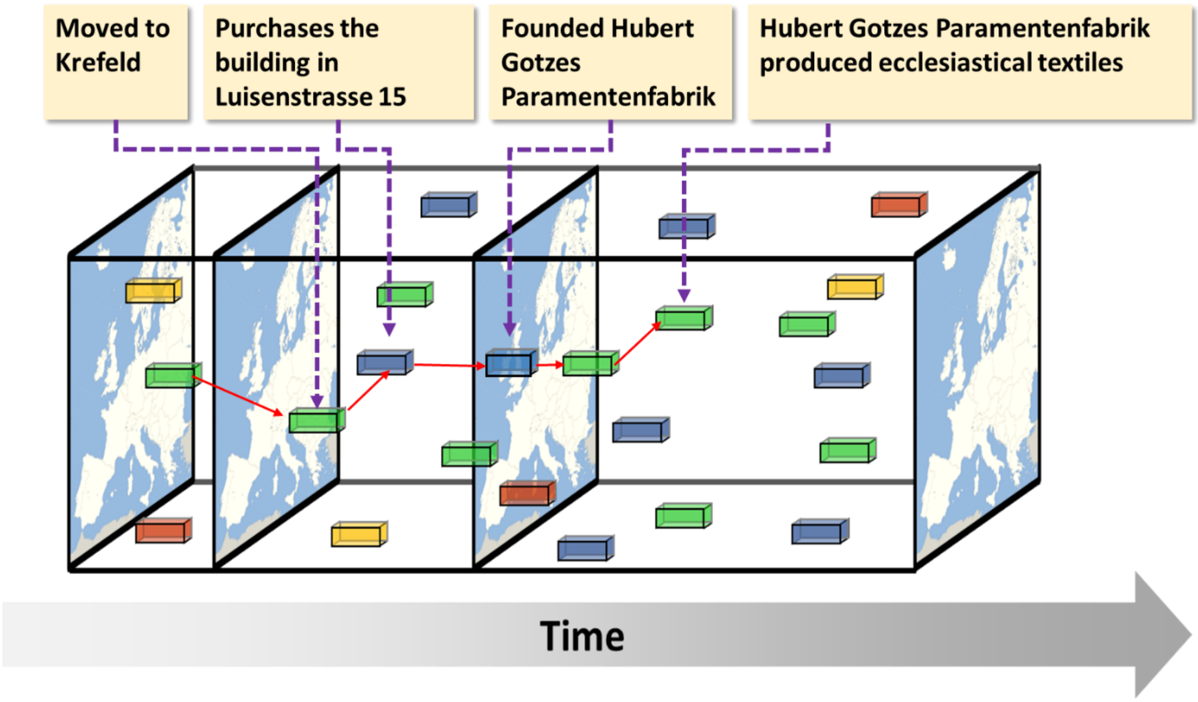


Figure 29. Schematic illustration of a fabula.

A MOP component facilitates the authoring (Figure 30). In MOP, the fabula authoring components allow the semantic linking of events that have been already authored. It is recommended that most of the Events presented by a Narrative and contained in a 'Fabula' are instantiated before the creation of the Fabula. Nevertheless, this process can be iterative and new Events can be added at any stage of development. This enables data for the iterative re-evaluation and refinement of the knowledge.

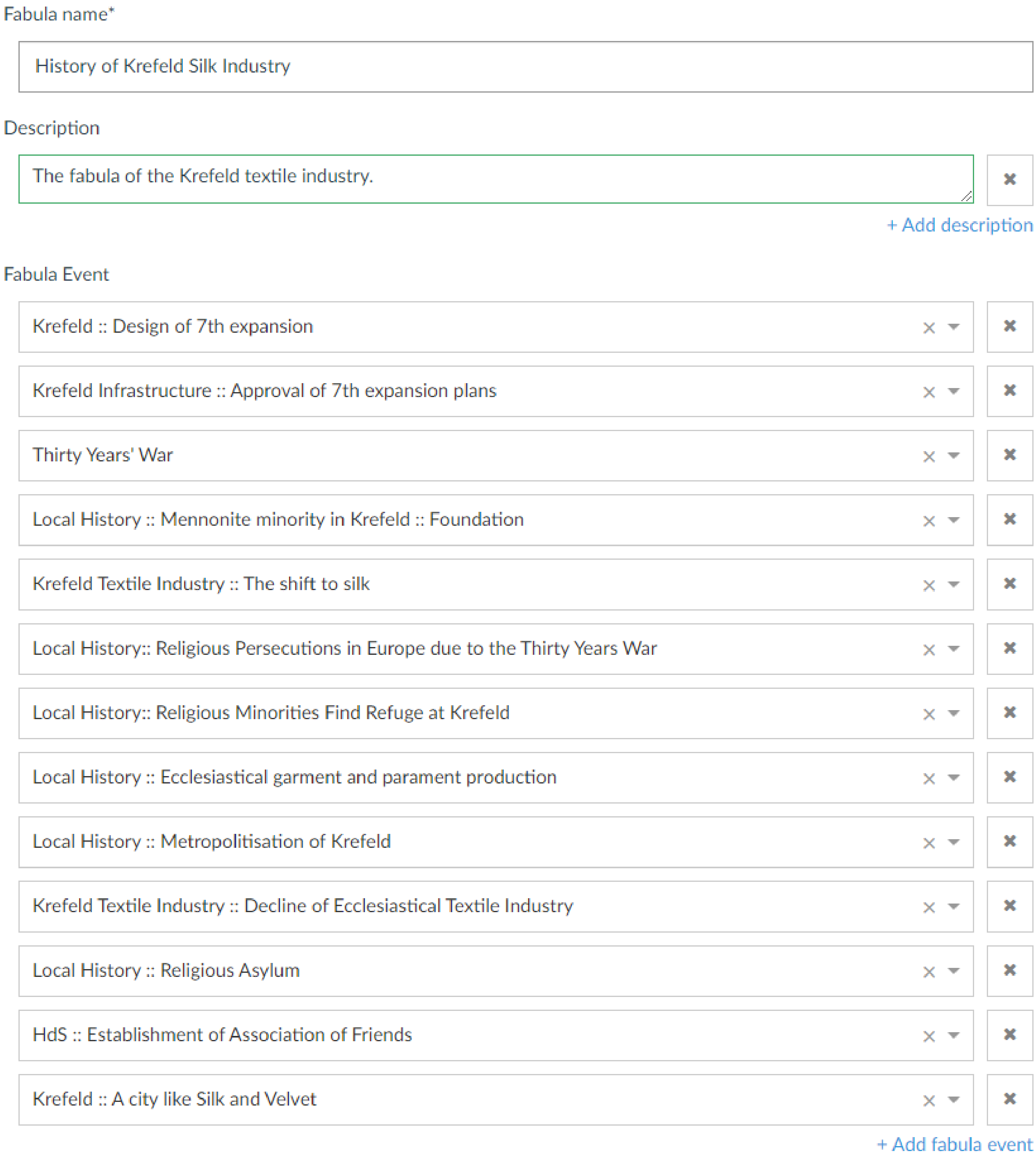


Figure 30. Fabula authoring – "History of Krefeld Silk Industry".

6. Crafting processes

The documentation of crafting processes entails some research on its own. We provide the steps that we follow for crafting processes in particular.

The first two, ethnography and data collection are to take place along with the collection of digital assets and knowledge elements, described earlier.

These two steps are crucial for the insightful representation of processes. It is at this point that the curator must distinguish between the differences in the crafting process with a recipe, or in other words, identify practitioner decision points. An example is shown in Figure 31; the video playlist is available at [this link]. Though the process is segmented in sequential steps, much like a recipe, each step includes a multitude of decisions and parallel occurring tasks.

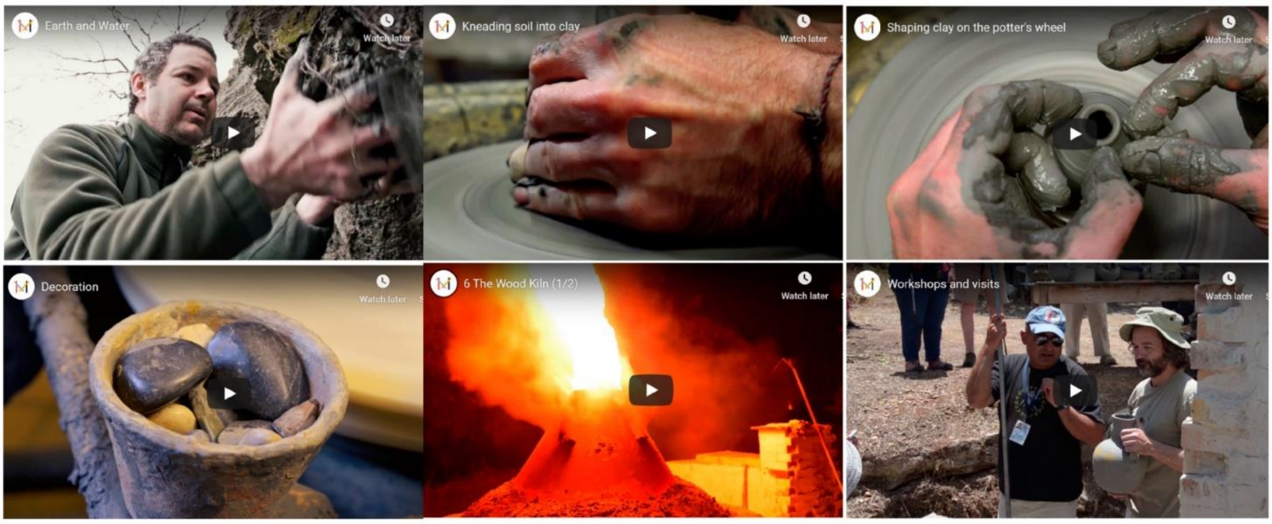


Figure 31. Pottery process from collection of raw material to the firing of pottery.

6.1 Ethnography

Ethnography identifies and describes the activity of a social unit as the "textual construction of reality". Recently it has been applied in the workshop, with examples found in carpentry, glasswork, and textile manufacturing.

An ethnographic approach to understanding the crafting process is to consider it from a problem-solving viewpoint. From this perspective, the abstraction of a process schema can be treated similarly to an algorithm. This treatment is convenient as the crafting process schema may have decision points and, thus, alternate workflows. Decision points are relevant to properties of individual pieces of material and environmental conditions, as well as practitioner observations and judgements. Besides decision points, process steps may refer to parallel or combined activities, by one or more persons. Some steps take place only to handle exceptional events, such as a repair for a mistake or an accident. This has two outputs. The first is a vocabulary of terms with verbal definitions and visual descriptions of the involved knowledge entities. The second is a (thick) description that enables the study of the activity beyond the context of a visual demonstration. This is implemented in the form of a *storyboard*, which serves as a detailed explanation of the crafting process that is visually captured and encodes temporal order, spatial arrangements, and purpose of actions. We call *s*toryboard sequences of images or brief videos, in chronological order, enhanced with text and audiovisual annotations.

6.2 Data collection

We refer to Step 2 for the collection of digital assets, upon the endurant and perdurant components of the crafting process. We use the term *media object* to abstract the heterogeneity of pertinent media types. The obtained digital assets are assigned with technical metadata and unique identifiers. The organisation of the recording sessions is facilitated by the vocabulary and storyboard, in identifying the objects, sites and practitioner actions to be digitised. Process recording may include alternate expressions of the schema, recorded by repeating steps of the schema that did not occur in the initial performance. Unforeseen decision points are noted and used to revise the vocabulary and the storyboard.

6.2 Workflows

An activity diagram is authored, for the crafting process. The diagrams.net can be used to create the diagrams and export them in XML. An activity diagram for the creation of a glass carafe is shown in Figure 32. The process refers to two persons, having the roles of a master and an assistant. In the diagram, decision points are observed. The use class Branch is used to represent such decisions.

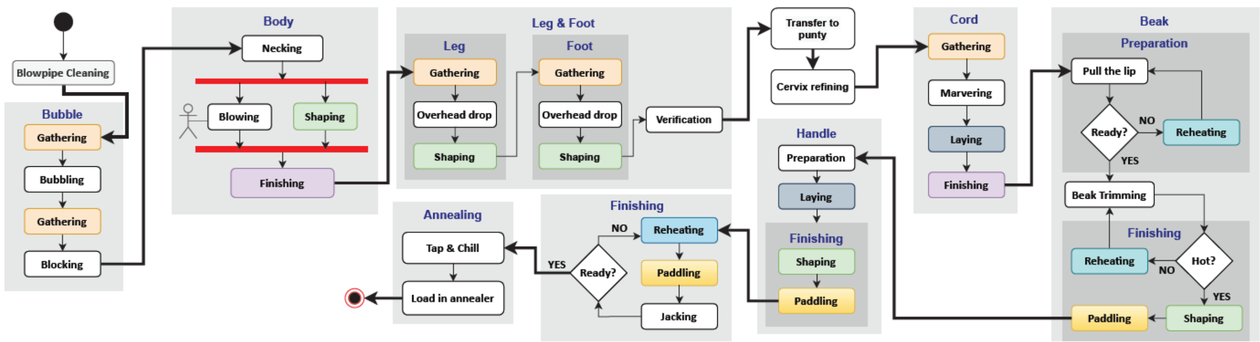


Figure 32. Activity diagram for creating a glass carafe.

Recursive refinement of steps is supported. The granularity of representation is determined by the curator. In Figure 33, the treatment of synchronised collaboration and decisions is shown. The top shows a step, where the process is bifurcated into two concurrent flows, each for one person. The assistant blows from the other end, moving in synchrony with the master. Both workflows start and end together. On the bottom, shown is a decision point, where the practitioner separates the glass body from the blowpipe. The way that the body should be detached from the tip of the blowpipe depends on the viscosity of the bubble, that is, its temperature. If judged to be hot enough, it is cut using a pair of shears (middle), without the danger of breaking. Otherwise, it is carved and broken away from the blowpipe, using a pair of pincers (right).

Figure 33. Representation of concurrent actions and decisions.

6.4 Process Schemas

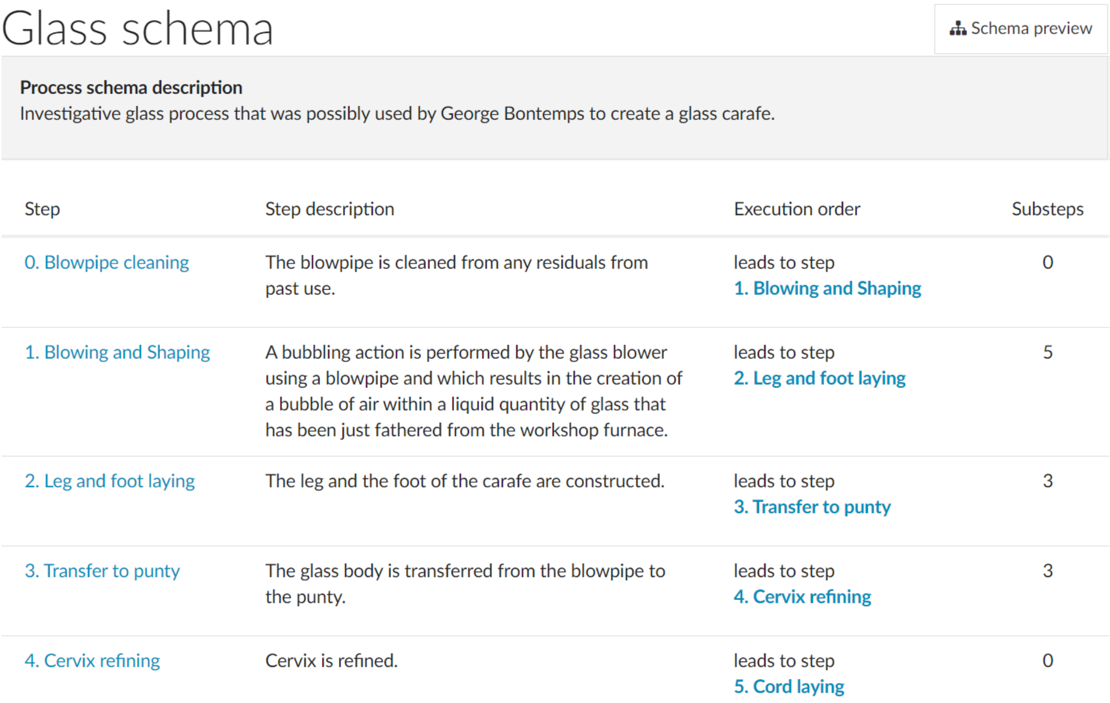
A process schema encodes the actions to be performed to execute in a particular crafting process. Examples of schemas are wedding ceremonies, recipes, or soccer games. A defining feature of crafting process schemas is that they contain branching points in their workflow. The decision to take one action or another relies on the judgment of the practitioner and can be influenced by a range of factors.

Visual, unambiguous, and formal encoding of schemas is borrowed from UML activity diagrams to unambiguously encode process schemas. The visual nature of activity diagrams facilitates the collaboration between technical and heritage partners.

Process schemas are analysed in process schema steps. The analysis ends when a targeted level of detail is reached. This level is set to that of simple actions that practitioners can identify. This recursive decomposition yields a hierarchy of schemas that start from a coarse description down to a fine analysis of elemental actions. The finest sub-steps are individual postures and elemental gestures, such as “grasping a hammer” or “a strike of the hammer upon a nail”.

In the schema and activity diagram, crafting events are connected by transition nodes (Simple, Fork, Merge, Join, and Branch), which suffice for the definition of crafting workflows. Fork, Merge and Join nodes enable the representation of simultaneous and synchronized actions, performed by multiple persons or body members. Branching nodes represent conditional actions of the practitioner, due to which executions of the same process schema may lead to the execution of different actions. Transition nodes relate process steps temporally and causally, while sub-step decomposition organizes them hierarchically.

The process schema is transcribed into a semantic representation, using the MOP. The UI for authoring a process schema is shown in Figure 34. The UI component enables the instantiation of process schemas and their steps. Data fields are used to enter appellations and informal descriptions. Step order is determined by the transitions that link process schema steps or can be explicitly set. In the image, shown is the editor’s view of a process step schema called and its sub-steps. Edit buttons enable the management of the step list and the transition relations between them.



Glass schema

Schema preview

Process schema description
Investigative glass process that was possibly used by George Bontemps to create a glass carafe.

Step	Step description	Execution order	Substeps
0. Blowpipe cleaning	The blowpipe is cleaned from any residuals from past use.	leads to step 1. Blowing and Shaping	0
1. Blowing and Shaping	A bubbling action is performed by the glass blower using a blowpipe and which results in the creation of a bubble of air within a liquid quantity of glass that has been just fathered from the workshop furnace.	leads to step 2. Leg and foot laying	5
2. Leg and foot laying	The leg and the foot of the carafe are constructed.	leads to step 3. Transfer to punty	3
3. Transfer to punty	The glass body is transferred from the blowpipe to the punty.	leads to step 4. Cervix refining	3
4. Cervix refining	Cervix is refined.	leads to step 5. Cord laying	0

Figure 34. The MOP UI for authoring a process schema.

Transitions are instantiated via a dynamic UI component that adapts to transition type. At its top, a menu enables the choice of transition type. Once selected, the UI component adapts to offer the transition-specific parameters. Incoming and outgoing links are instantiated using dynamic menus that contain the names of already defined steps. In Figure 35, these components are shown. The dialogue box on the left indicates the parallel and synchronised execution of two actions. The dialogue box on the right image is the UI component for a branch transition.

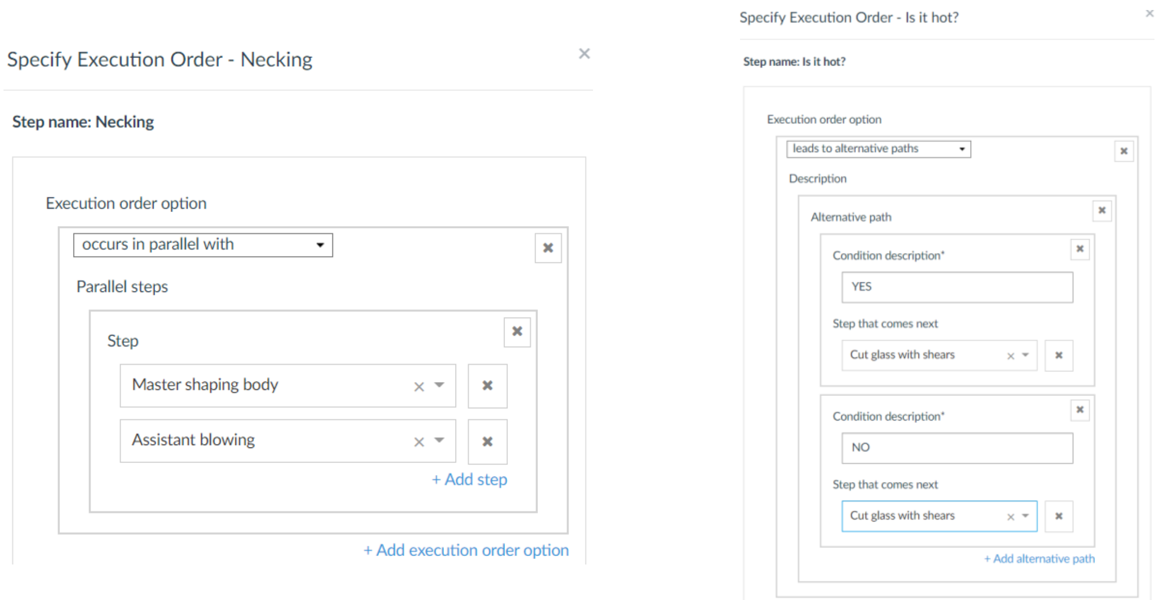


Figure 35. MOP UI components for authoring process schema steps.

6.5 Processes

Processes are comprised of the events that occurred during the crafting process. If these events conform to a process schema, we identify a process that executes that schema. A process is one of the potential flows of a process schema and, thus, two different sets of events may still conform to the same schema. A process contains a reference function, which identifies and chronologically orders the events that occurred during its execution. The digital assets are recordings of the events that took place and the digitization of the objects involved in them. The UI for instantiating a process and its steps are shown in Figure 36.

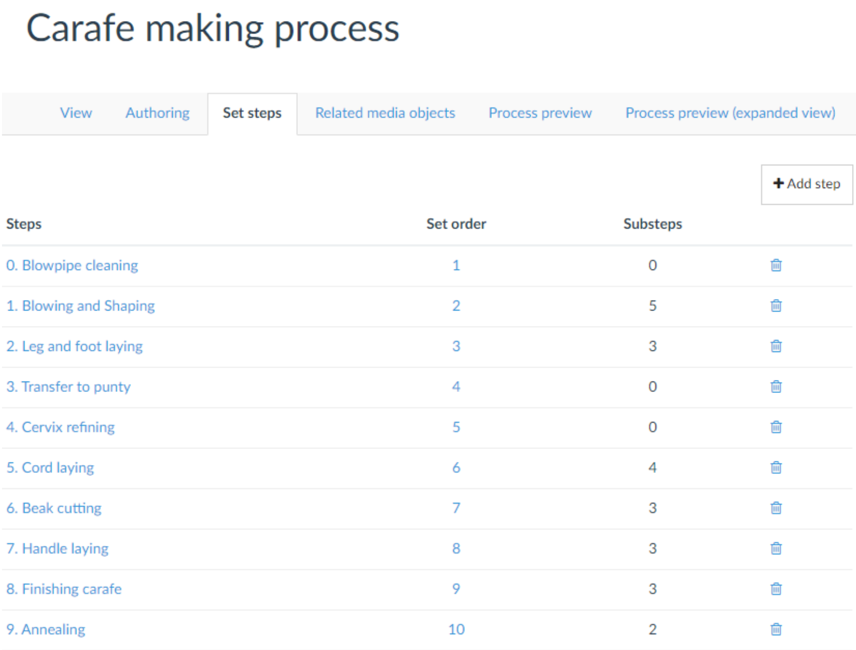


Figure 36. The MOP UI for the instantiation of crafting processes.

A set of UI components enable the instantiation of processes as activities, via the entry of attribute data, chronological ordering, and the association with recordings that document them. The UI enables linking an arbitrary number of knowledge entities to a process step. It facilitates the task through contextual searches in the form of dynamic, auto-complete, pop-up menus, for materials, tools, and participants. The UI components are shown in the right pair of images, in Figure 37. The UI in the second from the left image enables the linking of processes and process steps with their corresponding process schemas and step schemas. This is implemented by the field 'Corresponds To' that is used to associate a process step with a process step schema. The task is facilitated by a dynamic menu that follows the process schema step hierarchy, as shown at the bottom of the rightmost image. Nevertheless, creating this link is optional. The rationale for this choice is the following. The process schema is an abstraction of all the processes that follow that schema. To achieve this abstraction, multiple process demonstrations may have to be studied. Thus, instantiation of processes without association with a process schema allows for the definition of this schema later on, after sufficient data have been studied.

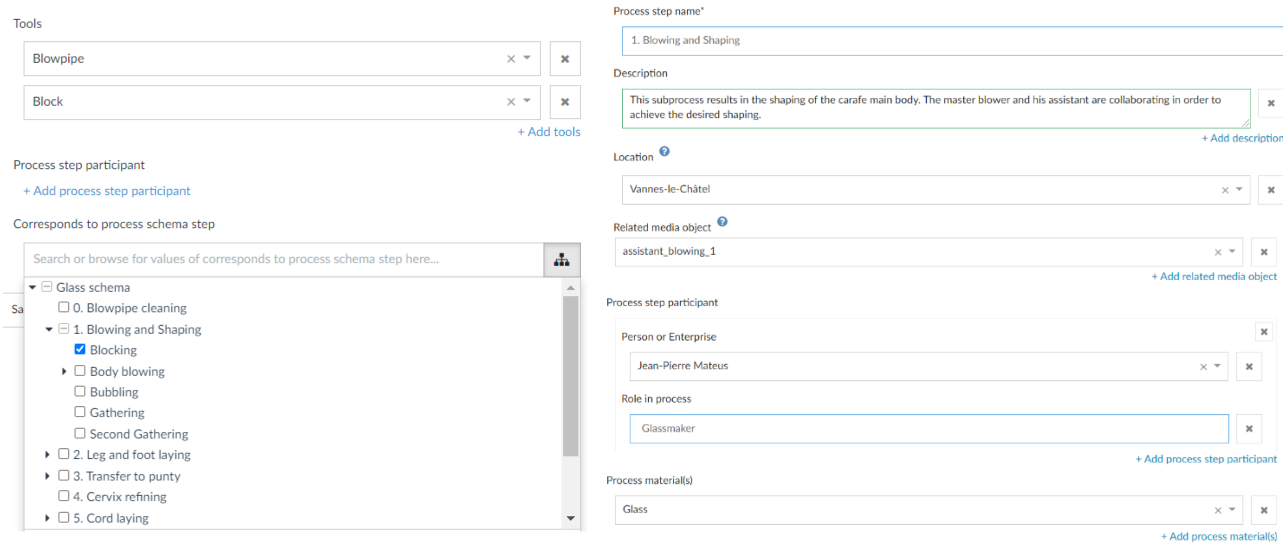


Figure 37. MOP UI components for authoring of crafting processes.

7. Documentation and digital conservation

This step regards to access and the presentation of the assets and knowledge stored in the MOP. Both capabilities are provided in

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

Machine interpretability ensures that the collected knowledge and digital assets can be accessed through third-party applications without the need for a MOP. In this way, content can be directly imported and re-used in these applications. Besides conventional digital assets, the knowledge base contains semantic representations of narratives and emotion-driven narratives that can be queried and systematically accessed by software clients. Digital preservation templates export knowledge and assets, in machine-interpretable formats.

A **human-comprehensible** way to present the represented knowledge network is hypertext. The implementation employs a Web interface that dynamically generates HTML pages from the knowledge queries and a Web server that transmits them to the Web client (browser). An individual documentation page is provided for each entity. Semantic links are implemented as hyperlinks that lead to the pages of cited entities. This way, browsing and exploration of knowledge through semantic associations are enabled.

Contents can be organised and presented spatiotemporally or thematically. A keyword-based search is provided. Documentation pages for media objects contain links to digital assets, textual presentation of metadata, and previews of the associated digital assets. One or more URLs are provided on each page. For media objects, these links point to the source data files. For knowledge entities, the link points to the RDF encoding of that entity. For locations and events, specific UI modules are provided. For locations, embedded, dynamic maps are provided. Time-line and calendar views are available for events.

7.1 Digital assets

Digital assets are in conventional and open formats. Each asset has a unique IRI to be directly integrated by third parties. Assets are accompanied by technical metadata, enabling content type identification and transformation to future formats. A mapping between our ontology and the EDM enables the utilisation of Europeana assets and the ingestion of new assets in Europeana. The crafting process representation is digitally preservable in machine-interpretable format. It is encoded in the ontology schema, with semantic links and knowledge statements stored in RDF. The RDF guarantees syntactical interoperability and can be shared across implementations. Semantic interoperability is guaranteed by the use of an ontology that is based on the CRM. The MOP maintains a representation that might be continuously updated.

The documentation pages for media objects contain links to digital assets, metadata, and previews of the digital assets. Some assets are comprised of multiple files, e.g. 3D reconstructions contain geometry and texture files, videos are accompanied by multiple subtitles etc. For video, MoCap, and 3D models, embedded viewers are provided. In Figure 38, examples of pages are shown for a photograph (left), a 3D model of a tool (middle), and a 3D reconstruction of a village (right).

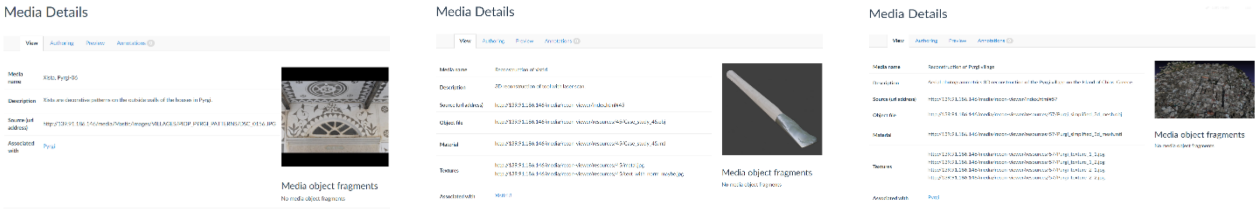


Figure 38. Documentation pages for digital assets (media objects).

7.2 Knowledge elements

Documentation pages for knowledge elements are type-specific3. Pages for instances of class Person provide biographical information and a portrait image. Location instances contain maps and, if any, the previews of associated digital assets. The pages for a tool, a location, and an event, are shown in Figure 39. In reciprocity, the pages for media objects include hyperlinks to the pages of the knowledge elements that refer to them. For example, the page for the 3D reconstruction of the village shown in the previous figure contains a hyperlink to the documentation page for the location (Pyrgi).

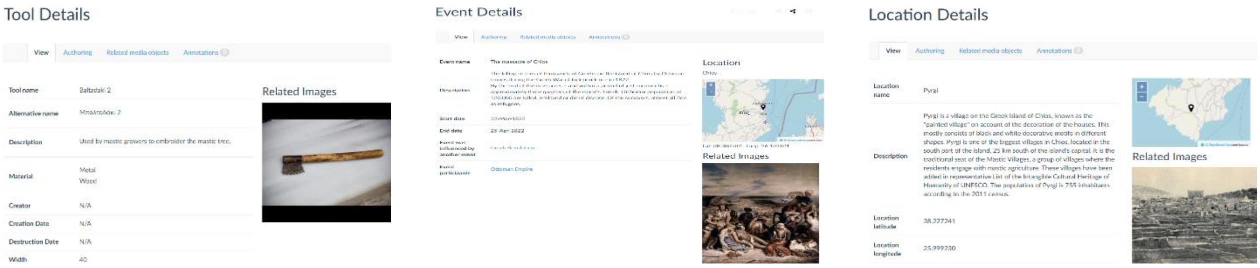


Figure 39. Documentation pages for knowledge elements.

7.3 Vocabularies

An output of this organisation of knowledge is illustrated vocabularies of tools, which bring together verbal descriptions and visual recordings. In the same way, the steps where a specific tool is used can be retrieved, along with video recordings of such actions; and similarly, for the tools and materials required for a certain process. An example is provided for the case of Glass tools, in Figure 40. Queries that exhaustively retrieve members of semantic classes are used to support browsing and cataloguing.

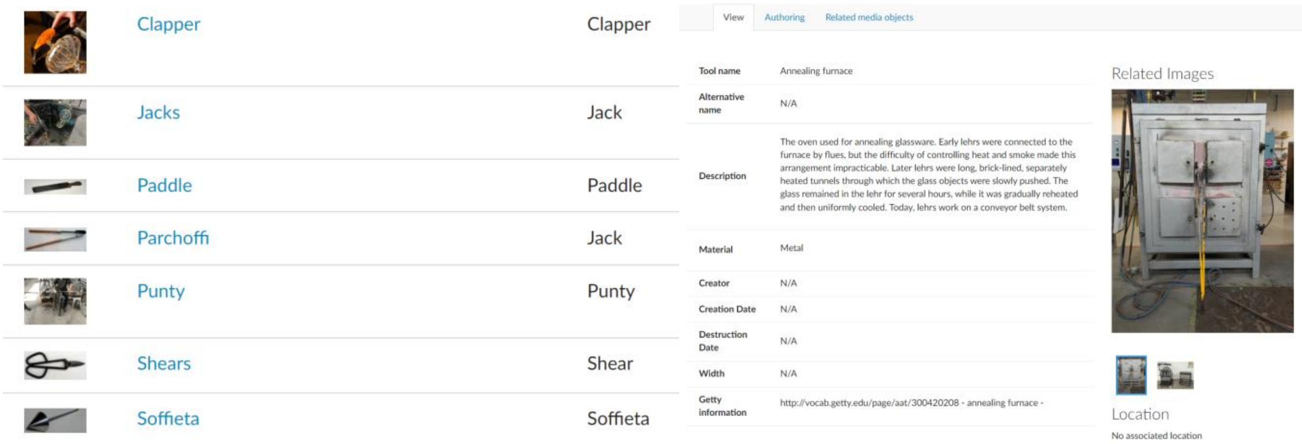
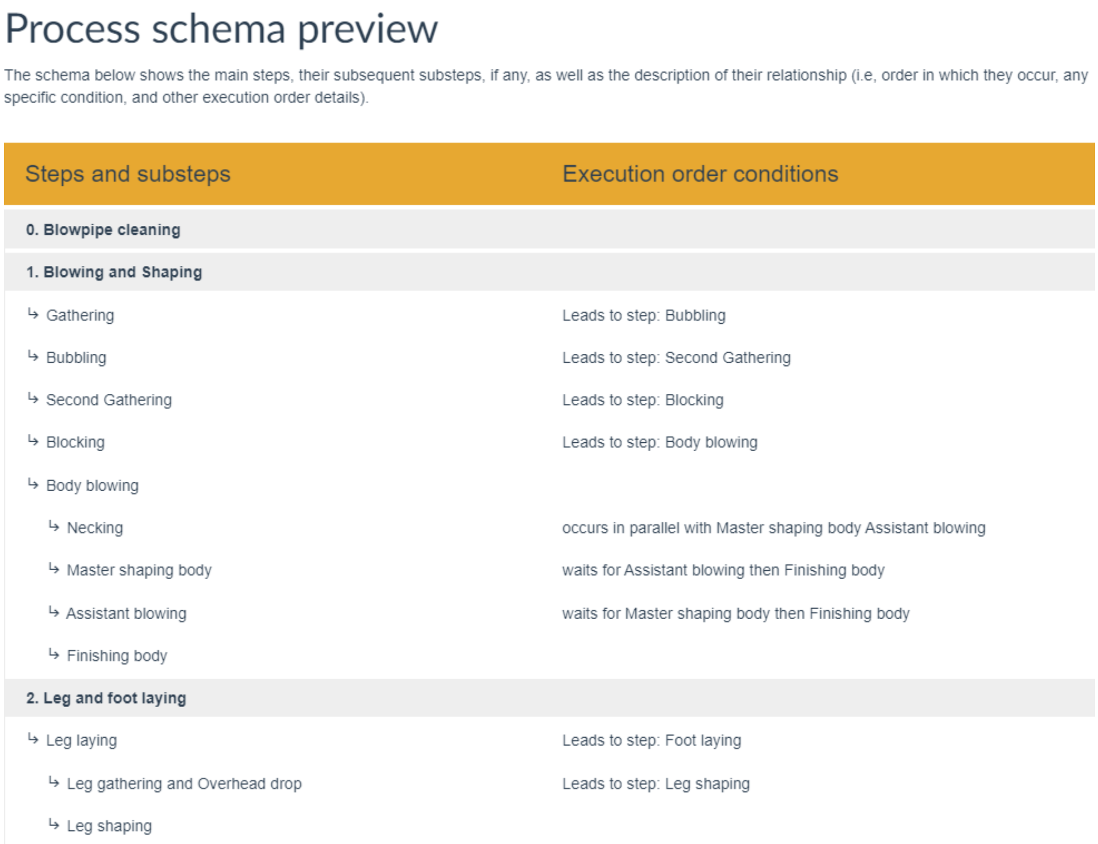


Figure 40. Automatic vocabulary creation in the MOP.

7.4 Process schemas

Documentation pages for process schemas show step schemas and their relations using hypertext. A serial presentation of the step hierarchy is provided, as tabulated text. In Figure 41, the documentation page for a process schema is shown.



Process schema preview

The schema below shows the main steps, their subsequent substeps, if any, as well as the description of their relationship (i.e, order in which they occur, any specific condition, and other execution order details).

Steps and substeps	Execution order conditions
0. Blowpipe cleaning	
1. Blowing and Shaping	
↳ Gathering	Leads to step: Bubbling
↳ Bubbling	Leads to step: Second Gathering
↳ Second Gathering	Leads to step: Blocking
↳ Blocking	Leads to step: Body blowing
↳ Body blowing	
↳ Necking	occurs in parallel with Master shaping body Assistant blowing
↳ Master shaping body	waits for Assistant blowing then Finishing body
↳ Assistant blowing	waits for Master shaping body then Finishing body
↳ Finishing body	
2. Leg and foot laying	
↳ Leg laying	Leads to step: Foot laying
↳ Leg gathering and Overhead drop	Leads to step: Leg shaping
↳ Leg shaping	

Figure 41. Process schema documentation page.

7.5 Processes

Processes are presented as a series of events, while also denoting cases of concurrent activities. Events are knowledge entities and are presented on an individual documentation page each. The process step documentation page (see Figure 42) is a specialisation of the generic documentation page for instances of the class event. It contains links to the recordings of the knowledge elements for the tools and materials involves, the participating practitioners, the date, and the location of the recording. If the process follows a process schema, a link to that schema and its preview are also provided. The hierarchy of process steps is presented using insets, each one presenting textual information and previews of the available digital assets. To present step organisation, insets can be dynamically unfolded to any depth of the process hierarchy. Each inset dynamically unfolds and each step is associated with image previews and embedded videos. An index of the first level of process steps of the hierarchy is provided on the left. The result is a multimedia-enriched semantic presentation of the process. The knowledge entities and digital assets linked to these events are available for the presentation of the process.

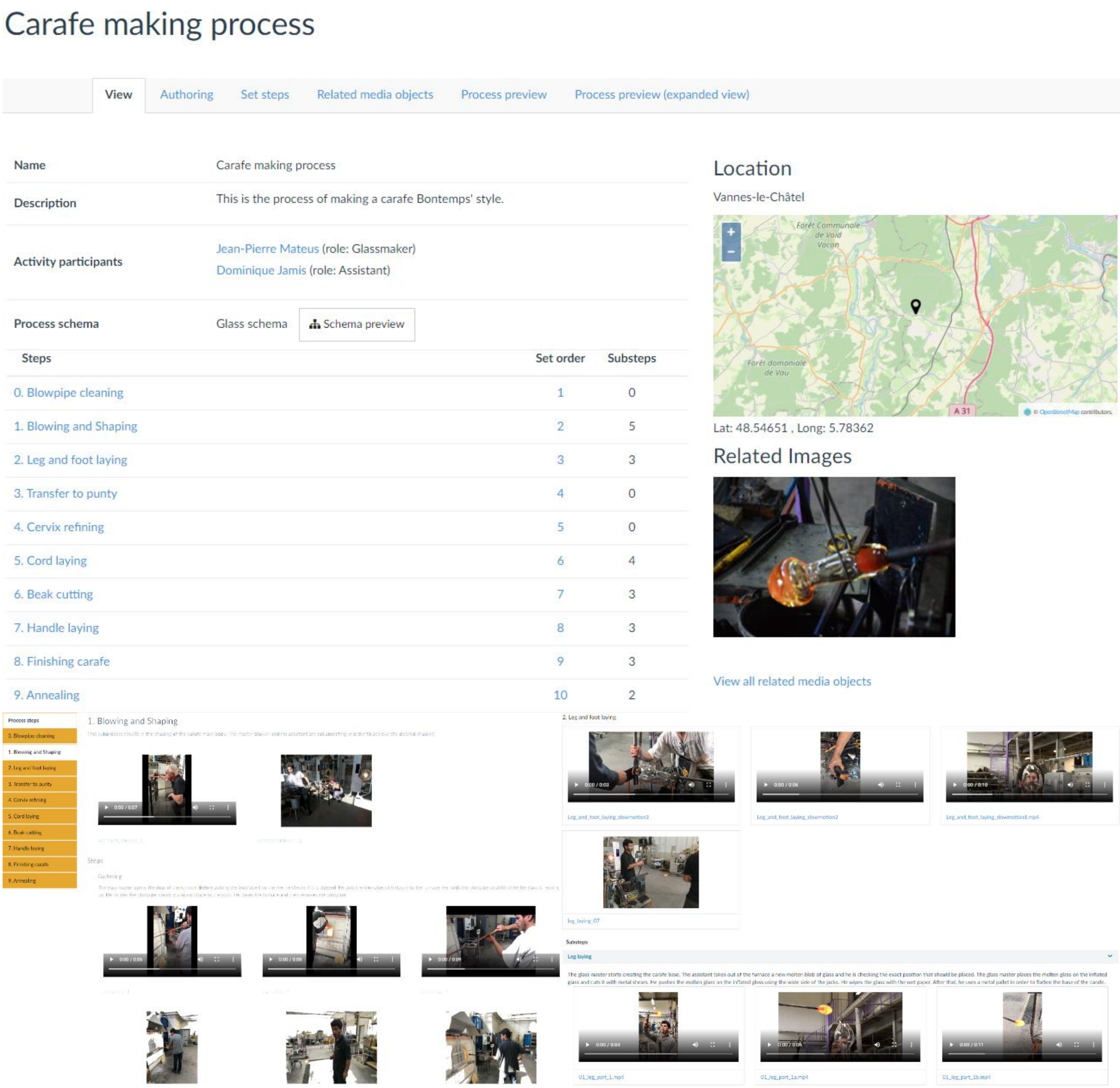
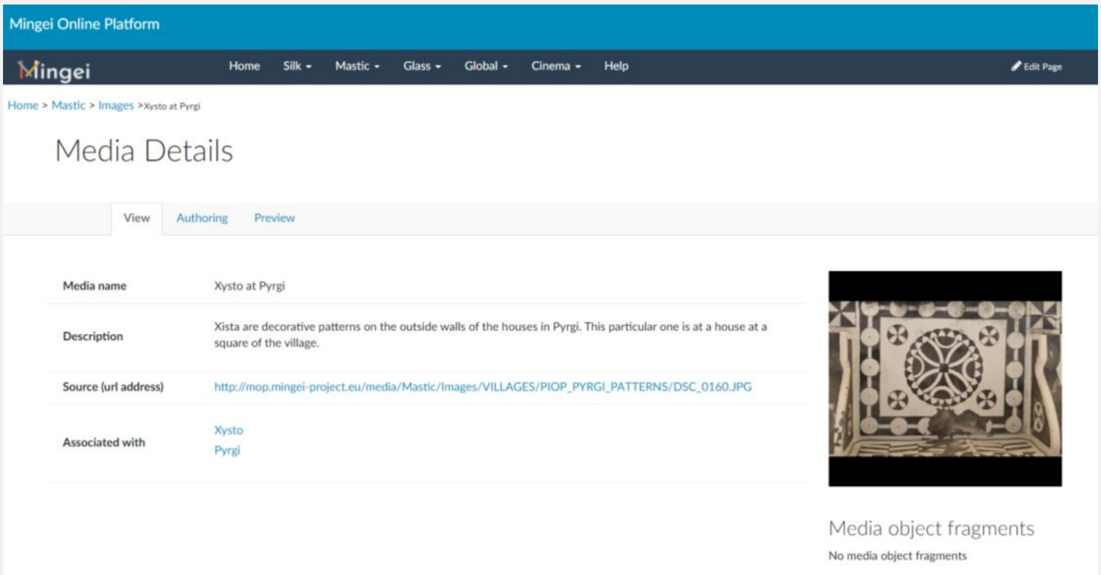


Figure 42. The documentation page for a crafting process.

7.6 MOP Tutorial – How to create a Europeana compliant digital asset

Theory

On the top of the page, you will see a horizontal menu reading “Home”, “Silk”, “Mastic” and so on. These are just different projects we are running and want to keep separate. This example is in the project (or context) of “Mastic”.



The content of this Web page is automatically generated for a digital asset, a digital image in this case. We acquired this photograph and uploaded it on a webserver at FORTH. Its URL is active and shown. There is a description note and the asset is associated with two hyperlinks. The first is “Xysto”. The second “Pyrgi” is a location.

The concept is a class that tells us “what” is in the picture, in other words, a ‘semantic annotation’.

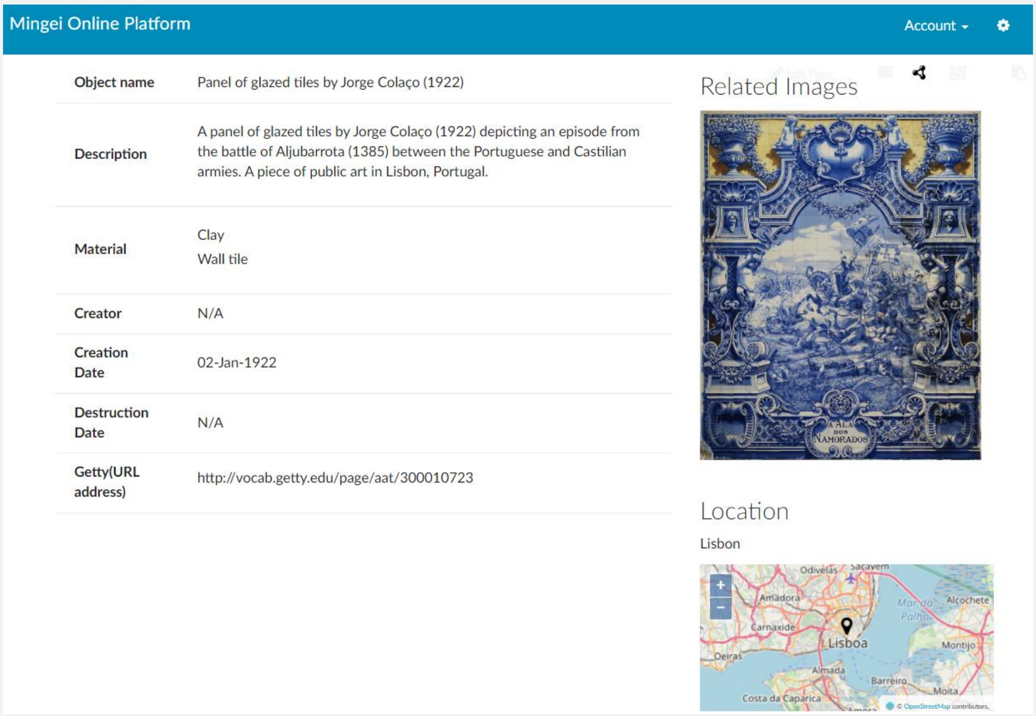
If you follow the ‘Pyrgi’ link, you will get to another automatically generated page. This page describes the concept of “Xysto” in a description note and provides also the local naming. Notably, it provides three (3) links to the Getty Arts and Architecture vocabulary that we talked about. If you follow these links, they will get you to the Getty vocabulary pages for the concept of “decorations”, the “relief” sculpture technique, and the “dry sgraffito” technique. These are the closest concepts the dictionary has to describe our asset, as it does not include “Xysto”. This concept page contains our image (see the thumbnails) but images of other Xysta, as well. This is because our database contains more images of these ornaments.

If you follow the location link (Pyrgi) you will see another automatically general page. We created this page semi-automatically using the name of the village and the GeoNames online database, through our platform. The description we got from Wikipedia. The map and all images acquired at that village are also shown.

Using this mechanism, the systematic creation of meta-data facilitates the process. The concept definitions are entered once and can be used for multiple objects. Most importantly, you can export the meta-data of digital assets in the way Europeana and many other databases require (see “Statements” on the top horizontal menu).

Hands-on example

This is a walkthrough in creating an asset as above. For our example, we will work on the “Global” context. You will have to log in to the DigiTraining account using the provided credentials. After logging in, I used the command in the menu Global->Objects to go to a page that shows me all objects in the “Global” context.



We will pretend that we are the curator’s assistant at the municipality of Lisbon and our job is to document a panel of glazed tiles by Jorge Colaço in 1922 at a wall in the city.

We use the button “Add new object”, which we name “Panel of glazed tiles by Jorge Colaço (1922).” Using the “Authoring” tab I enter as much information we know and add the description first. We use the “Save” button to save my data entry. We use the “View” tab to verify if it was entered correctly.

Then, we add Lisbon as a location. We try to write Lisbon on the auto-complete field “Location” but nothing comes up. Hence, we press the “Create new” button next to the Location text field. We use another browser tab to look up Lisbon in the GeoNames database, which is https://www.geonames.org/6458923/lisbon.html. The next time Lisbon will be on the list of places that can be reused.

Likewise, we get the URL of the object’s image from Wikipedia and do the same thing for the image which is https://upload.wikimedia.org/wikipedia/commons/9/94/Azulejos_Parque_Eduardo_VII-2.jpg

Then we look up azulejo on Getty and, since it is an existing entry, we directly get its URL which is http://vocab.getty.edu/page/aat/300010723 and add it in the Getty URL address attribute. Nevertheless, we also see that this particular azulejo is a mural and so we look up the term mural in Getty. We get multiple answers back and we decide that the most appropriate is “murals (general, decorations on the wall)” which has the following URL http://vocab.getty.edu/page/aat/300182732.

We use the mini-calendar to enter the creation date. We do not fill in the destruction date as the object still exists.

To create the material concept, we use the “Global->Materials” and then I “Add new Material”, which is clay. We use again Wikipedia images and the Getty dictionary. We do the same to create a “Wall tile” material. Then we go back to the *“Panel of glazed tiles by Jorge Colaço (1922)”* using the authoring tab and add the two materials.

8. Presentation modalities

In this step, we show how to author presentations of crafting processes and contextualisation narratives.

Multiple media can be employed to deliver narrations, starting from verbal and visual and reaching up to immersive and interactive narrations. A narration medium is utilized to communicate the story to the audience. Each narration has multiple presentations, which may differ in language or format (textual, audio, audiovisual, subtitled audiovisual, graphical novel, sign language etc). Our primary communication channels are **verbal** and **visual.** Conventional narration media, or narration channels, are voice, text, and audio-visual media, and their combinations.

A range of presentation modalities of relevance to craft presentation and presentation are presented. These modalities are tailored to present different dimensions of a craft expression. For these presentation modalities, the MOP is utilized as an infrastructure to provide content to the presentation tools. This content can be digital assets, knowledge elements, narratives, and demonstrations, each one provided through an IRI in the linked knowledge base. Each presentation modality is a different narration medium and its format determines the use of the content, the intended audiences, and the experiences to be rendered. Depending on the content type, an appropriate **narration channel** is required. A narration fragment can be presented in more than one channel. For example, a piece of text may be presented in written or audio form. In turn, audio narration may include dialogue, which can be recited by a single or multiple speakers etc. At the same time, music can be played in the background on an independent audio channel. A mixer may modulate the levels of individual audio channels over time.

We use the same software mechanism in presenting, or “narrating”, both crafting processes and contextualisation narratives as, in both cases, the presented content is a set of events. In contextualisation narratives, narration may visit the events of the fabula in any order. In processes, however, we follow the chronological order of the manufacturing process.

The added value of the Mingei approach is found in the presentation of the contents of the knowledge base. As process steps are associated with both signal and semantic descriptions, they can be presented together, the signal components used to show recordings of events and the semantic components to interpret them. Moreover, using visualisation and storytelling tools knowledge encoded in the representation can be presented in multiple ways and using multiple presentation modalities.

8.1 Storytelling

We explain the relation between concepts first. A story, or a fabula, may have multiple narrations. Individual **narrations of a narrative** may differ as to their focus on different subsets of events in the fabula or may be adapted per user interest, language, age, or special needs.

The authoring of narrations uses the fabula and is implemented using narrative fragments corresponding to fabula events. The content of these fragments originates from text authored particularly for this narration, but also from digital assets related to knowledge elements linked to the referenced events. A benefit of using the knowledge base is that updates on knowledge can be propagated the pertinent narratives, without requiring their recreation.

The first example, shown in Figure 43, regards the example of the fabula illustrated in Figure 29. A textual narration is authored for each event. In this case, the narration is 1-1 correspondence with the fabula (and is, thus, chronologic too).

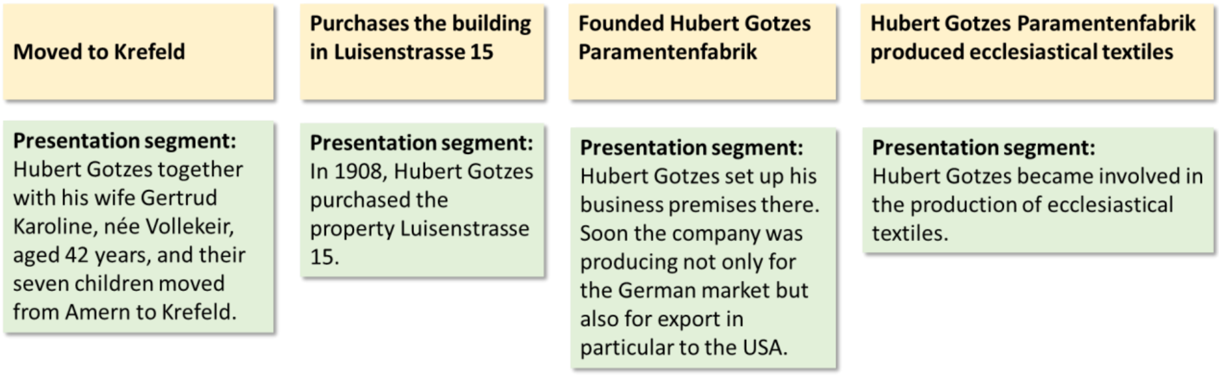


Figure 43. A fabula (top) and the narrations of its events (bottom).

In the MOP, verbal descriptions are employed to assist comprehension of each entity. The curator can manage the set of Narratives and, for each one, link the appropriate Narrations. On the Narrative authoring form, the curator provides additional information, including a description, linked Media Objects for the entire narrative, and determines the associated Fabula from a drop-down menu. New Narrations can be associated using Add Narration to create new narrations of select from existing ones from the drop-down list. The authoring of a Narrative and a Narration are shown in Figure 44.

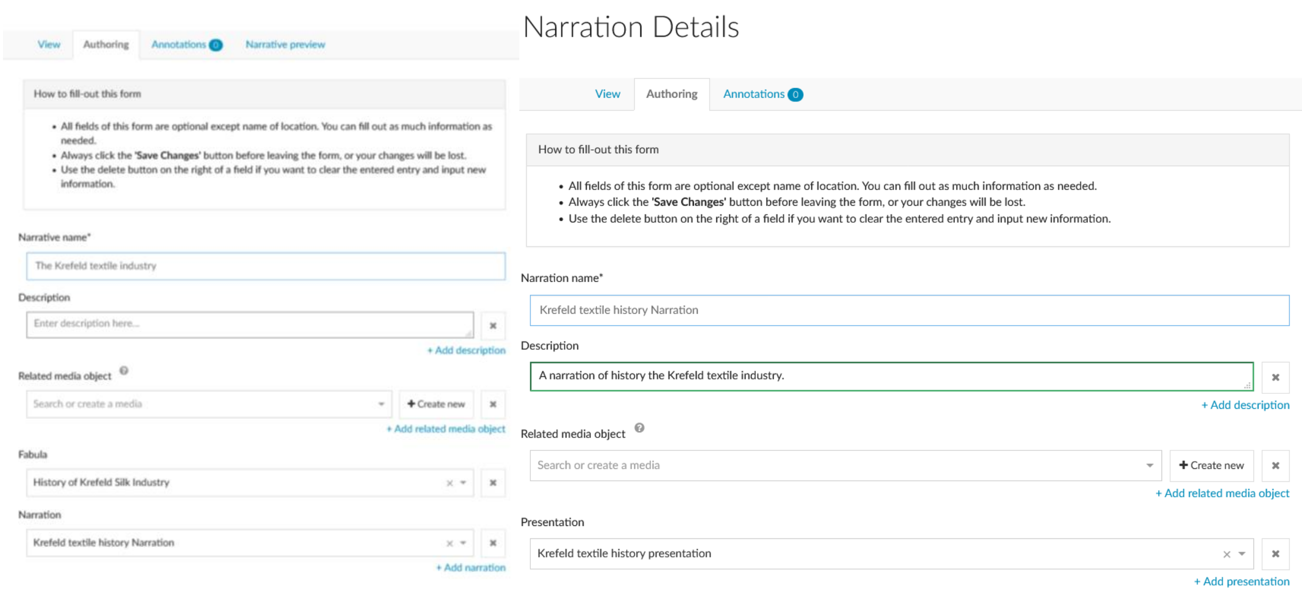


Figure 44. Narrative and narration authoring in the MOP.

8.1.1 Hypertext and Web

In the MOP the presentation entries are created using the Authoring tab. Presentation segments can be added and linked to corresponding narration segments. The MOP by default provides a template for a Web preview for any presentation. Figure 45 illustrates the user task. On the left, the configuration of the Web presentation is shown. On the right, the result is shown as a web page, with two narrative segments magnified.

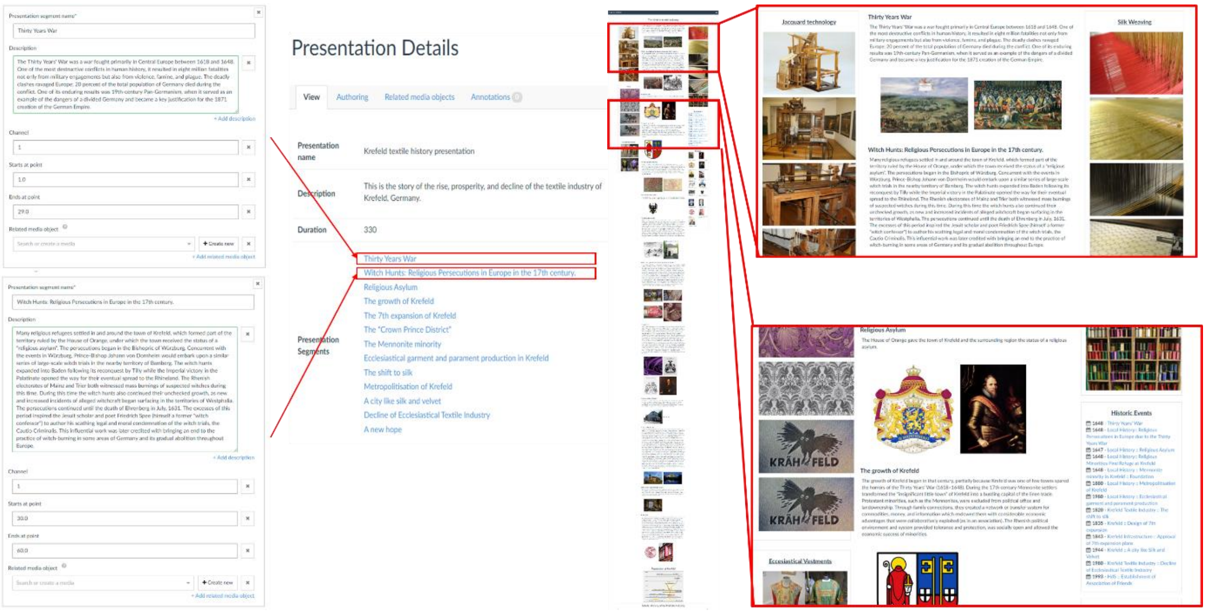


Figure 45. Presentation authoring and webpage preview.

A **temporal organisation** registers events on a timeline. Narration segments are deployed along channels in the temporal dimension of the presentation, in a historic plot. In this way, the presentation of narration segments can be visualised on a timeline. Individual channels correspond to individual sources of audio or video input. The author of the narration may select which audio and video segment is played along with the narration. Events can be accessed in the form of a timeline where the operator selects the events to include in the narrative. The events populating the timeline can be the result of a search. The example of Figure 46 is shown in such a case, where the timeline shows events that occurred in Krefeld and in which any member of the Gotzes enterprise participates.

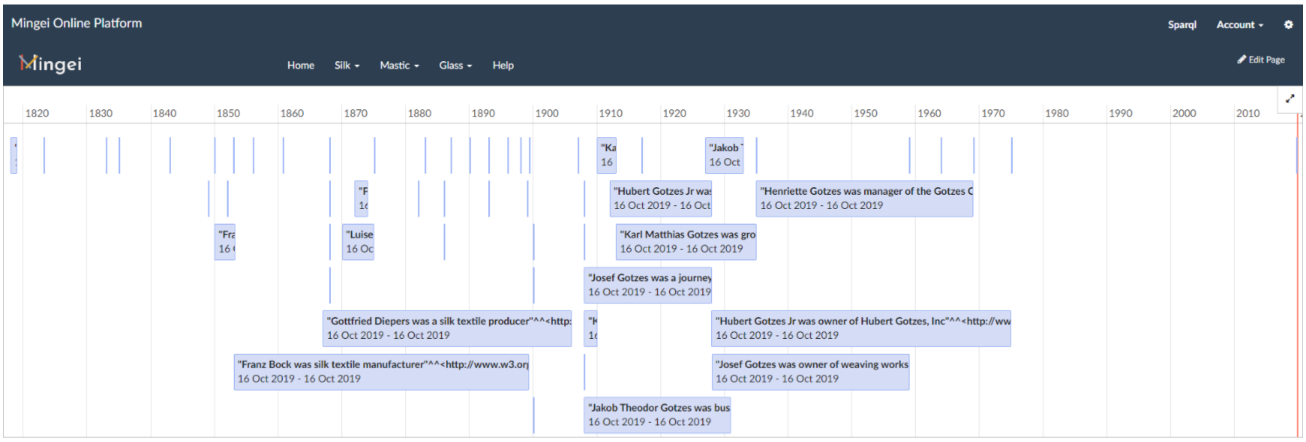


Figure 46. A timeline of events.

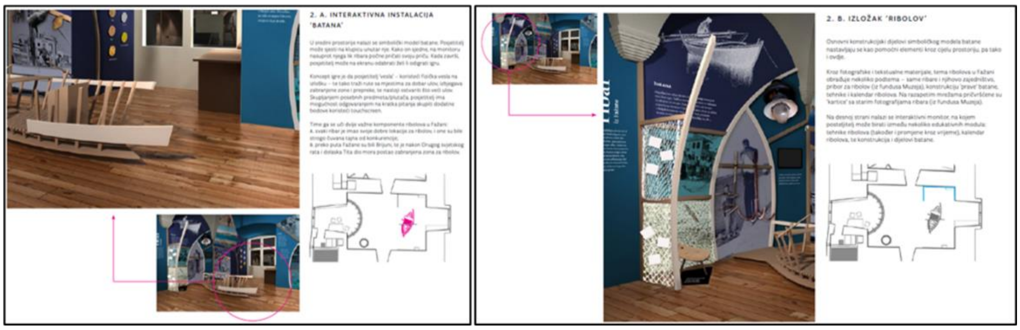
8.1.2 Audio and multimedia guides

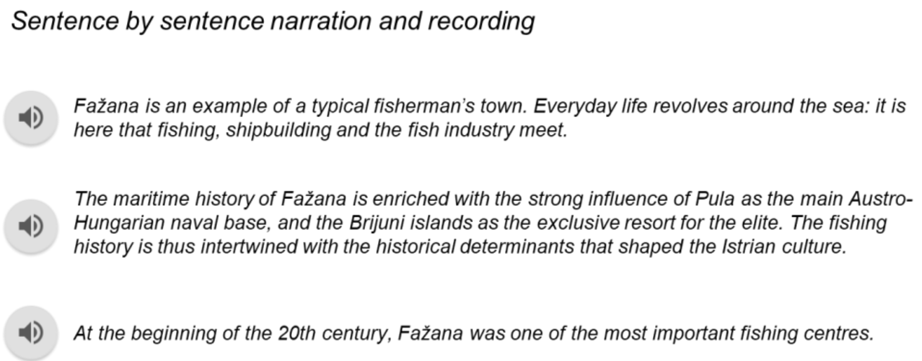
The potential of audio guides has increased with the proliferation of mobile devices. Starting from podcasts a variety of online and offline solutions exist today that enable museums and visitors to rapidly release accompanying content to permanent or temporary exhibitions. A central point in this effort is the organisation of content and digital assets.

Usually, for audio guides, the content has to be formalised for the duration needs of audio presentations. As such, it is recommended to prepare and organise content in a new presentation dedicated to the audio guide. A humble solution is to use the verbal narration content and multimedia and a voice synthesizer to create the audio narration. Better results are achieved with relatively little effort and still modest hardware equipment, namely a microphone.

It is important to record audio in a way that economizes post-processes and maximises compatibility with audio guide platforms. A sentence by sentence recording is recommended as it leads to initial audio files per sentence. Each sentence was recorded twice and the best recording was selected. The same recording equipment, speaker, and conditions should be preferably used for the recordings to economize on post-processing costs.

The example below follows these instructions in a work of the curators of the Ethnographic Museum of Istria in Croatia. The exhibitions present traditional professions dedicating a room for each. Each exhibit inside a room is associated with a small narrative. The curators recorded their text sentence by sentence and compiled this content into an audio guide.





A survey was provided to the CHI as per their options on using open tools to host their work on mobile devices of visitors (thus with no cost at all for the CHI). Introduce open and proprietary solutions to the CHI for instalment in an audio guide platform for their premises. Polykarpos Karamaounas, & Xenophon Zabulis. (2022). Audio Guide Survey. Zenodo. https://doi.org/10.5281/zenodo.6526364

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

8.1.3 Place-oriented presentation modalities

The presentation of environments is facilitated by spatial presentation modalities. The geographical organisation of narratives can be directly utilised in presentation modalities oriented to the presentation of geographical and spatial information. All spatial representations are enriched with locations of interest that are associated with knowledge elements in the ontology and occurred as predetermined locations on the map. These locations and associated digital assets are retrieved directly from the knowledge base or other repositories. This way, spatial presentations can be enriched with any type of digital asset in the knowledge base, such as 3D reconstructions, historical information, video data, etc.

The **spatial dimension** registers events and narration segments upon a spatial reference. This can be either a geographical region or a mapping of a craft workshop. In this way, narrative segments can be associated with regions upon a map structure (that of a geographical region or that of a workshop) and be presented in an exploratory nature. Like in the temporal organisation, the results shown in the example below are the result of a query. The resulting page is shown in Figure 110. Shown are events related to the narrative of the Krefeld industry, during the 19th century. Naturally, the majority of events are located in Krefeld. But, the location of the rest of the events is not at all random. They are situated along the Rhine waterway, which facilitates trade across cities. Neighbouring Aachen is relevant also, as it was of the first locations to connect by train to Krefeld.

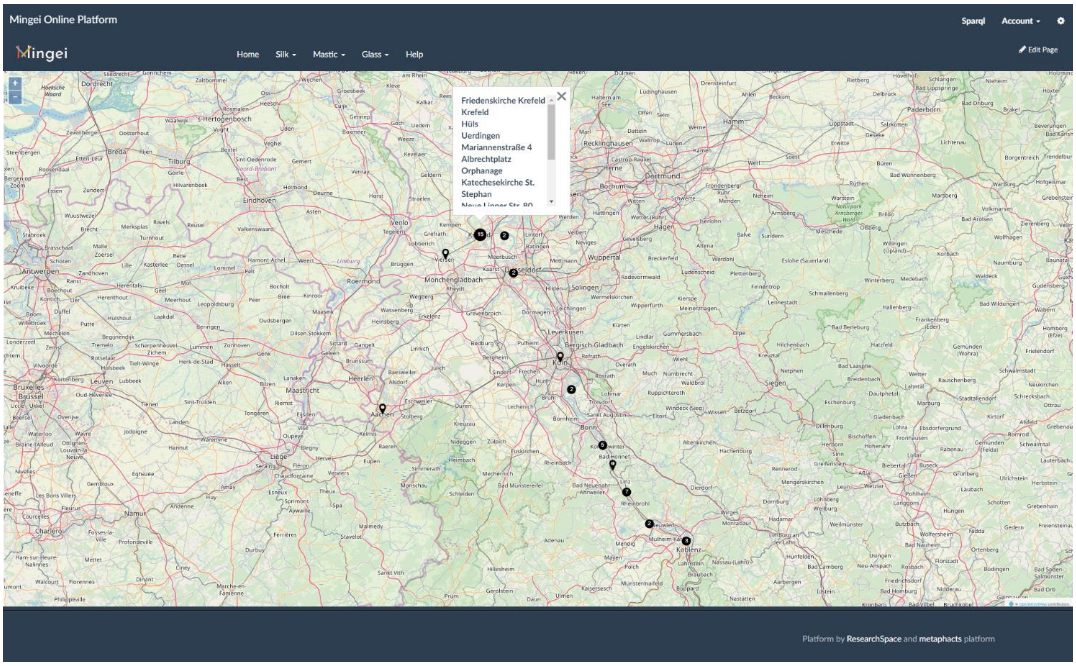


Figure 47. Access a narrative as a geographic map.

For immersive and mobile presentations, a basic map-oriented presentation modality is shown in Figure 46. At the same scale but relevant to the local environment and its resources 3D geophysical maps are proposed. Two corresponding modalities are provided in the Mingei tools. The first is a system to create an immersive projection room that overviews a 3D environment, interactively navigating from bird-eye viewpoints. The second is a lightweight presentation of a 3D geophysical for mobile platforms. In Figure 48 these modalities are shown.

Figure 48. Immersive and VR presentation of geophysical context.

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

A component that produces video output for a predetermined walkthrough of the virtual camera has been developed in Unity and is recommended as part of the MOP. The tool contains a few common trajectories that can be parameterised, such as circling through an object of interest, rotating an object for inspection, looking around, etc. We use this extension to systematically create videos of 3D digital assets, for demonstration purposes. The primary video can then be enhanced with narration, subtitles, music etc. In addition, the tool provides additional rendering modes (i.e., textureless, wireframe, etc.), to provide a detailed illustration of the geometrical structure where needed.

The tool is demonstrated in the two examples containing hyperlinked videos. The first regards the craft of Dry Stone Walling (ICH, UNESCO inscription 14.COM 10.b.2). In the example (see Figure 49), traditional settlements for moving husbandry (ICH, UNESCO inscription 13.COM 10.b.10), which were built by Dry Stone Walling is presented, via a guided virtual walkthrough. The scene is composed of multiple scans, to support viewing both the inside and the outside of the structures.

Figure 49. Virtual walkthrough of husbandry settlements at Psiloritis UNESCO Global GeoPark.)

The second example regards the architecture of Mastic villages at Chios. The overview shows how the architecture served as fortification of the village, for protection against invaders and pirates. Information on geographical location and context shows the environmental aspects affecting craft practice and development. During the flyover, users can stop at each village and retrieve multimedia and text information related to those villages as shown in Figure 50.

Figure 50. Airborne indicative screens.

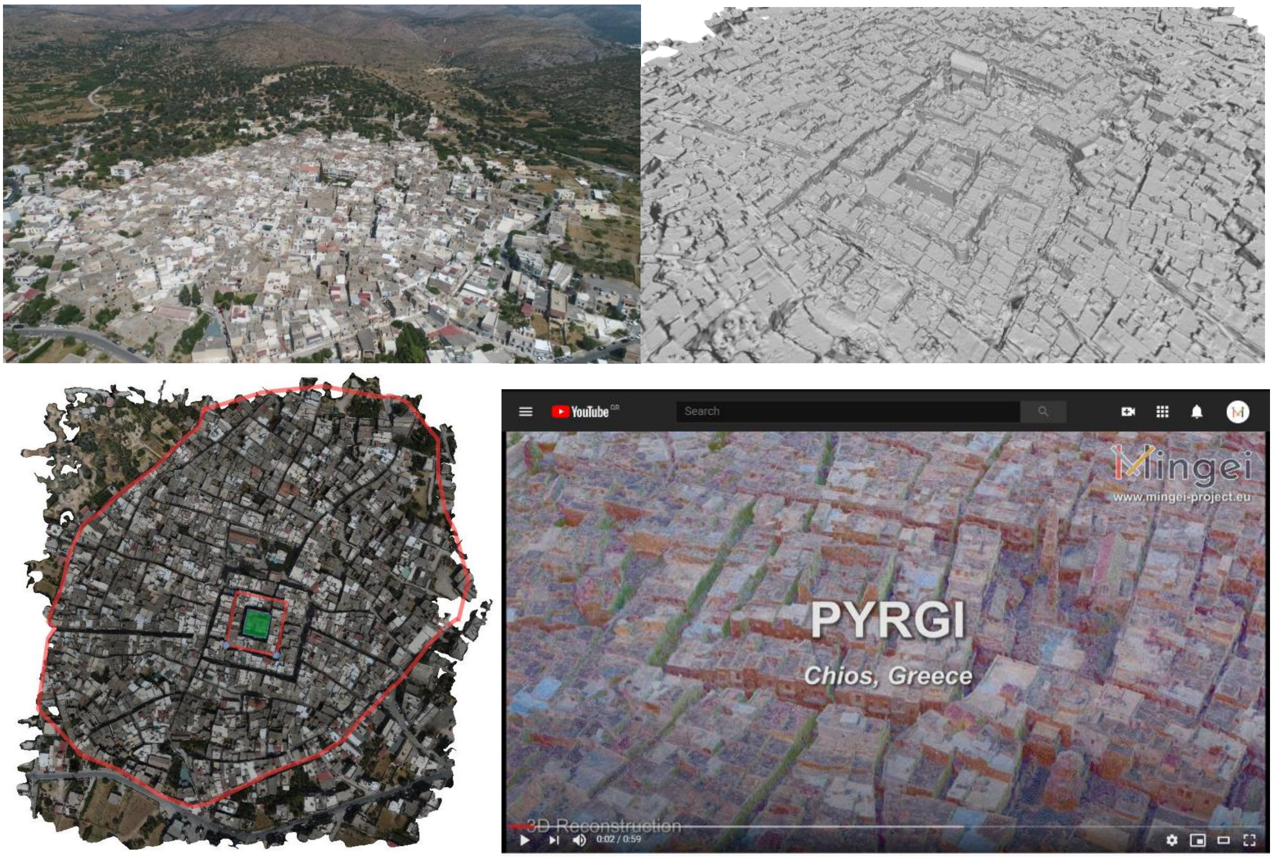


Figure 51. Annotated 3D reconstruction and virtual walkthrough.

Virtual exploration. A VR application template has been developed (see Figure 52) that enables virtual exploration of the natural environment from a terrestrial viewpoint. The terrain of the game was generated by importing the geophysical map into unity3D. Then flora and fauna were imported together with 3D reconstructions of villages. The concept of the game is to explore the island in different eras and acquire knowledge about the cultivation and trade of mastic in each one, through a mission-oriented approach. Digitised rural environments are also important to the realism of such application.

Figure 52. A VR application for the exploration of the natural environment of Chios.

8.1.4 Virtual Humans for Narration

Virtual Humans are today considered a commodity in the domain of computer animation, cinema, and games. In a sense, they are changing the way that audio-visual information is presented and in a gaming context, they have contributed to a more human-like interaction metaphor through Non-Playable Characters. Recent technical advances in VR and AR are accessible to the public through powerful mobile devices and inexpensive VR headsets.

In the light of the above, we present a cost-effective methodology for achieving realistic storyteller VHs creation for CH applications. The proposed methodology covers all steps of the creation and presentation of virtual storytellers in various settings including VR and AR, focusing on their looks, movement, and speech.

The primary hypothesis of this work regarding realistic storytelling animation is that it is important that they look, move, and sound natural. We have decided to use ultra-high-resolution VHs to make them look realistic, MoCap ensures that animations look natural, and software that can use voice recordings, lip-synching and facial expressions. The workflow proposed is shown in Figure 53. First, high-resolution VHs are created. Then, a MoCap is used to record the narrator's motion for the stories. Furthermore, we propose that the voice clips of each narration should be recorded in parallel with the motion capturing, as this will allow for synchronization between the recorded animation and the audio. To retarget the captured animation to the VH, a game engine is employed (in our case Unity). Voice recordings are used for narrations instead of synthetic speech. We propose that the face and lips of the VH are automatically controlled via software and that face-capturing solutions should be avoided in the context discussed so that updates in voice recordings need not be accompanied by a re-capture of facial motion.

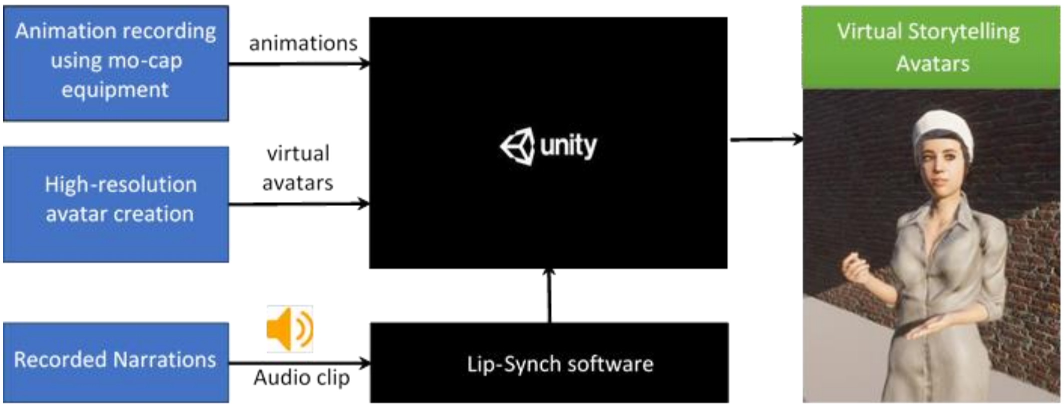


Figure 53: The workflow we adopt to bring narrator VHs to life.

<u>Animation recording</u>

Using MoCap we recorded body motion during narration and to be more realistic, we also narrated the stories during the recordings and recorded voice. This way, synchronization of voice and movement in the narrations was a lot easier and guaranteed natural narration. To enhance the realism of the animation we used male and female "actors" for this process according to the scenario of the narration and the gender of the expected scenario narrator (see Figure 54). The recorded animations were exported in .fbx format.

Figure 54: Female (left) and male (right) “actor”.

Retargeting recorded animations to Virtual Humans

The next step is to import the narration animations and the VHs into the Unity game engine. After that, we can add the VH to our scene, and define an animator component to control their animations. The controller defines which animations the VH can perform, as well as when to perform them. The controller is a diagram that defines the animation states and the transitions among them.

Recording natural human voice in virtual narrators

The main purpose of storyteller VHs is to complement a user’s visit to a CH site with audio stories. The narrator’s voice sounds clear and natural, while slight fluctuations in the narrator’s tone, speed, and volume can arise users’ interest and draw their attention to what’s important. This comes at the cost of having to process or re-record the audio clip every time the narration script changes. Thus, we propose to record natural human voice for every narration part that the humans have to reproduce, in separate audio clips so that the re-recording part (if needed) should be easier. In this work, we recorded human voice and then all audio clips were trimmed and lightly processed to remove excess parts and ensure the audio level will be equal among all the clips.

Lip synchronization and face morphing

When it comes to VH’s facial expressions, we propose to avoid using face capturing techniques for building storyteller VHs for CH applications. That is because, in practice, storytellers' VHs do not make very vivid facial expressions (such as surprise, fear, over-excitement, etc.) and, thus, mild facial morphs automatically controlled by software cover our needs. Secondly, building virtual storytellers implies that curators will be in charge of providing the scripts that the VHs should narrate, and they should be able to slightly alter those scripts without needing to re-capture facial animations from scratch; they should only need to process or re-record the respective audio clips. In the case of face capturing, the slightest change in the scripts would make the whole face look out-of-synch, as the VHs would move their lips in a different way than one would expect during narrations. The same would happen for the different languages supported – each language would require a new face capture to look and feel natural. Auto facial morphing and lip-synching provide the advantage of automatically controlling the VH’s face based on the provided audio. In terms of quality, automatic face morphing and lip-synching results are inferior to facial capturing; but as the VH's voice and body language remain the main focus of the users this is a fair trade-off.

We used software for controlling both facial morphs and lip-synching, as these two should comply with each other. We have used the Crazy Minnow Studio's Salsa lip-sync suite, which creates face morphs and lip synchronization from any given audio input, produces realistic results and is fully compatible with the Unity game engine and the software used for the creation of the VHs. Such compatibility is important because the lip-synch algorithms fuse the existing blend shapes of the VHs, and such blend shapes differ depending on the software used to create the VHs. We have applied Salsa lip-sync to the VHs provided by the Miralab and we assigned to each VH the corresponding recorded animations.

Putting them all together

The Unity game engine was used to compile VHs, animations, lip-synching, and voice recordings together. The animations and the VHs were imported using the Filmbox (.fbx) format, and a humanoid rig was applied to them. Then, animation controllers were built. Each character was bound to one animation controller which defines which animations he/she will be able to perform and controls the transitions among them using transition parameters. Such parameters can be then triggered via code each time we need a specific animation to be played. Colliders were also used to define proximity areas around the VHs so that specific parameters would be triggered upon their trespassing of them. An example is that, when a player's VH approaches a virtual narrator, the latter greets and introduces itself. Such a collider is shown with green lines in Figure 55 (left). On the right part of the image, the collider's properties are shown. Notice that the collider is set to be a trigger because we don't want to stop other objects from entering the collider area, but we need the VH's introduction animation to be triggered upon a character's trespassing the collider's borders.

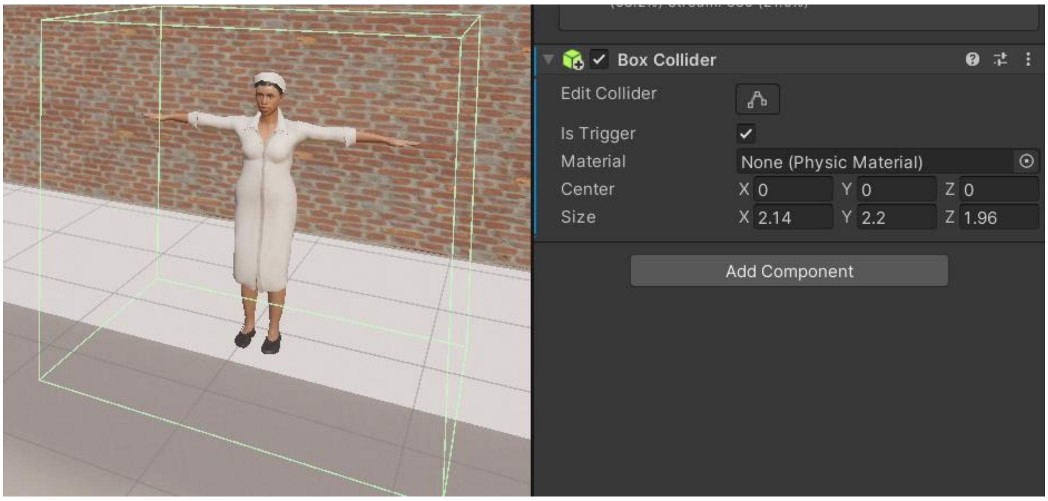


Figure 55: VH collider and control panel.

An AR application has been built to augment exhibits of the Chios Mastic Museum with VHs. Viewing the machines through the museum's tablets, the visitors see VHs standing next to them, ready to share their stories and explain the functionality of the respective machines. In Figure 56, a screenshot of the application running in the lab is shown.

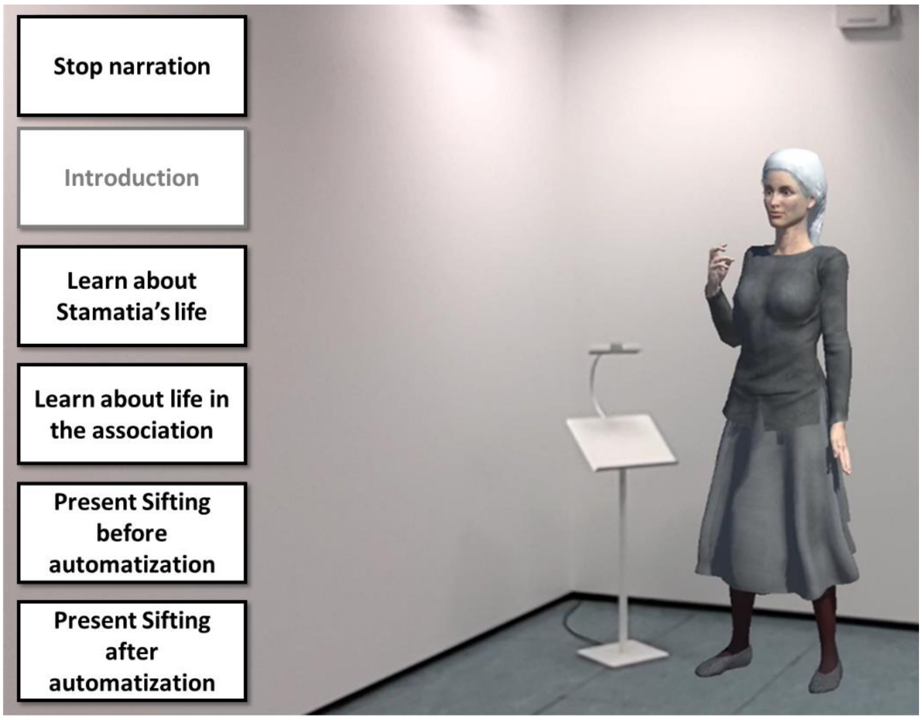


Figure 56: A VH narrating a story.

8.1.5 Sign Language Narrations

The accessibility of CH content for the diverse user population visiting CHIs and accessing content online has not been thoroughly discussed. Considering the penetration of new digital media in such physical and virtual spaces lack of accessibility may result to exclusion of a large user population. To overcome such emerging barriers, we propose a cost-effective methodology for the implementation of VHs capable of narrating content in a universally accessible form to act as virtual storytellers in the context of online and on-site CH experiences. The methodology is rooted in advances in MoCap technologies and VH implementation, animation, and multi-device rendering. The idea that cultural venues, as a service to the public, have a responsibility to welcome all in inclusive settings is far from being universally embraced in the cultural sector.

The proposed methodology is comprised of six sequential steps as shown in Figure 57. In the first step, the narrative is authored by CH professionals based on several research methods that could include archival research, ethnography, interviews, etc. The script is reviewed by the sign language translators and is optimized for oral sign language presentation. Then the VHs are implemented considering the characteristics of the personality narrating the story (e.g. age, gender, occupation, historical clothing, etc.). Then, the narration is recorded using a MoCap suit and gloves both in sign language and orally. In the oral recording, the narration audio is also recorded. Then the segmentation occurs to identify possible reusable parts of the recording to be integrated into the sign language vocabulary. The resulting animations are imported into a 3D game engine and retargeted to animate the Virtual Narrator with the animation sequence defined by the recorded animation file. In this stage, the resulting retargeted animations must be validated by sign language translators to assess their accuracy and readability. Finally, since the resulting animations can be exported again in .fbx format these can be employed to augment the content of various 3D applications delivered through a standalone application, the web, mobile devices, and VR.

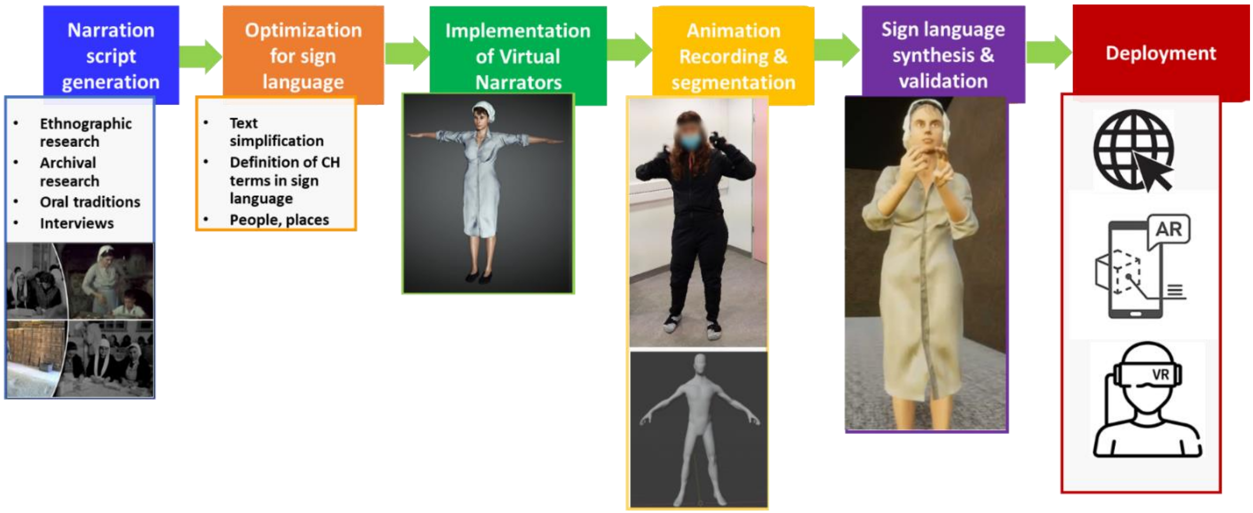


Figure 57. An example of a female VH (Stamatia).

Narration script generation

The first step of the proposed method regards the research needed to create a narrative that could relate to various aspects of CH such as an object, a collection, a historic event, a personal story, etc. In this sense, research may include any scientific process that could include archival research, a study of resources, ethnographic research, oral traditions and testimonies, interviews, curatorial work, etc. The result is the collection of sufficient information for the creation of a narrative. The outcome, as envisioned by this research work, is the text of the narration and the characteristics of the person narrating the story. Such characteristics may also include gender information, age, clothing, etc., and are useful for the implementation of the narrator VH.

Optimisation for sign language

In this step, the initial narration text that is meant to be used for oral narration must be reviewed and optimized by the sign language translators. This includes, if needed, text simplification which replaces text with simpler equivalents to simplify the sign language translation and enhance understanding. We propose that since sign language translators are part of the methodology they are also involved in the simplification of text. This is also important since content for CH applications is more challenging since it usually contains specialized CH terms that may pose requirements in terms of translation. For such terms, in many cases, no translations exist so a more descriptive sign language translation is needed.

Implementation of Virtual Narrators

This step regards the implementation of the VH that will perform both the oral and the sign language narration. In this work, no emphasis is put on the creation of VH as any form will suit the needs of this research work as soon as it is compatible with several basic characteristics such for example be represented by a humanoid, rigged, and skinned model. Any free or commercially available software can be employed for this reason. Of course, the software toolchain used will affect the realism of the final model since more advanced software solutions come with more features in terms of skinning, clothing, texturing, etc.

To this end, several guidelines can be provided. The VHs' bodies and clothes should be created to obtain one unified and optimized model, enhancing the visual impact of the characters with texture mapping and material editing. The 3D generation of the virtual bodies has also to take into consideration the total number of polygons used to create the meshes to keep a balance between the 3D real-time simulation restrictions and the skin deformation accuracy of the models. For VHs acting as conversational agents, an extra requirement regards the use of a blend-shape system for the facial animation meant working with software that supports one had the external BVH files for the animation of the body and on the other hand gives tools for controlling the facial animation.

Animation Recording & segmentation

For animation recording, a Human Motion Digitization technique should be used that can capture motion from the entire body of the captured person but at the same time can capture with high-accuracy hand gestures. Achieving the capture of accurate motion data is extremely important for ensuring a “readable” final result. Based on the authors' understanding and experience a motion capturing suit and smart gloves are a particularly satisfactory solution as it has the capacity of capturing full-body motion and at the same time, the individual recording of hand provides high-quality hand movement recordings.

Once the narration animations were recorded, their segmentation is done and segments are exported in fbx format, using the HumanIK skeleton. This action creates a series of bones, body joints, and muscles, and defines their rotations in the 3D space over time. Segmentation is important for several reasons. First, it creates several isolated animations that can be validated individually. Second, in the case of an error, this is easily located and can be fixed by manually editing the animation. Third, if the error cannot be easily fixed only the specific animation segment needs to be recaptured.

The segmentation process is done in collaboration with the sign-language narrators and regards the isolation of key phrases for the recording that can be reused in the future and the definition of the core narration part. The first part of isolated “sentences” is used to create a vocabulary of sentences that can be reused in the future and thus do not be to be recorded for each narration (e.g. the introduction of the person acting as the narrator that could occur in different narration texts). Regarding the narration part, the output of the segmentation process is a collection of sentences in the form of motion data.

In this stage the final narrations were available and the sign language translators were requested to prepare one narration per recording session. For the acquisition of motion, the Rococo MoCp suit and smart gloves were used. The sign language translator was requested to wear the suit and then narrate in sign language the simplified narrative. Simultaneously recording was done using the equipment. Each session concludes with the narrator previewing the acquired narrations to ensure that the raw capture data previewed through a simplified skeleton are accurate. To make sure that minimum re-capturing occurs narrations were segmented into parts (paragraphs) and each part was captured and reviewed individually. Figure 58 shows examples of the sign language narrator in action.

Segmentation is the process where the recorded segments are further segmented into parts that can be translated to an instance of an animation. This process was used to create a set of exported motion segments that were then exported and used to implement the actual animations on each VH. Reusable phrases were kept also in the sign language dictionary for future use.

Figure 58: An example of a female VH (Stamatia).

Sign language synthesis & validation

The segmented animations from the previous step are used to create animation sequences combined with a VH model. To do so, it is proposed to import the narration animations and the VHs into the Unity game engine. After that, add the VH to a scene, and define an animator component to control their animations. The controller defines which animations the VH can perform, as well as when to perform them. At the end of this step, a VH with integrated all the animations of the narrative is available. In the case where the oral narration is also recorded this is also integrated into the final model. For easiness, a script in JSON format is created for the orchestration of animation sequences.

What is important, in this step, is the validation of synthetic sign language narrations by VHs before any deployment of a signing solution to a CHI. To this end, the sign language translators must preview the signed narration and perform a validation of the readability of the outcome. This is crucial considering that minor errors in the retargeting process may result in an unnatural experience for end-users. For example, a false thumb position is something that may be detected by a sign language translator but not by a developer that does not have an adequate understanding of sign language gestures.

In the use case, VHs employed already contained animation recordings for the oral presentation of the narrative. Thus, the process involved the addition of new animation and their grouping under the sign language narrative group. Furthermore, an extra animation sequence was implemented to support the sign language narrative.

The result was then used to implement a demonstrator application running in standalone mode through a desktop computer. This demo was used for the validation of the sign language synthesis by the sign language translators. Sessions were organized with their participation. The objectives of these sessions were to preview the resulting animations and locate any issues that reduce the understanding or even alter the meaning of the sign language translation. Any errors were corrected either by altering the animation itself or retaking the entire animation if needed. In our case, only minor adjustments were needed to the animations so no recapturing was performed.

Upon activation of a spot, the VH appears and provides different narration options. All narrations are available in plain language and sign language. Examples are presented in Figure 59.

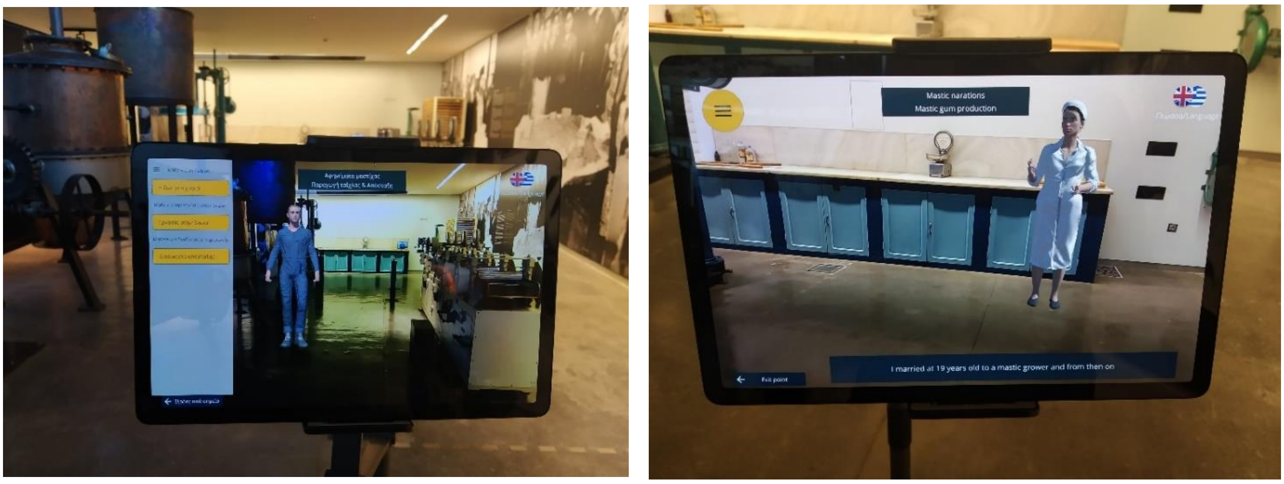


Figure 59: VHs as seen in AR at the Mastic Museum of Chios

employment

Regarding deployment, the proposed methodology does not pose any constraints on the development platform/technology. The created signer VHs can be integrated into any 3D-enabled software technology compatible with fbx format. Furthermore, the output can be easily ported to support WebGL technologies for web-based integration. Finally, VH animations can be rendered to video to be hosted by any other app that supports video rendering.

In the case where VH are to be presented in a physical space, several issues should be considered. The first is the registration of the device in space. This regards the possibility of the device understanding its location within space. This can be done by localization algorithms and the detection of image features that are located in fixed locations in the space. Upon localization calibration, the AR device can be moved to whichever location with the space without restrictions regarding its localization. The second is the correct placement of the VH in the physical space. This can be achieved through-plane detection provided by SLAM algorithms and appropriate scaling of the VH. For AR deployment another consideration that should be considered is device compatibility with ARCore for android based devices and ARKit for iOS-based devices.

8.2 Instructions

Of relevance to motion-driven narratives are the formats of theatrical script and storyboards, as they accommodate a description of the environment, such as a workshop, or an outdoors environment.

Schemas and processes representation of crafting processes is presented in chronological order, interpreting the causal relations between conditional transitions and parallel tasks. An activity diagram is recommended accompanied by visual examples.

Postures and gestures. The selection of keyframes in posture documentation comprises knowledge abstractions that can be used in exemplars. Posture visualisation is available through avatars. The digitised 3D tool model is aligned with the avatar hand reference frame, using the stored grip posture. This way, tool grip, relative configuration, and motion can be rendered in 3D, enabling close inspection and viewpoint of choice.

Explanations. Are in verbal format and complements visual instructions with the purpose of the action and a way to verify if it was properly achieved.

Pictorial gesture presentation. The juxtaposition of keyframes in chronological order guides inference of what occurred in between them, while motion annotation facilitates comprehension of the recorded movement even in single frames. **Animated gesture presentation.** 3D motion and posture recordings are retrieved from the knowledge base. They are mapped to avatars and digitised objects, respectively, to create animated 3D gesture presentations. The 3D animations are produced, mapping the recorded movements to avatars and using the recorded postures for handled tools and objects. The 3D animations can be viewed in the 3D or conventional video.

Directing the spatiotemporal arrangement of content in channels entails the selection of which content is presented when for each channel. Of primary importance is the selection of the medium which determines the way that verbal content is formulated. A primary distinction is between **static** media that can be read or explored and **dynamic** media that either stream or interact with the audience. Correspondingly, different narrations of the same story are created, which are tailored for the respective media and the presentation modalities of the next step.

8.2.1 Audiovisual

The ideas narrations can be in a form of ethnographic documentaries. The simplest narrative type is **expository, which** focuses on the provision of information on a topic and is based mainly on speech if the form of voice-over narration and interviews. The narration can be enhanced with images interviews, and archival material, assisting in the understanding of the subject.

Besides crafting process descriptions a list of prepared topics helps to motivate narration in front of the camera. The narration can contain the crafting process, the origin of materials, the tools used, and the final products. It is important to observe the area and the place and locate interesting shots.

After collecting the material, it is recommended to watch the collected material, select the interesting video and audio clips, and through a simple editor (e.g. VideoPad).

You can use such an editor to assemble the shots you need and add the title of the documentary at the beginning of the video, including the name of the workshop and the place where it is situated. Add the logo of the project to be shown at the top right corner of the screen during the video.

Using such editors you can also use custom audio, including voice-over segments or music and adapt the visual material (images, videos) to the audio material and make use of interesting and attractive scenes, which are going to engage the interest of the viewers. Multilingual subtitles should transcribe voice and important sounds. Multiple languages can be supported this way.

At the end of the video, add credits to the people who participated in the video and those who worked behind the scenes. Provide information about your projects, such as the name and the source of funding. Export the final video in an mp4 file.

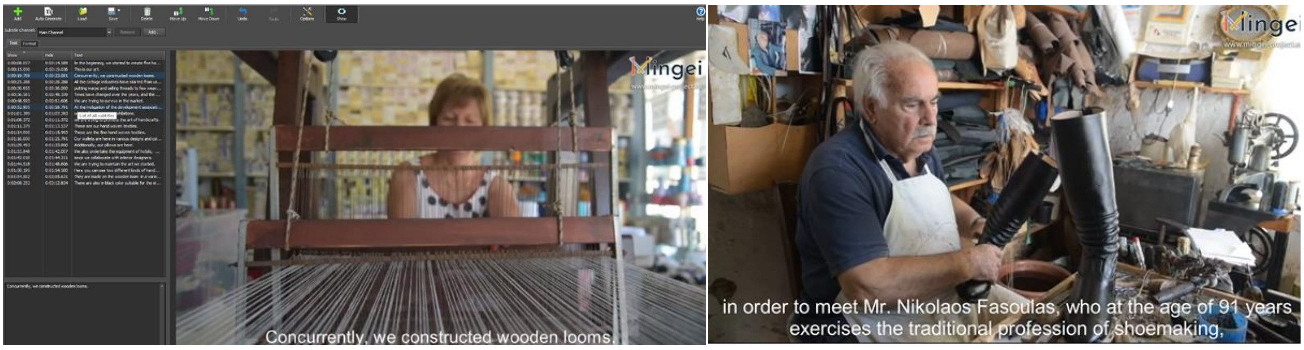


Figure 60. Creation of audiovisual narrations.

8.2.2 Virtual exhibits in real places

The **Virtual Museum** modality (see Figure 61) presents collections of digital assets in a physical space through interactive projections. The modality is designed having in mind that several museums have a large collection of artefacts in their storage, but no room to display them o represent past period exhibitions, to virtually re-visit them after they have ended. The modality enables interactive inspection of artefacts through gestures, and access to accompanying verbal and visual assets relevant to the exhibit, which are retrieved from the knowledge base.

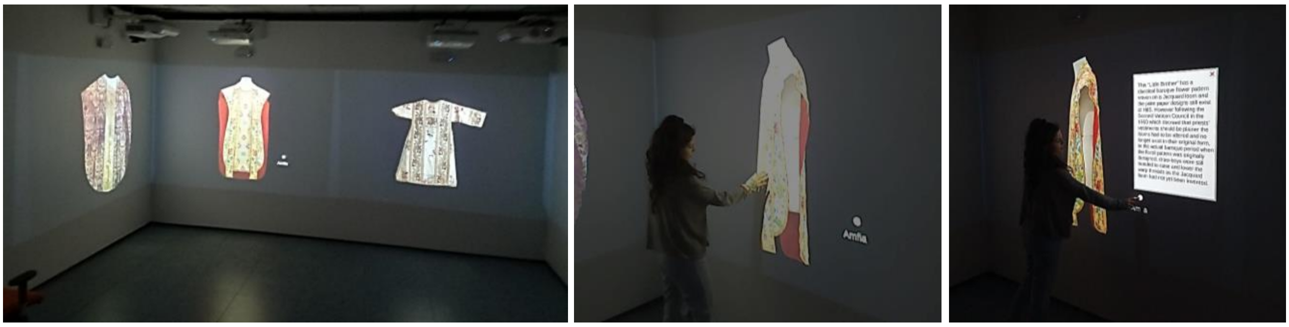


Figure 61. The Virtual Museum presentation modality.

8.2.3 Tool and machine usage

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

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

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

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

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

Using MoViz, the components of the physical interface of a machine, are associated with the body members of the Virtual Human. The avatar and the piece of machinery are "situated" in a common virtual space, such as a workshop. The interaction of the avatar with the machine interface is simulated, by importing the motion recording and a model of the machine component.

The physical interface of a loom beater component is illustrated, along with the description of the operation and the predicted effect. A possible grip of this object is illustrated in Figure 62.

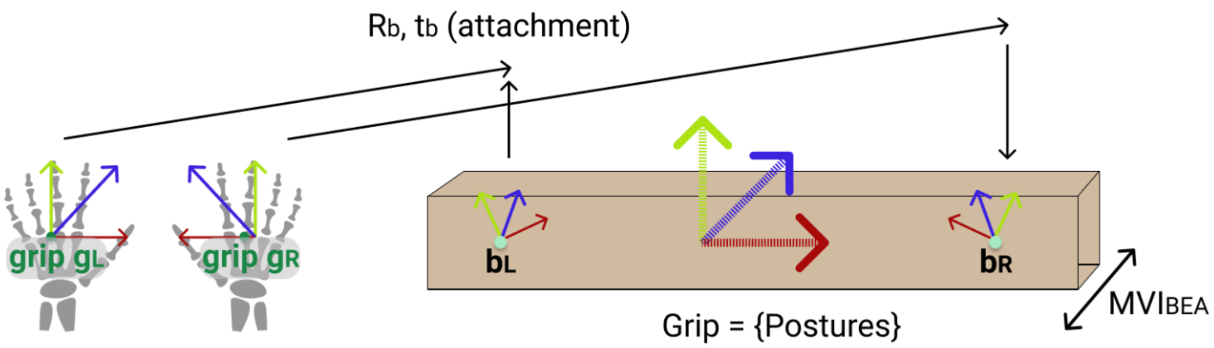


Figure 62. Bimanual gripping posture for a component of a loom's physical interface, or beater.

In Figure 63 (left, middle), the beater component is shown at its two extremal positions. This is the component at which the recorded motion from the weaver's hand will be mapped. In Figure 63 (right), the incorporation of the component in the model of the loom is shown, in blue highlight.

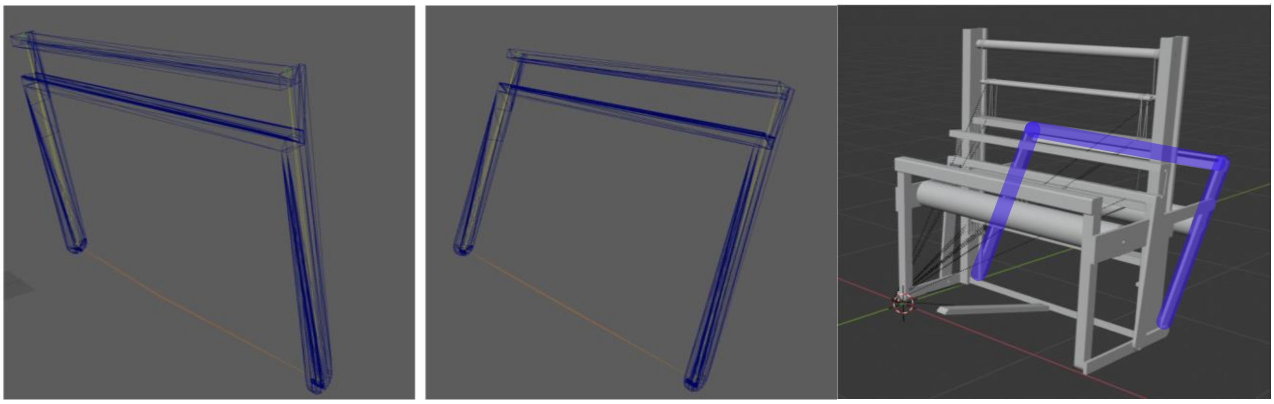


Figure 63: Loom beater model.

In Figure 64, the rendering of the virtual human operating the loom is shown. On the left, shown is the virtual re-enactment of the recorded activity. The detail on the right shows the motion of the second component of the physical interface, the treadle, which is represented using the same procedure.

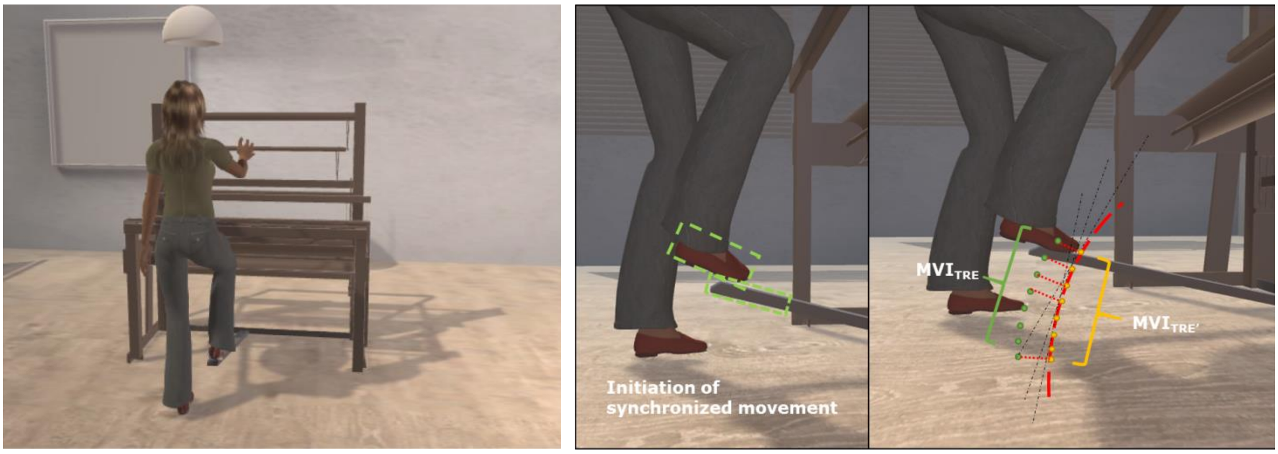


Figure 64. Visualisation of induced motion on a loom treadle.

8.2.4 Virtual reenactment

VH animations were used for the implementation of the 3D representation of crafting activities, available for inspection and learning by example (see Figure 65). The processed gestural know-how of the captured craft practitioner is used not only for replicating the movements of the practitioner, but also for setting digitised craft tools in motion using a technical approach for attaching tools to VHs, and by inferring tool motion from human motion. Moreover, the presented 3D models of machinery are accessed with the knowledge entities that represent them. As such, the presented digital assets are treated as knowledge elements, retrieved from the MOP, with consistent naming, and linked to their semantic annotations. This is important because through these associations we can retrieve the actions and, in turn, corresponding motion assets demonstrating their use. Inversely, in the VE when interacting or inspecting an object, the aforementioned semantic associations are directly available.

Figure 65. Demonstration of the mastic cultivation activities by a VH.

8.2.5 Mobile clients

Online educational games were created in the form of mobile applications, available on Android and iOS. For textile design and manufacturing, two games specifically designed to explain both the design of a pattern for a Jacquard loom and how the punching card is created from the paper design were. For mastic cultivation, applications focus on seasonality and the cultivation tasks per time of year (see Figure 66).

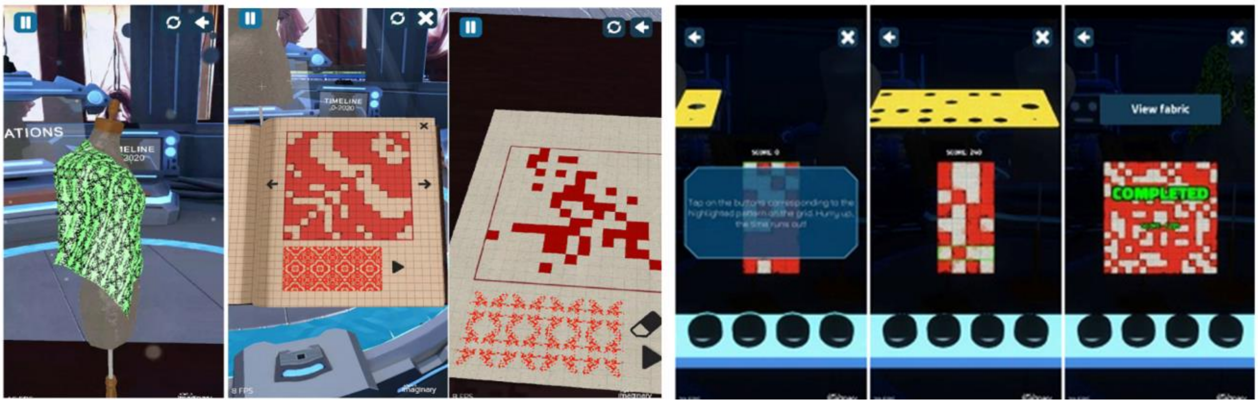


Figure 66. Edutainment applications for textiles design and manufacturing.

A generic access client for mobile devices provides access to the knowledge base. The application provides access to related to the craft information in the form of textual narrations, events, videos, images, and 3D reconstructions, that are associated with the location. The prototype was enriched with an interactive map of a region with marked Points of Interest (POI). The content presented in the selected POI is drawn from the repository and is authored via the MOP. Indicative screens from the AR mobile prototype of Silk are shown in Figure 67 and Figure 68.

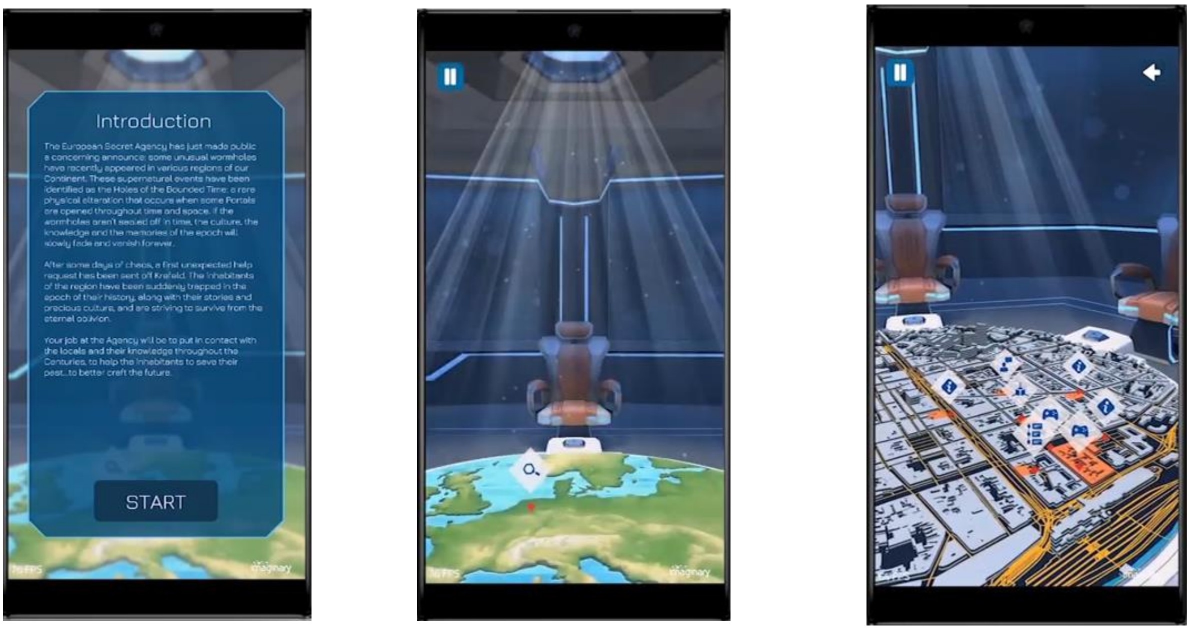


Figure 67: Mobile application prototype for the Silk pilot, showing a map and verbal information at POIs.

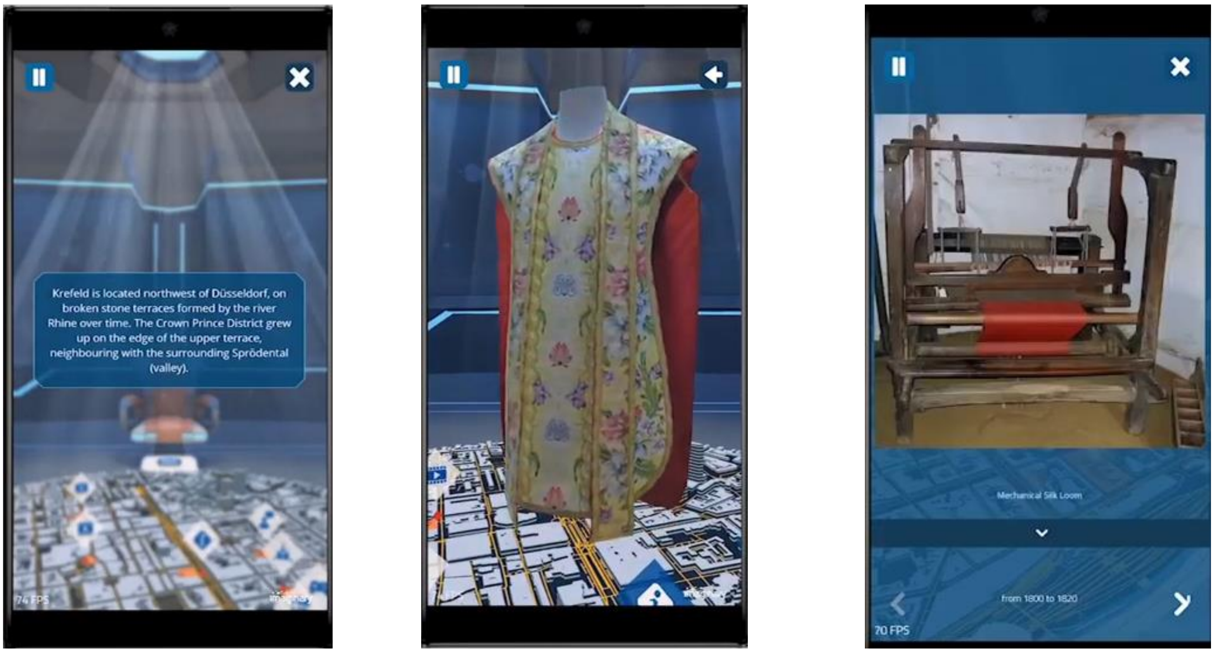


Figure 68: Mobile application prototype for the Silk pilot, showing assets from the repository.

8.2.6 Visual instructions

MotiVo is an interactive system that simplifies the process of motion visualisation by offering several visualisation tools as integrated components to an interactive system and provides insightful and visually pleasant results requiring minimum expertise and knowledge from the user. Using those tools, motion is visualised by parameters, such as the blending of key poses of activity, the visualisation of motion trajectories, and the application of image filters to visualisations and their 3D and 2D combinations to create hybrid depictions of motion. In Figure 69, shown are illustrated examples.

Figure 69 Use of MOTIVO in the creation of illustrated instructions.

9. Outlook

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

9.1 Limitations

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

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

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

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

9.2 Future work

Our effort towards the exploration of CH digitisation does not end here. Parts of this work have been showcased as good practices in the "DigiTraining" Creative Europe co-funded project. Furthermore, this work has been published in several scientific publications in Open Access and public deliverables of Mingei. They are all available on the website of the project at https://www.mingei-project.eu/

This is the first version of this handbook, with our intention to keep updating it along with the opportunities we have for research.

Public comments and invitations for collaboration in further research are welcome.

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