

# A Representation Protocol for Traditional Crafts

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**Abstract:** A protocol for the representation of traditional crafts and the tools to implement this are proposed. The proposed protocol is a method for the systematic collection and organization of digital assets and knowledge, their representation into a formal model, and their utilization for research, education, and preservation. A set of digital tools accompanies this protocol that enables the online curation of craft representations. The proposed approach was elaborated and evaluated with craft practitioners in three case studies. Lessons learned are shared and an outlook for future work is provided.

**Keywords:** craft preservation; cultural heritage; digitization; documentation; digital curation



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## 1. Introduction

Crafts, handicrafts, traditional, or “heritage crafts” [1] are an integral part of cultural heritage [2,3], and are in many cases endangered due to the “declining number of practitioners and apprentices” [4]. In contrast to other forms of intangible cultural heritage, traditional crafts bring together multiple tangible and intangible dimensions, as “the most tangible manifestation of intangible cultural heritage” [5]. A classification of craft dimensions as tangible and intangible by ICCROM [6] identifies tangible dimensions as the materials, tools, workspaces, and the produced artefacts, and intangible dimensions refer to knowledge and skill but, also, to the social, technological, and historical context that led

to the evolution of each craft. This work aims to present accurate representations, documentation, instructions, and training aids to support the digital and living preservation of craft knowledge and practice.

The challenge addressed in this work is the representation of a “practice” [7] rather than structures and movements. In this context, actions have the purpose of material transformation and, moreover, invisible components are involved, such as knowledge and dexterous motion. This knowledge may reflect social components of human activity, such as the collective values and memories often depicted in traditional motifs. Crafts span heterogeneous dimensions; multiple types of representations are required. The appearance and geometrical structure of products, tool, and materials and actions are recorded, or “digitized”, in “signal” representations, i.e., audiovisual and 3D/4D. Knowledge is encoded using “semantic” representations. This knowledge is related to the way of making craft articles, the required materials and skills, but also their societal culture, economic impact, and historical significance.

This work proposes a protocol for (a) the identification, organization, and collection of the required information, digital assets and knowledge, (b) their organization into a digital representation, and (c) the use of this representation to digitally preserve the encoded craft knowledge and physically reenact the digitized craft processes. As multiple information types are relevant, the proposed protocol provides a blueprint for the format, order, and interdependence of steps in achieving a craft representation. The work behind this paper is described in the context of the multidisciplinary Mingei Innovation Action of the European Commission [8].

Several digital tools have been developed to provide an implementation basis for the proposed protocol. The basic infrastructure is the Mingei Online Platform, a collaborative, Web-based authoring platform for craft representations [9]. Several supporting editors that facilitate the digital curation of pertinent digital assets accompany this platform and are presented below. The platform incorporates prior work on the representation of crafting processes [10] and contextualization narratives [9]. A set of tools have been developed that, based on the achieved representation, enable the creation of key applications that make the represented knowledge more available to the general public and researchers.

An overview illustration of the proposed protocol is provided in Figure 1. We propose the curation of a craft representation in a series of steps that correspond to the information flow during its digital curation. 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.

The remainder of this paper is organized as per the protocol steps. In Step 1 (Section 3), we acquire craft documentation in the form of digital assets. Based on these assets, basic knowledge elements are formed in Step 2 (Section 4). Using these elements, we build a semantic craft representation in Step 3 (Section 5). Using this representation, we establish a foundation of knowledge for presenting crafting processes and craft contextualization narratives, in Step 4 (Section 6). These narratives fuel informational tools, educational presentations, and multimodal training experiences in Step 5 (Section 7). In Step 6 (Section 8), digital presentation modalities are used in applications that serve craft preservation, cultural tourism, and education. In Section 9, applications of the protocol are presented along with lessons learned through their elaboration. The paper concludes in Section 10 with a discussion on the limitations of the proposed approach.

The following abbreviations are utilized in this paper. AR, Augmented Reality; CH, Cultural Heritage; CIDOC, ICOM’s International Committee for Documentation; CIDOC-CRM, CIDOC Conceptual Reference Model ISO 21127:2014; CrO, Crafts Ontology; FRBR, Functional Requirements for Bibliographic Records; FRBRoo, FRBR object-oriented; GUI, Graphical User Interface; HTTP, Hyper Text Transfer Protocol; ICCROM, International Centre for the Study of the Preservation and Restoration of Cultural Property; ICH, Intangible Cultural Heritage; ICOM, International Council of Museums; ISO, International Organization for Standardization; IPR, Intellectual Property Rights; IRI, Internationalized

Resource Identifier; MoCap, Motion Capture; MOP, Mingei Online Platform; OWL, W3C Web Ontology Language; TCs, Traditional crafts; UNESCO, United Nations Educational, Scientific and Cultural Organization; URI, Uniform Resource Locator; W3C, World Wide Web Consortium; WWW/Web, World Wide Web.

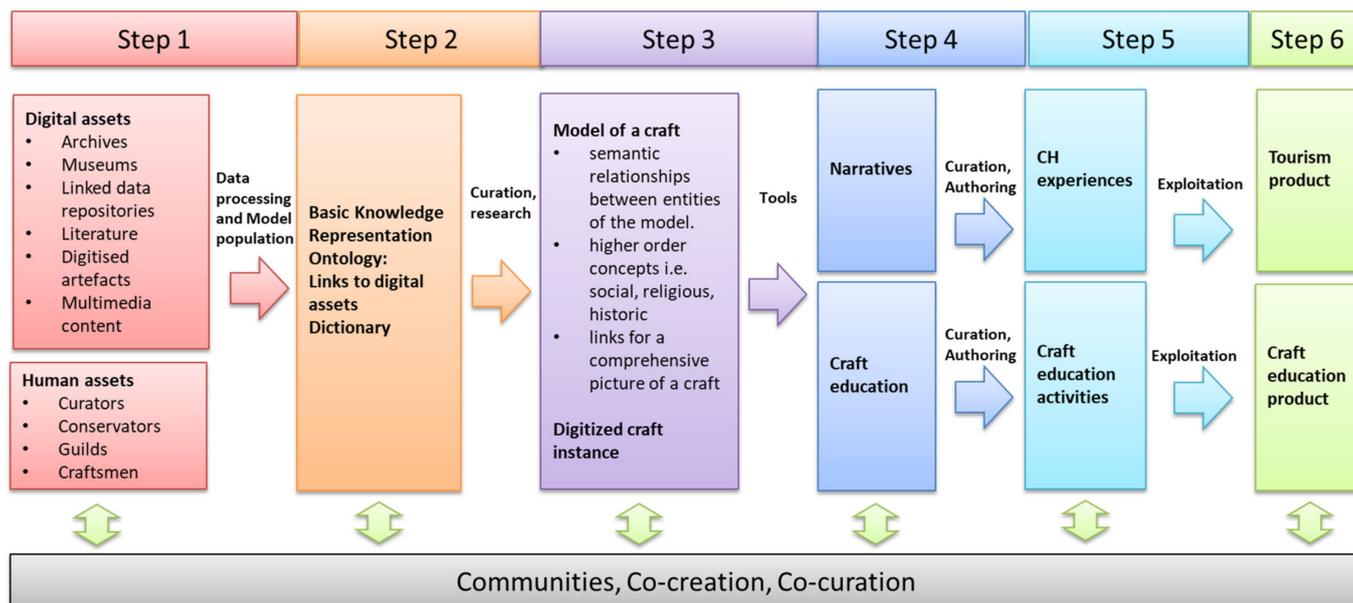


Figure 1. Illustration of protocol steps.

## 2. Related Work

### 2.1. Craft Documentation

UNESCO's recognition of traditional crafts as ICH [4] generated awareness and compliance of craft descriptions according to scientific and ethical guidelines. Descriptions following these guidelines can be found in the Representative List of the ICH of Humanity of UNESCO [11] and national inventories, e.g., [12–15]. These craft descriptions emphasize cultural content, social components, ownership, IPR, and authenticity certification, but do not include sufficient technical descriptions to support craft understanding and re-enactment. In 1990, UNESCO published a data collection guide for traditional crafts [16]. Though technologically outdated, it identifies the essential elements to be recorded: artifacts, materials, tools, and the crafting process. Photographic documentation is deemed necessary to record the practicalities of the making process, which are often simpler to show visually than describe verbally, such as the way to hold and manipulate a tool.

Ethnography [17] identifies and describes the activity of a social unit as “textual reconstructions of reality” [18]. Recently this has been applied in workshops, with examples in carpentry [19], glasswork [20], and textile manufacturing [21]. The Living Human Treasures program of UNESCO focused on talented tradition bearers and practitioners who, through ethnographic documentation, could contribute to the transmission of their knowledge and skills to the younger generations [22].

Cinematography and digital technologies facilitated the recording of directly comprehensible, visual examples. Video dictionaries of crafting gestures were proposed in [23]. In [24], a worn camera was proposed to capture the viewpoint of the practitioner. The 3D recording of crafting motion was used to enable any viewpoint in [25]. In [26], digital ethnographic tools were proposed.

### 2.2. Prior Work on Craft Representations Adopted by This Work

The Crafts Ontology (CrO) in [27] is based on CIDOC-CRM [28] and enables the formal representation of crafts. It is an application ontology obtained by integrating several existing ontologies, notably (a) the CIDOC-CRM, a top ontology and an ISO standard

forming the conceptual backbone of the CrO, (b) the Narrative Ontology [29,30], a domain ontology for the representation of narratives, (c) the FRBRoo, a domain ontology for bibliographic records, resulting from the harmonization of FRBR with CIDOC-CRM and (d) OWL Time [31], a domain ontology recommended by W3C for the representation of time.

We use the CrO to formally represent crafting processes, as in [10]. The digital narratology approach in [9] is adopted for the representation of narratives that contextualize artifacts, collections, and techniques. Furthermore, it is used to model the stories comprising the technological, social, and historic context of crafts.

The Mingei Online Platform (MOP) [9] is a Web-based authoring platform that integrates the aforementioned craft process and narrative models and provides a GUI for the instantiation of craft representations. This GUI facilitates this process and user collaboration, allowing different access roles. The MOP is built on top of ResearchSpace [32,33], a research platform that introduces modules for CIDOC-CRM and integrates a repository of digital assets that assigns IRIs to the resources managed. For the resources that have other identifiers in Wikidata or any other knowledge base, connective links are asserted in the MOP knowledge base. Each digital asset is endowed with metadata, including semantic annotations from controlled vocabularies for objects, activities, and locations.

### 3. Step 1. Understanding and Recording

A mapping of the topics and knowledge items to be documented is established. The pursued outcome is an identification of the entities required to comprehend (a) the practice of the craft and (b) the social and historical context of this practice by a community.

Prior knowledge on the topic catalyzes discussions with practitioners and communities. This preparatory task regards secondary source research. The targeted sources provide an identification of the basic concepts and their appellation. Recordings of objects (endurants) and events (perdurants), such as human actions, complement the documentation by visually capturing the craft tools, workshops, machines, and products.

#### 3.1. Understanding

This task then enables understanding of the craft practice and context, through interaction with practitioners and CH professionals, in particular through (a) collaborative creation workshops, where TC communities are facilitated in the definition of the craft roles, traditions, and contextual elements of the craft, and (b) ethnography to comprehensively document the crafting processes is proposed. Practitioners explain and demonstrate the making of artifacts, identify the required skills to do so, and recommend a teaching or demonstration process. Communities and CH professionals explain the history and social context of a community and the traditions followed within and along with craft practice. Preparation includes stakeholder mapping to identify stakeholders and identify the pieces of information to be sought from each stakeholder group.

Understanding craft practice requires the identification of at least the following types of concepts and their appellations. Physical items are materials, artifacts, and manufacturing tools or machines, protective or traditional clothing, and workspaces. Actions refer to the transformation of materials into intermediate or final craft products. Quantitative data include the measurement of quantities relevant to craft practice such as the amounts of materials, number of workers, as well as production and economic figures. Narrations and stories of direct relevance to craft representation are collected. They are selected based on the historical events that have influenced the history and economy of social groups, technological advances, and artistic movements relevant to the craft of study. In [34], ways to identify pertinent topics are proposed.

The output of this task is preliminary documentation, in the following forms. For the crafting process, a vocabulary of (a) physical items (i.e., products, materials, tools, and machinery) and (b) crafting actions for the transformation of materials into products. For the craft context, a collection of narratives pertinent to the (a) evolution of the craft's genre

and technological evolution and (b) the social and historical context of the practice of the particular craft instance at a place and/or by a community. Stemming from the above, a catalog of recording, or digitization, of targets is prepared, for the next task. Optionally, objects of historic or symbolic significance to the story of a craft can be appended to the digitization targets. For all of the above, references to sources where each piece of information was discovered are included.

### 3.2. Recording

This task concerns the recording of objects (endurants) and events (perdurants). Recordings of endurants are photographic documentation and 3D digitization. Event recordings are acquired through audio, video, and 4D reconstruction. The digitization also includes contextualization items, literature, and other information-carrying media, e.g., documents, technical drawings, images, and audio recordings. The digital assets are associated with technical metadata to interpret them appropriately as computer files. The multiplicity of types is facilitated by the concept of digital assets, which are linked to the knowledge base independently of their file type and storage location.

#### 3.2.1. Endurants

Items of interest are materials, tools, machines, products, information carriers, and sites that are related to the craft practice and its context. The conventional recording of endurants is through photography and 3D reconstruction. Comprehensive guides in the photographic recording of CH artifacts and sites are recommended for this purpose [35,36]. For 3D documentation, in [37] the data processing pipeline is comprehensively explored, along with recommendations for the use of conventional digitization modalities. The digital assets are images and 3D models of structure and appearance, typically encoded as 3D textured meshes.

The digitization of endurants regards structures of a wide variance of spatial scales, in indoors and outdoors environments. The choice of 3D scanning modality depends on subject size, material, and environment type. Often digitization employs multiple scanning modalities, each operational in a specific scale or environment. Rooms and outdoor areas require the combination of laser scanning and aerial photogrammetry to systematically cover. For smaller artifacts, photogrammetric reconstruction and active illumination sensors are nowadays simple and widely accessible. In [38], an approach to the full scope of 3D data curation through the collection, processing, archiving, and distribution from multiple modalities is proposed.

In some cases, the historic or artistic significance of artifacts requires their meticulous digitization for conservation purposes. In other cases, as in the case of ordinary tools, it is only the structure that is of importance to the representation and a less detailed model may suffice. In most cases, post-processing is required when using multiple scans, to spatially register them and harmonize their appearance.

#### 3.2.2. Perdurants

Digitization of perdurants mainly regards the craft practice and archive data regarding demonstrations of extinct techniques or documentary recordings of historic events. The collection of the latter follows the conventional practices of linked audiovisual data in the semantic web.

For craft practice recordings, the events of interest are practitioner postures and gestures. The digital assets are audio, video, and 4D motion recordings, which we call “animations”. The applicability of MoCap and video modalities depends on the type of environment. Inertial MoCap is more suitable than optical in the cluttered space of workshops, due to reduced installation requirements and independence to occlusions. For the digitization of motion using video, markerless visual methods are employed [39]. Albeit significantly less accurate than MoCap recordings, they require solely a camera and are the only way to treat archive video.

### 3.2.3. Parts

Objects and animations have parts of individual importance. For objects, spatial regions may be associated with meaning, e.g., a symbol, or an affordance, e.g., a handle. Human motion is interpreted in actions, gestures, or postures per body member. The articulation of static or dynamic scenes in, respectively, spatial or temporal parts, contributes to the analysis of the recorded object or activity. To facilitate the segmentation of animation recordings into body postures and gestures, an editing tool was developed [40].

### 3.3. Technical Implementation in the MOP

The collected digital assets are linked to the knowledge base as “media objects”. These recordings are abstracted as media objects when inserted in the knowledge base. Media objects are the way the MOP treats digital assets. New digital assets that are not web resources, i.e., new media objects, are made such by uploading them to the MOP repository, associating them with new URIs, 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 similarly treated, albeit their storage location is transparent to the user.

Though digital assets are abstracted in the MOP, the format in which these are encoded is relevant to the sustainability of their digital preservation. In this respect, it is important to use open formats and provide metadata on digitization parameters, so that they are convertible to future ones.

## 4. Step 2. Knowledge Elements

The basic elements of the craft representation are instantiated. These elements are the conceptual entities identified in Step 1. For crafting dimensions, these are the materials, objects, places, actions, and products involved and can be found in the vocabulary and storyboard. For contextual dimensions, these entities are the places, persons, events, and objects mentioned in the collection of contextualization narratives. The types of the basic knowledge elements are Product, Person, Material, Object, and Event.

The instantiation of knowledge elements refers to the creation of a record for each via the assertion of semantic metadata and relations, as well as the linking of digital assets. Thus, knowledge elements contain curated information encoded as knowledge statements and links and their instantiation is a digital curation task. The user task includes the selection of the entity type, the provision of the semantic metadata for that entity, and the linking of digital assets relevant to the entity.

### 4.1. Conceptual Usage

To introduce the conceptualization of knowledge elements and our event-oriented representation, we present two examples. The first regards a contextual event and the second a crafting event.

The first example illustrates the event of a building acquisition, which hosted a craft workshop that we study. The building was built by its original owner and then sold to another person. The building was an equipped textile manufacturing workshop. In Figure 2, we illustrate the digital assets gathered from Step 1. To instantiate 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 entities 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 is referred to by other entities, besides the event which we study, such as the construction of the building or its renovation (shown only for illustration). The figure also illustrates the use of the geographical database of GeoNames. Given the association of this location with Krefeld, it is possible to reason that this location is in Germany and Europe. Finally, the figure illustrates two more events (the construction and a renovation

event), which are implicitly related in the knowledge base, through the location and the participants.

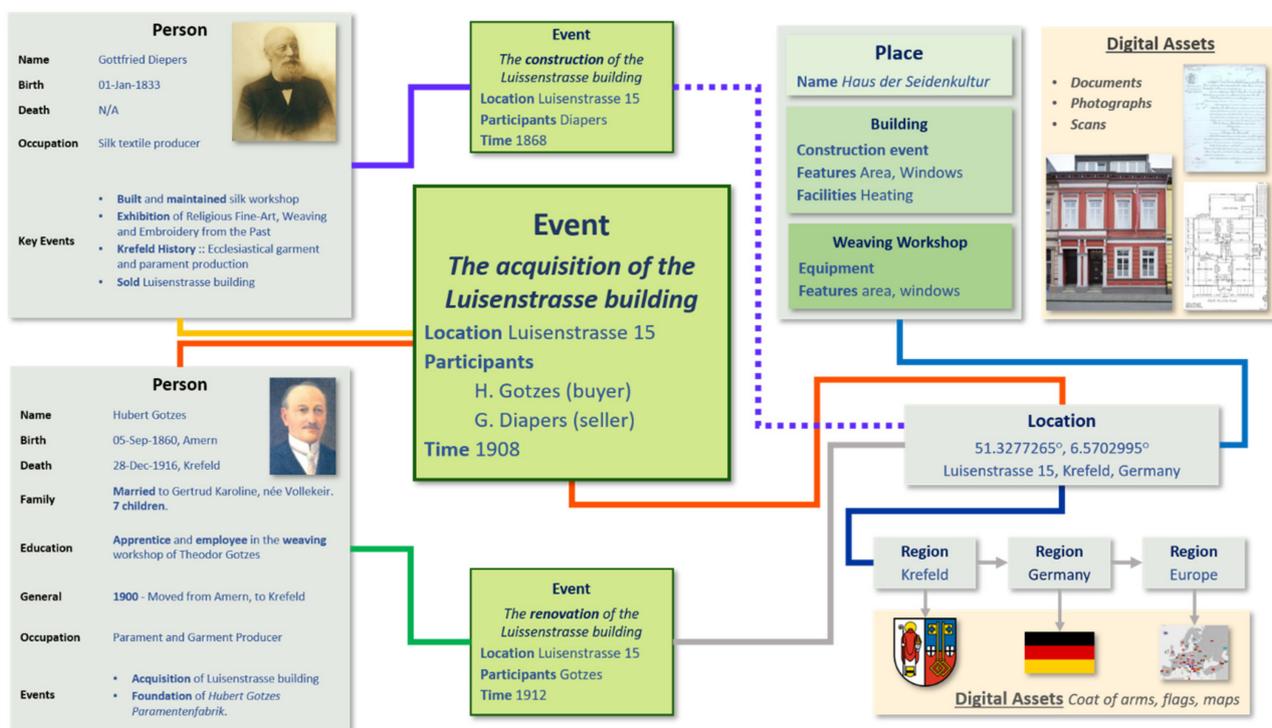


Figure 2. Illustration of the representation of an event and related knowledge elements.

The second example is illustrated in Figure 3 and comes from the glassblowing craft. 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.

#### 4.2. Basic Knowledge Elements

Each knowledge entity has one unique system handle, which can be in any language. Each entity may have an arbitrary number of appellations to support multiple languages and idioms.

##### 4.2.1. Events

Following [28], we call events the changes of state in cultural, social, or physical systems brought by phenomena or influenced by other events. In the ontology, events are instances of class E5 Event. We are interested in two types of events, which are used as the building blocks of contextualization narratives and crafting processes. Respectively, they are called “contextual” and “crafting” events and are used to represent changes in (a) social, technological, and economic systems and (b) materials that are transformed into craft products, respectively.

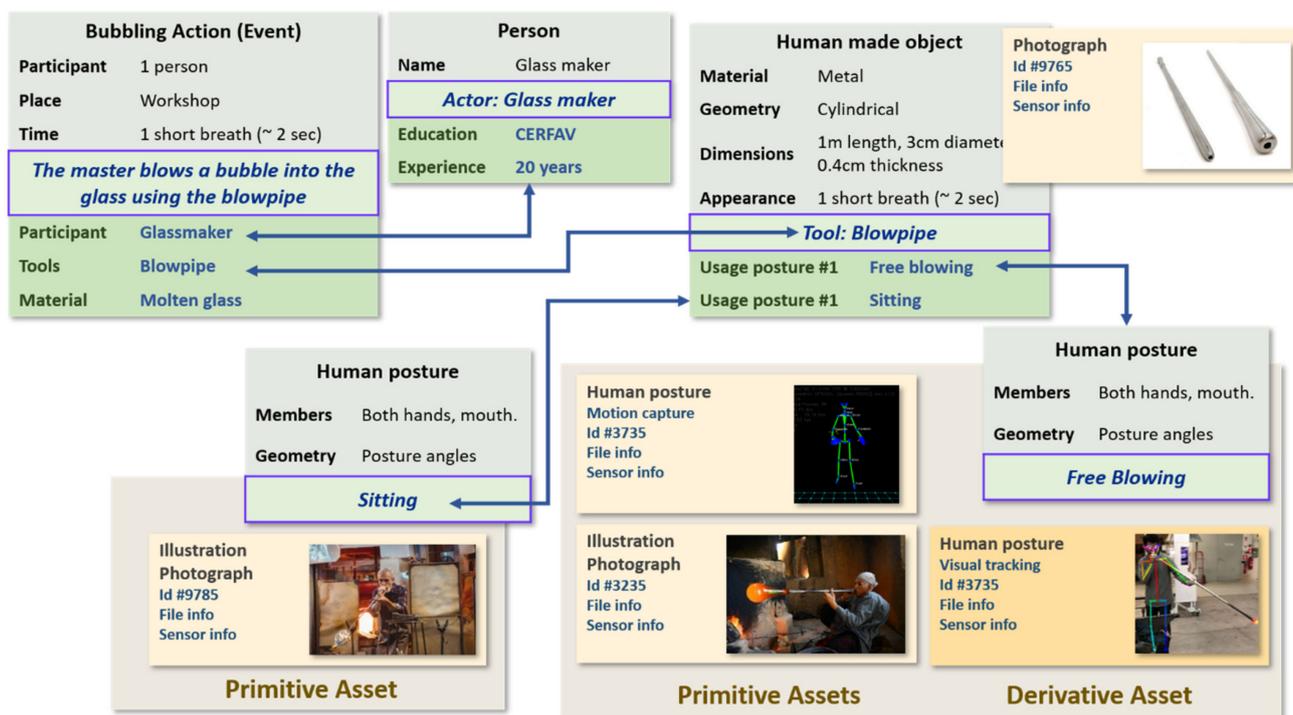


Figure 3. Illustration of a representation of a craft action.

Events are organized in the ontology by three types of relations: (1) Mereological, relating events as parts of other events. This allows the hierarchical organization of events in a coarse-to-fine detail analysis. (2) Temporal, enabling the representation of the order or simultaneous occurrence of events as described by Allen’s temporal logic [41]. (3) Causal, relating events that in normal discourse are predicated to have a cause–effect relationship in the curator’s opinion.

Events may relate to an arbitrary number of places, objects and locations. Persons and social groups are related as participants to the event. Places are related to the place(s) of occurrence. Objects and materials may be used or produced in the event.

#### 4.2.2. Materials

Materials extend class E57 Material. In our ontology we extend the class with an optional Place attribute to represent the material origin, which can be relevant to the quality, reputation, authenticity, and cost of the produced craft article.

#### 4.2.3. Objects

Objects are used to represent craft products, tools, machines, and other objects of historical significance in craft contextualization. Both extend E22 Man-Made Object. Pertinent digital assets, such as photographic and 3D documentation, are associated with the entity. The entity contains optional links to the Materials that compose it as well as a Place for its location. Through the representation of the crafting process, craft products can be associated with the crafting process, its place of occurrence, and the practitioner(s) involved in the process.

#### 4.2.4. Places

Places extend class E53 Place and may contain one or multiple links to geographical locations. For crafting processes, both the geographical location and type of the place are of relevance. The geographical location is relevant to the origin of materials or the manufacturing site of craft products. The classification of places is of relevance to represent the type of place where crafting processes occur, such as a workshop or a harvesting

site. For contextualization narratives, geographical locations enable the documentation of historical events. In addition, some places may be imaginary, as in legends or tales, and are not associated with a geographical location. The implementation is integrated with a database of location names [42], which provides geographical coordinates and hierarchical organization of locations into cities, regions, and states. The definition of arbitrary, user-defined locations is also supported.

#### 4.2.5. Persons and Social Groups

Person entities extend class E21 Person and are used to refer to individuals. Social groups refer to organizations of individuals and extend E74 Group. In process representations, persons and groups are used to represent individual practitioners and workgroups. Specific individuals are of relevance as participants in crafting processes. Furthermore, persons are semantically classified as to their role in that process. In narrative representations, person and social group entities are used for historical figures and social groups, such as companies, parties, guilds, or art movements.

#### 4.3. Technical Implementation in the MOP

In the MOP, dedicated forms for the composition of knowledge each knowledge element type are implemented, as supported by the CrO. Several efficiency facilities are provided for the interlinking of digital assets and locations. For all knowledge elements, their semantic annotation using the Getty Arts and Architecture Thesaurus [43], the UNESCO Thesaurus [44] and, optionally, additional thesauri from National Documentation Centers. For location names, we have integrated a geographical reference [42].

### 5. Step 3. Representation

The entities represented in Step 2 are related to craft representation. This includes the representation of pertinent crafting processes and contextualization of events contributing to narratives. Both representations are comprised of events organized by relations. Crafting events occur each time an individual, handcrafted product is made. We say that all the expressions of a particular crafting process follow the same schema. In this step, this schema is represented according to [10]. The schema of the classes introduced in this section is elaborated in Appendix A.

#### 5.1. Fabulae

Craft context representation is based on the collection of narratives defined in Step 1. For this purpose, we adopt the computational treatment of narratology proposed in [30]. Central to this approach is the term “Fabula”, which denotes the series of events that make up a narrative, in chronological order. The Fabula may contain parallel and simultaneous events but has only a single version.

Each narrative is individually modeled, using the events that comprise its Fabula and which were created in the previous step. Common events can be shared across fabulae. Events are linked inside the Fabula by mereological, causal, and temporal relations. Mereological relations are important to analyze complex events into simpler ones. Causal relations encode the curator’s account of events. The Fabula of each narrative is instantiated using the MOP.

#### 5.2. 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 [45] to unambiguously encode process schemas. The visual nature of activity diagrams facilitates the collaboration between technical and heritage partners.

Following the conceptual segmentation of the crafting process created in Step 1, process schemas are analyzed 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.

### 5.3. Technical Implementation in the MOP

The process schema is transcribed into a semantic representation, using the MOP. The authoring of both process schemas and fabulae is supported by the MOP. In Figure 4, the initial panels for authoring a Fabula and a process schema are shown. Detailed information on Narrative authoring is provided in [9], while the semantic representation of process schemas in the MOP is covered in depth in [10].

**Glass schema**

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 1. <a href="#">Blowing and Shaping</a>	0
1. <a href="#">Blowing and Shaping</a>	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 2. <a href="#">Leg and foot laying</a>	5
2. <a href="#">Leg and foot laying</a>	The leg and the foot of the carafe are constructed.	Leads to 3. <a href="#">Transfer to punty</a>	3
3. <a href="#">Transfer to punty</a>	The glass body is transferred from the blowpipe to the punty.	Leads to 4. <a href="#">Cervix refining</a>	3
4. <a href="#">Cervix refining</a>	Cervix is refined.	Leads to 5. <a href="#">Cord laying</a>	0
5. <a href="#">Cord laying</a>	A glass cord is laid for decoration.	Leads to 6. <a href="#">Beak cutting</a>	4
6. <a href="#">Beak cutting</a>	Creation of the beak.	Leads to 7. <a href="#">Handle laying</a>	3
7. <a href="#">Handle laying</a>	The glass handle is created by laying.	Leads to 8. <a href="#">Finishing carafe</a>	3
8. <a href="#">Finishing carafe</a>	The carafe is finished for stability.	Leads to 9. <a href="#">Annealing</a>	3
9. <a href="#">Annealing</a>	Controlled cooling of glass a heat avoids the formation of cracks, increases its ductility, and reduces its hardness.		2

**Fabula Details**

View | Authoring | Timeline | Annotations

How to fill-out this form

- All fields of this form are optional except name of fabula. You can fill out as much information as needed.
- Always click the 'Save Changes' button before leaving the form, or your changes will be lost.
- Use the delete button on the right of a field if you want to clear the entered entry and input new information.

Fabula name\*  
History of Haus der Seidenkultur

Description  
This fabula is about History of Haus der Seidenkultur

Fabula Event

- The purchase of the building in Luisenstrasse 15
- The restoration of HfS building
- The first appearance of HfS building
- The building no. 4 in the Mariannenstrasse was recorded as being undeveloped.
- The building no. 4 in the Mariannenstrasse belonged to the business premises of Dieters&Reeve
- Select fabula event here...
- Hubert Gotzes worked as an ETGP at Krefeld.
- Gotzes Parlamentenweberl - Acquisition of the house at Luisenstrasse 15
- Birth of Hubert Gotzes Jr
- Death of Hubert Gotzes Jr
- Birth of Jakob Theodor Gotzes

**Figure 4.** Left: editor for an ordered list of actions that comprise a glassmaking process. Right: Fabula authoring form, showing a list of events that can be linked to the Fabula.

## 6. Step 4. Narratives

Narratives are authored and semantically represented. Narratives implement the ways that fabulae are presented or narrated. Contextual events are used in narratives and are events that have occurred in the past. Narratives are represented following [29,30]. In [9], these ideas are implemented in the MOP.

### 6.1. Narratives

Narratives implement the ways that fabulae are presented or narrated. A narrative may have multiple narrations. Each narration contains references to events of the Fabula in some particular order that is not necessarily chronological. Individual narrations may differ because we wish to present them in multiple ways, for various audiences, and through a multitude of presentation modalities. Individual narratives may focus on particular subsets of the Fabula. Each narrative contains a reference to a Fabula and a reference function that determines the order by which events in the Fabula are narrated. In this way, knowledge elements and digital assets associated with the event are accessible to the narration. Individual narrations of a narrative may be adapted per language, age, or special needs. Last but not least, narrations may differ due to their adaptation to the format of the presentation medium, whether it is audio, visual, textual, or multimodal.

To represent the orchestration of stimuli presented during a narration on a particular medium, we introduce the class of Presentations. For each event referenced by the narration, a presentation segment is authored. This segment contains the links to the digital assets to be presented during the narration, or their spatiotemporal arrangement. Authoring presentation segments is facilitated by the MOP, through the retrieval of knowledge entities and digital assets.

### 6.2. Processes

Processes are comprised of the events that occurred during the crafting process. If these events conform to a process schema, we identify it as 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.

Like a Fabula, a process contains a reference function, which identifies and chronologically orders the events that occurred during its execution. Likewise, the knowledge entities and digital assets linked to these events are available for the presentation of the process. The digital assets are recordings of the events that took place and the digitization of the objects involved in them.

### 6.3. Technical Implementation in the MOP

Multiple media can be employed in the delivery of process and narrative presentations, starting from verbal and visual and reaching up to immersive and interactive narrations. The authoring of presentations in segments that follow the narrative events and crafting process steps is facilitated by the MOP, which retrieves the knowledge elements and digital assets in pertinence to each event.

The presentations entail the spatiotemporal orchestration of stimuli for each segment, in individual media channels. Authoring of narrative and process presentations is relevant to the medium, as it imposes requirements and constraints on the format and content type. The MOP provides native support for web pages, verbal narrations, and audio guides. Figure 5 shows the primary form in the MOP for creating a narrative based on a Fabula or process schema and the way that events are presented within the Fabula.

Home > Silk > Events List > Local History :: Ecclesiastical garment and parament production

## Event Details

View **Authoring** Related media objects

Home > Silk > Narratives > The story of Hubert Gotzes' company > Narration: Narration of Hubert Gotzes Company

### Narration: Narration of Hubert Gotzes Company

View **Authoring** Narrative preview

**Tip**

- Always click the "Save" button before leaving this form.
- When finished with authoring this narration, click on the view page to add its presentationId.

Narration name\*

Description

This narration is about Hubert Gotzes' company that was famous for the production of textiles in Krefeld, Germany

Related media object

[+ Create new](#) [+ Add related media object](#)

**Event name** Local History :: Ecclesiastical garment and parament production

**Description** The Krefeld textile industry and trading companies provided all the services and materials required to manufacture ecclesiastical fabrics: colour-fast yarns, equipment, design drawings workshops, point paper designs and punched cards to weave patterns. The influx of Catholic workers from the surrounding region meant that many new churches were constructed in the new districts on the outskirts of the town towards the end of the 19th century and beginning of the 20th century and consequently the demand for ecclesiastical textiles was high. Orders were completed quickly despite the complicate handicraft involved. Depending on the pattern, a weaver could weave the fabric for a priest's vestment in two to five days on average. Velvet brocade took more than 10 days. The fabric was then cut out, sewn together and embroidered so that the order was completed within 2 to 3 weeks. The Krefeld producers of ecclesiastical textiles had a good reputation for their very high quality products and for the colour fastness of the fabrics.

**Start date** 01-Jan-1790

**End date** 01-Jan-1980

**Event was influenced by another event** [Krefeld Textile Industry :: The shift to silk](#)

**Occurred during another event** N/A

**Event participants**

- [Krefeld Textile Industry \(role: Participant\)](#)
- [The von der Leyens \(role: Participant\)](#)
- [Hubert Gotzes Paramentenfabrik \(role: Participant\)](#)
- [F.J. Casaretto \(role: Participant\)](#)
- [Franz Johann Joseph Bock \(role: Participant\)](#)
- [Gottfried Diepers \(role: Participant\)](#)

**Getty information** N/A

**Location** Crown Prince District



Lat: 51.33645 , Long: 6.55381

**Related Images**



Figure 5. Configuring narration content and parameters.

## 7. Step 5. Presentation

Craft presentations are built on top of events and event schemas referenced through the narrative and associated with knowledge elements and digital assets, which can be retrieved to illustrate the narration. Narrations are associated with events and, in turn, with knowledge elements and media objects. Alternative presentations of these narrations are enhanced with objects and actions reproduced in 3D, in a virtual environment. In this environment, human action is re-played from motion recordings by animations performed by virtual humans. In this way, the human motion and handling of tools and machines can be seen from multiple viewpoints and better understood.

For all the presentation modalities of this step, 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. Machine interpretability offered by the MOP ensures that the collected knowledge and digital assets can be accessed through third-party applications. 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 motion-driven narratives that can be queried and systematically accessed by software clients.

### 7.1. Basic Presentation Modalities

#### 7.1.1. Place-Oriented Presentation Modalities

The presentation of environments is facilitated by spatial presentation modalities. The geographical organization of narratives in Step 4 can be directly utilized in presentation modalities oriented to the presentation of geographical and spatial information. Spatial representations are enriched with locations of interest that are associated with knowledge elements in the CrO 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.

For large-scale representations, map-oriented presentation modalities at the same scale but relevant to the local environment and its resources 3D geophysical maps are

proposed [46]. This is demonstrated through the implementation of two modalities. The first is an immersive projection room and its standalone PC version that overviews 3D environments, interactively navigating from bird-eye viewpoints (see Figure 6a). The second is a lightweight presentation of a 3D geophysical map in mobile platforms (see Figure 6b).



**Figure 6.** (a) Immersive projection room. (b) Geophysical map in mobile devices.

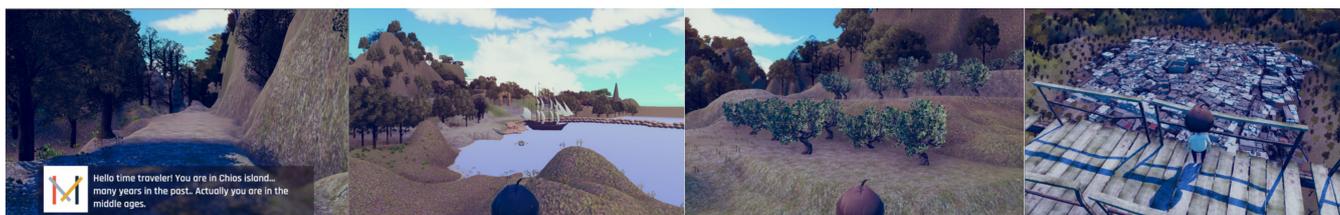
For inspecting or navigating through 3D environments, a 3D virtual reality (VR) viewer can be employed whether on the computer screen or through an immersive visualization system (i.e., wide-projection, VR headset). In particular, software that produces video output for a predetermined walkthrough of the virtual camera in the 3D environment is required. The primary video can then be enhanced with narration, subtitles, music, etc. This is demonstrated by the two examples below. The first regards the craft of dry stone walling [47]. In the example, traditional settlements for moving husbandry [48], which were built by dry stone walling, are 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 (see Figure 7a). 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 (see Figure 7b).



**Figure 7.** (a) Dry stone walling; (b) mastic villages at Chios.

### 7.1.2. Virtual Exploration

More complex presentations can be implemented through a virtual exploration of the natural environment from a terrestrial viewpoint enhanced with 3D reconstructions of heritage sites and landscapes. This is demonstrated by a 3D game [49]. 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. Digitized rural environments are also important to the realism of such application. The game is enriched by re-using the digital representations of garments, machines, and original tree structures that were acquired from the Mastic Museum at Chios (see Figure 8).



**Figure 8.** The Chios exploration game.

### 7.1.3. Virtual Exhibits in Real Places

Virtual museum modalities present collections of digital assets in a physical space, bearing in mind that (a) several museums have a large collection of artifacts in their storage, but no room to display them, and (b) to represent past period exhibitions, to virtually re-visit them, after they have ended. This is demonstrated by virtual museum applications both through the web and physically installed in the museum space (Figure 9).

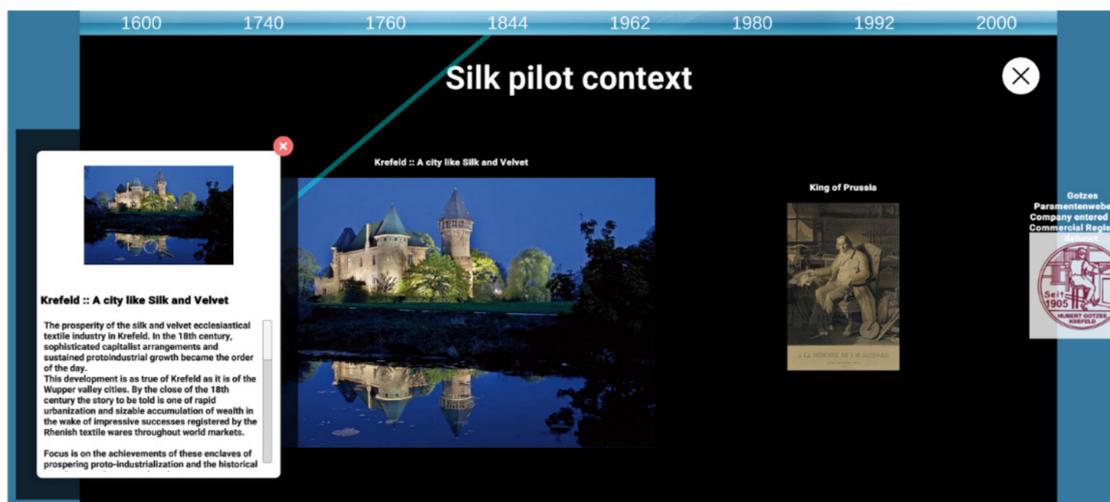
### 7.1.4. Virtual Storytellers

Virtual storytellers enhance the museum visit with narrations of the life and events of people from the craft community. This is demonstrated by enhancing the factory space of the Mastic Museum of Chios with eight virtual humans, workers of the factory that narrate their life and stories [50] (Figure 10).

## 7.2. Narratives

### 7.2.1. Web-Based Narratives

The primary presentation method in the MOP is a form of documentation that maps the contents of a craft representation and provides an overview of the craft and its context. This is provided as a digital, online presentation that provides initial orientation on the craft and its context in the form of an introductory narrative, which provides an overview of the craft instance, in an overview narrative. From this presentation, all narratives, assets, and events are available in multiple views. Such views are temporal (timeline), geographical (map-based), event-based (calendar), object-based (galleries of artifacts, tools, etc.), person-based (galleries of key actors), and so on. All of these are available through “templates” in the MOP [9]. The authoring and presentation of Web-based narratives through the MOP are presented in depth in [9]. An example is shown in Figure 11.



**Figure 9.** Physical and web-based virtual museums.



Figure 10. Virtual human storytellers in the museum.

Narration: Narration of Ecclesiastical Fabric Weaving in Krefeld

View Authoring Narrative preview

### The story of Ecclesiastical Fabric Weaving in Krefeld

**Narration**  
 Narration of Ecclesiastical Fabric Weaving in Krefeld

**Presentation**  
 The Ecclesiastical Fabric Weaving in Krefeld

#### The Ecclesiastical Fabric Weaving in Krefeld

The settlement of religious refugees in Krefeld as stimulus for church textile production

Krefeld began to develop into one of the most important silk metropolises in the German-speaking territories in the 17th century. One reason for this was the fact that many religious refugees settled in and around the town which formed part of the territory ruled by the House of Orange under which the town received the status of a "religious asylum".

The transition from linen weavers to silk industries

Many of the Mennonite families which move to the town were linen weavers, spinners, merchants and employers of weavers. At the beginning of the 18th century linen weaving was increasingly being replaced by silk production, a development which was also supported by the government. Silk fabrics being luxury articles were in greater and greater demand and due to the influx of specialists, in particular from France, the quality of the fabric continuously improved. The silk industry in Krefeld experienced its biggest boom in the mid 18th century. Krefeld became Germany's silk town. Some companies specialised in certain products, for example, velvet weaving, heavy-weight and light-weight, patterned and plain silk fabrics. One special field was ecclesiastical textiles.

The contribution of F.J. Casaretto

In Krefeld one of the first producers of textiles for the church was F.J. Casaretto, descendant of an Italian silk weaving family who moved to Krefeld in the 18th century. Casaretto was a Catholic entrepreneur in the silk weaving sector which was dominated by Protestants and Mennonites and it was the daughter of the main church St. Dionysius, Franz Beck, who persuaded him to venture into this unfamiliar sector and start to make his own contributions on historic patterns. The company set up in 1842 presented its new "ecclesiastical fabrics" to a wide public in an exhibition of religious art organised by Beck in 1852. The company situated on the "Garten" subsequently set up a fabric workshop in order to offer clients the finished liturgical vestments. Casaretto even exported his products to the Netherlands, Belgium, Switzerland and Austria.

**Related Events**

- 1687 - Mennonites arrived in Krefeld
- 1785 - The invention of the first mechanical loom
- 1842 - Foundation of Casaretto's Company
- 1852 - Exhibition of ancient masterpieces of Christian art
- 1887 - Exhibition of Religious Fine-Art Weaving and Embroidery from the Past
- 1905 - The foundation of Hubert Gotzes company called "Hubert Gotzes Paramententwerk".

**Key Actors**

- Franz Johann Joseph
- Georg Friedrich Dierker
- Hubert Gotzes
- Jakob Theodor Gotzes
- Karl Mathias Gotzes
- Mevardts inheritance L.
- Edmund Corthwight
- F.J. Casaretto

**Hubert Gotzes' image**

**Timeline**

1600 1650 1700 1750 1800 1850

**Map of events**

Figure 11. Web-based narrative presentation.

7.2.2. Augmented Physical Artifacts

Object-oriented presentation modalities can occur by enhancing contemporary TCs objects with digital stories that bind them with history, society, traditions, and values. Such stories can support new interest in TCs objects by enhancing their meaning, value, and uniqueness. This is demonstrated by a handbag that stands both as a woman's accessory and as a contemporary craft creation that can be experienced to reveal its unique history and identity [51] (see Figure 12). The handbag is augmented by an augmented reality (AR) application that is providing three layers of pattern recognition. The first layer shows the bag which has its own story, its creation. The second layer has multiple patterns which reveal the story of textile weaving in Krefeld. The third layer shows that the stories of the patterns have a story of their own.



Figure 12. A handbag acting as a storyteller.

### 7.2.3. Mobile Clients

Mobile devices can provide access to the represented knowledge before, during, and after a visit to a craft-related heritage site. Presented information includes textual narrations, events, videos, images, 3D reconstructions associated with the location, and serious games to present craft processes and techniques (see Figure 13).



**Figure 13.** Mobile client presenting a narrative on mastic cultivation.

## 7.3. Processes

### 7.3.1. 2D Presentation of Actions

Two-dimensional visualization of actions is particularly useful for conveying motion and instructions on the printed matter [52] and physical surfaces, opening a wide avenue of applications that involve physical objects and surfaces (i.e., mixed reality). Our approach is to use useful concepts from the world of art, in the world of motion visualization. Our goal is to utilize the insight that such visualizations provide to efficiently create meaningful visualizations of human motion, on 2D media. The reason we choose art for this purpose is that artists have long studied the perceptual appeal of motion visualization methods over centuries of experimentation. Painters, illustrators, and directors use motion lines, contrast, and superimposition and juxtaposition of visual frames to facilitate the mental recreation of the depicted motion by the observer. Abstractions, such as motion lines, provide insight into understanding the motion.

To ease this user task, the MotiVo computer-aided authoring system for the visualization of human motion was developed [53]. MotiVo is an authoring system that simplifies the process by offering several visualization tools as integrated components. Using those tools, motion is visualized by parameters, such as the blending of key poses of activity, the visualization of motion trajectories, the application of image filters to visualizations and their combinations. Using MotiVo illustration on glassblowing was implemented, which presents a carafe glassmaking process in the form of a graphical story, enriched with verbal content and visual annotations [54] (see Figure 14).

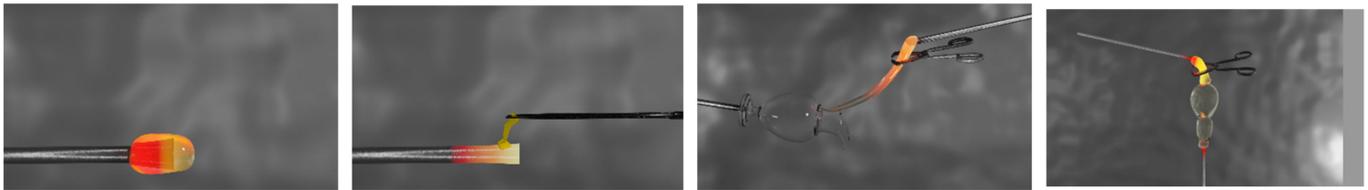


**Figure 14.** Illustrated demonstration of glassblowing.

### 7.3.2. 3D Presentation of Actions

Virtual humans can be used to present craft processes, as well as to demonstrate tool and machine usage. A motion vocabulary item is used to represent an instance of a specific motion segment. These items can be combined and interleaved to represent entire procedures and are considered building blocks of a motion vocabulary. This vocabulary can, in turn, be used to create “sentences” that encode actions and procedures. The vocabulary

can be demonstrated through visualizations of practitioner actions and abstractions of tool usage configurations [55] (Figure 15).



**Figure 15.** Intuitive visualizations of practitioner actions and techniques of glassblowing.

### 7.3.3. Skill Acquisition and Training

First-person acquaintance applications introducing basic skills are implemented, which will allow the manipulation of virtual and real objects and tools. Craft gestures that include tool handling are valuable for training purposes. The interactive training session may occur in the physical or digital environment. This can be demonstrated through a mixed reality installation at the museum of CNAM and in VR using controllers to enable the grasping and handling of tools and with the usage of the actual tools and real-time feedback on craft actions [55] (Figure 16).



**Figure 16.** Mixed reality training on glassblowing.

Training, in this case, refers to the handling of tools for cultivating and harvesting a mastic tree (see Figure 17). The game was built on top of a VR training SDK [56] and guides the player through the process with instructions. The player has then to select the appropriate tool and follow the instructions on how to use it to complete the task at hand. In the example, the task includes cleaning the soil under the tree (left) and creating incisions at the highlighted locations on the tree trunk (right).



**Figure 17.** VR training for mastic cultivation.

## 8. Step 6. Preservation

Supporting access and acknowledging CH related to TCs is the first step towards its preservation. TCs have traditionally been associated with individual practitioners, as well as with part-time activities or family businesses. Nowadays, many individually trade their craft products online. The simplification of learning and digitization of promotional

content support the operation and encourage the foundation of small enterprises. Thematic tourism makes use of engaging content, experiences, and training, and can enhance the sustainability of TCs.

### *8.1. CHIs and CCIs*

The sharing of digital assets and knowledge on TCs provides a resource for researchers and the general public, by availing the opportunity to makers and communities to promote their work. Narratives create new content, stories, and experiences, for content owners, craft makers, and TC communities. Corresponding applications raise interest in broader audiences, including the general public, visitors, tourists, and prospective apprentices. Storytelling and mobile technologies and installations provide comprehensive and captivating TC presentations. Benefits for CHIs and CCIs are the re-use of digital assets in new content and new presentations on TCs, and new ways of appreciating and experiencing TCs, which are important in reaching new collocated and distant audiences.

### *8.2. TC Education and Training*

TC training is important, as the ability to teach a TC enables its preservation. Off-site training can be facilitated through the MOP. Corresponding applications show how TCs have been practiced, and include insightful annotations of digital assets, such as illustrated instructions and motion summarization. On-site training is implemented by mixed reality installations and mobile devices where visitors are introduced to a TC through practical tasks, craft gestures, and the use of tools.

In Craft Centers, Maker Spaces, and FabLabs, TC practitioners and LHTs are engaged in the physical making of artifacts to reconstruct lost information on the making of artifacts, when no documentation or testimonies are available anymore. Re-creation of techniques on artifact making or material treatment can be captured, documented, and evaluated as the potential implementation of techniques, shedding light on lost knowledge on craft processes. Educational applications on TCs can contribute to contemporary issues of craft education [57]. In this work, a first step is taken by offering well-documented, introductory TC training experiences, to raise interest and attract potential apprentices.

### *8.3. Thematic Tourism*

The wealth and variety of expressions and forms of ICH are steadily becoming a principal motivation for travel around the world. Many forms of cultural tourism are associated with a longer duration of stay [58]. The UN World Tourism Organization (UNWTO) recognizes that an important challenge lies in identifying, protecting, and safeguarding ICH by investing in sustainable tourism development, in consultation with local communities and other stakeholders [59]. In line with the Faro Convention, the value of TCs in “sustainable development, cultural diversity and contemporary creativity” [60], means that profits will contribute and motivate the preservation of TCs.

## **9. Case Studies and Lessons Learned**

We have applied the proposed protocol in three case studies. For each, an online presentation pilot showcasing the obtained representation was developed. In addition, for each pilot, several installations were developed showcasing the craft in CHIs.

### *9.1. Glassblowing*

Glassblowing combines hand and body gestures, the sense of gravity, and a thorough understanding of the material viscosity. Glasswork is a challenging craft because, during production, glass changes state from liquid to solid and vice versa, posing handling requirements. We use glasswork to study dexterous aspects in tool manipulation. The online presentation of this case study can be found in [61].

Results were deployed in the context of a periodic exhibition at the Conservatoire national des arts et métiers (CNAM). A dedicated space at the cathedral, which is part

of the museum, was dedicated to the exhibition. For training, a bench was installed in front of the main display together with a glassblowing pipe to be used by visitors. A digital application was installed dedicated to craft training. This application enables users to mimic craft gestures using the tools and the bench. The scenario that was set up was that the presentation application sequence is executed first and then the main projection switches to the craft training applications so that users test what they learned from the craft presentations. The installation is described in detail in [55].

### 9.2. Silk-Weaving

Weaving is one of the oldest crafts developed by humans. Due to the industrial importance of textile manufacturing, there exists an extensive literature on weaving techniques. Thus, in this case study, we focused on the challenges of modelling the rich social and historical context of this particular craft, as well as finding modern and appealing uses of traditional textiles and motifs. The online presentation of this case study can be found in [62].

The historic context regards protoindustrial Germany and how the religious asylum that Krefeld offered to victims of religious prosecutions in the 17th century eventually made Krefeld an industrial center. The story is told through the evolution of one of the oldest companies in Krefeld, the “Paramentenweberei Hubert Gotzes Textilien”. The workshop of that company is now an industrial monument called Haus der Seidenkultur and is operated by volunteers that preserve the craft for posterity. The application is oriented in ten spots in the museum, each one connected to a narration that is accompanied by an audiovisual presentation. From a technical perspective, the narratives are retrieved by the MOP. Narrations by virtual humans enhance the presentation of narratives [63]. Details on the installation can be found in [64].

To investigate the combination of traditional motifs and textiles in modern contexts, a contemporary accessory was designed, studying the historical motifs of HdS and transforming them into text-based narratives. This was in line with one of the most important goals of HdS, which is to raise awareness regarding the unique CH possessed by the museum and at the same time connect its legacy with history and tradition. Each motif is linked to a narrative. An AR application provides three layers of pattern recognition, through the camera of a mobile phone. The first layer regards the bag which has its own story, its creation. The second layer regards individual patterns on the handbag that reveal the story of textile weaving in Krefeld. The third layer is the traditional stories linked to the patterns. Upon recognition, these narratives are presented audiovisually to the user. Details on the implementation of the system can be found in [51].

### 9.3. Mastic

This case study explores an indigenous craft, practiced in the south of the Island of Chios, Greece, where a single type of tree has shaped the local trade, culture, and built environment. The resin harvested from the mastic tree is used for a wide range of products, mainly culinary, but also including skincare and medicinal. The knowledge of mastic cultivation, on the Island of Chios, is inscribed on the Representative List of Intangible Cultural Heritage of Humanity of UNESCO. The culture of mastic represents a comprehensive social event for the community which considers mastic as part of its identity. The online presentation of this case study can be found in [65].

The protocol presentation technologies were used to implement an interactive exhibition at the Chios Mastic Museum of PIOP. The main areas of intervention were the main exhibition space of the museum and the rural space outside the museum. In the main space of the museum, this work targeted the presentation of mastic processing. In the rural space of the museum, there is a mastic field with metal sculptures that represent everyday people in the mastic field. The exterior interventions regarded the usage of AR for the presentation of craft activities in the mastic field. At the locations of interest, virtual humans narrate life stories of daily life and work at the factory. One of the requirements of presenting the

craft was to display its seasonality. Visitors of the rural space outside the museum can experience mastic cultivation in the field through AR. An application recognizes metallic sculptures that exist in that space, which “come to life” and present mastic cultivation activities. Details of the installation can be found in [50].

#### 9.4. Replicability of the Proposed Method

Replicability can be judged from the application of the TC representation protocol in three use cases. In all cases, we were able to apply several scientific approaches for each step and combine the results in a single representation. This became evident both in the craft understanding phase, where several approaches to studying social and historic context were applied, and on the data collection step, where several scientific methods were used for data acquisition. Regardless of the heterogeneity of the results, the MOP has proven sufficient as a representation and no surprises were encountered on the representation of processes and narratives. Another supportive finding for the replicability of this methodology was that, through detaching the representation from presentation in this work, multiple presentation instances were created from different technologies. This was achieved by applying the exporting functionality of the MOP in the representation and leaving it to the developers of the presentation layers to judge the most appropriate way of facilitating the representation in their presentation context. Finally, the included web-based presentation modalities in the MOP allowed the direct preview and dissemination of the represented knowledge through the web.

#### 9.5. Lessons Learned

##### 9.5.1. Collaboration

One of the main challenges faced by the application of this methodology was the need for several scientific disciplines to work together under a unique methodological framework. This was indeed challenging since different scientific approaches, technical tools, and research methods were applied. In this challenge, we learned that the MOP as a single point of representation of research data greatly enhanced the collaboration of the team as it allowed different scientific disciplines to report and document results under a uniform semantic representation. Of course, several adaptations in terminology had to be made for the entire team to have a common understanding of the represented data.

##### 9.5.2. Iterative Refinement of the Representation

Linear execution of protocol steps meant that the entirety of digital assets would have been acquired a priori. However, knowledge acquired in the second step in some cases referred to non-digitized items, which were only then identified, and needed to be digitized as new digital assets in the context of the first step. Moreover, more sophisticated digitizations of assets were acquired later in the timeline of this work, judged so by CH professionals. Thus, the main lesson learned was that the linearity in these steps can be disrupted by refining iterations when needed. However, the methodology was found to be very adaptive to such iterations, considering that new needs resulted in the application of the previous steps only for the acquired assets and their context.

##### 9.5.3. TC Representation Protocol Steps

Lessons learned per application of each protocol step are presented below.

**Craft understanding:** TCs are deeply rooted in the social and historic context of the communities practicing them. Through history and archival research, many dimensions were discovered that led to the formulation of social and historic narratives. Furthermore, the TCs surprised us by revealing hidden dimensions spanning from art elements to historical and social findings. These largely affected both the work conducted in this phase and the consequent phases multiplying the representation and data collection needs.

**Data Collection:** Sometimes interest in an artefact may rise after its digitization, as when inspected more closely a digital asset may intrigue researchers to revisit to craft

understanding to acquire knowledge on the specific subject that was not covered. From a technical perspective, considering that several digitization technologies were employed we learned that in some cases specific requirements of a study could lead to the need for new digitization techniques.

**Craft representation and process representation:** In these phases, it was important for the team to evaluate the capacity of the online platform to represent the vast amount of knowledge acquired. This posed two major challenges. The first challenge was the curation time needed to represent resources, and the second was the expressiveness of the representation to address complex knowledge elements such as processes. Regarding the first, we learned that significant effort is required from curators and that training and help are needed. Regarding the second, close work of semantic experts, developers, and practitioners were required to conceptualize the representation, create the authoring facilities, and train on the transformation of ethnography to process representations. The adaptation to these requirements led to several redesign iterations of the MOP.

**Craft presentation and preservation** faced two main challenges. The first was to create online presentations of the acquired representation so as (a) allow researchers to build narrations on the acquired representation, (b) disseminate knowledge through the MOP, and (c) create online educational material and process representations. The second was to ensure compatibility of the knowledge base with external sources both in terms of linking to external sources and importing in knowledge standards such as CIDOC-CRM and EDM. The lessons learned regarded the quality of our representation, which was capable of supporting several online presentations of the represented knowledge. Furthermore, considering that the system was based on existing knowledge standards, disseminating the represented knowledge was as simple as creating semantic associations of CIDOC-CRM encoded metadata to other knowledge standards and creating a SPARQL endpoint to deliver knowledge in standardized formats.

**Preservation:** The main lesson learned was that having a knowledge base and a rich representation including digital assets greatly enhanced the capacity to deliver results that could be experienced by visitors of a CHI. We learned that content makes a difference, as engaging narrations created through the web platform were disseminated in alternative means and modalities targeting a wide range of uses including information, education, and entertainment. The separation of the representation from its usage allowed us to use a plethora of technical tools to create different forms of presentations, thus unleashing the creative powers of UX designers and developers.

## 10. Conclusions

A special type of knowledge included in crafts is “felt” [66], “tacit”, or “embodied” knowledge, or otherwise knowledge that is based on the sensory perception of practitioners and the understanding of tool and material affordances. 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 color of an object, which are exploited by a skilled practitioner. In the context of using the TC representation 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, acquired representations include the knowledge for craft re-enactment, through the meticulous representation of craft processes and techniques.

This work uses crafts as a first step to the digitization of intangible dimensions, such as purpose and causal dependencies, that are encountered in many vocational domains. The crafting dimensions explored in the context of TCs are not much different than the skills required by contemporary professions in which tools are used, such as mechanics, medicine, industrial assembly, electronic manufacturing, and others. The use of contextualization narratives can serve more demanding challenges, such as the representation of technological history, as well social and historical events and their influence on social groups and their practices.

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## Appendix A

The tables below show the definitions of the classes utilized for the representation of crafting processes.

**Table A1.** Class ActorWithRole.

Property	Domain	Range	Links to
ActorWithRole			
hadParticipant	E5 Event	ActorWithRole	A process step
hasSubject	ActorWithRole	E39 Actor	A practitioner
hasRole	ActorWithRole	E62 String	Role appellation

**Table A2.** Classes Process Schema and Process Schema Step.

Property	Domain	Range	Links to
Process Schema/Step, subclass of E29 Design or Procedure			
P1 is identified by P3	Process schema/step	E41 Appellation	Appellation(s)
has note	E29 Design or Procedure	E62 String	Description(s)
hasSubStep	E29 Design or Procedure	E29 Design or Procedure	A step schema
	is sub-property of E69 has association with		

**Table A3.** Transition classes.

Property	Domain	Range	Links to
Transition, subclass of E73 Information Object			
transitsFrom	Transition	E29 Design or Procedure	The input step
transitsTo	Transition	E29 Design or Procedure	The output step
Fork, subclass of E73 Information Object			
forksFrom	Fork	E29 Design or Procedure	The input step
forksTo	Fork	E29 Design or Procedure	An output step
Merge, subclass of E73 Information Object			
mergesFrom	Merge	E29 Design or Procedure	An input step
mergesTo	Merge	E29 Design or Procedure	The output step
Join, subclass of E73 Information Object			
joinsFrom	Join	E29 Design or Procedure	An input step
joinsTo	Join	E29 Design or Procedure	The output step
Branch, subclass of E73 Information Object			
branchesFrom	Branch	E29 Design or Procedure	Input step
Alternative, subclass of E73 Information Object			
hasAlternative	Branch	Alternative	Alternative step
hasPredicate	Alternative	E62 String	Predicate
hasAlternativeDestination	Alternative	E29 Design or Procedure	Output step
<i>All, sub-properties of</i>	E106 is composed of and E73 Information Object		

**Table A4.** Classes Process and Process step.

Property	Domain	Range	Links to
Process/step, subclass of E7 Activity			
P1 is identified by	Process/step	E41 Appellation	Appellation
P3 has note	E7 Activity	E62 String	Descriptions
P16 used specific object (was used for)	E7 Activity	E70 Thing	Material or immaterial objects
hadParticipant	Process/Process step	ActorWithRole	Actor
hasSpatialRegion	E7 Activity	SpatialRegion	Place
refersToMOSource	MObject	E7 Activity	Media object
has time-span	Process	E52 Time-Span	Time region
correspondsTo	E7 Activity	E29 Design or Procedure	Schema step
has order	Process	Integer number	Integer number
hasProcessStep	E7 Activity	E7 Activity	A process step
	sub-property of P9 consists of		

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