Enhancing the educational value of tangible and intangible dimensions of Traditional Crafts through role-play gaming

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Abstract. Advances in Cultural Heritage (CH) representation and presentation technologies are explored concerning new potentials brought by the gaming industry. These include the use of digitisation technologies for the creation of realistic digital assets, educational gaming concepts, and immersive technologies. In this context, it is shown how the creative sector can exploit these potentials in novel educational and gaming experiences, inspired by CH. The aim is to enhance the way that cultural content is experienced in the digital world, to present, and to valorise intangible dimensions and, ultimately, exploit technological advances to enhance our understanding, appreciation, and preservation of tangible and intangible heritage.

Keywords: Culture, Cultural Heritage, Heritage Crafts, 3D reconstruction, Digitisation, Semantic Knowledge Representation, Role Play Gaming, Virtual Reality, Education, Training

1 Introduction

Traditional Crafts (TCs) exhibit tangible and intangible dimensions. Tangible dimensions regard craft articles and products, materials and tools, as well as natural resources, built workshops, and workplaces. The tangible, or material, aspect of TCs is evident in their practice, where materials are transformed with the use of tools. At the same time, intangible dimensions as skill and technical knowledge are intimately involved in this process, evidencing that "crafts are probably the most tangible of intangible heritage" [40]. Moreover, craft artefacts reflect the socio-historical content of the communities, times, and places within which they were developed, reflecting their history, values, collective memories, and oral traditions. TCs are part of the history and economic life of the regions and communities in which they flourish. As Kurin points out, long-standing market or exchange economy systems have an impact on geographical regions and networks [17] and reveal the way for sustainable development.

In the Mingei project [24], we focus on representing tangible and intangible content due to TCs [45], to enhance the appreciation and value of a cultural visit. This is strategized by providing educational content and engaging experience for uses prior, during, and after a visit. These facilitate engagement with local culture, using modern, intuitive, and attractive presentations that impact a wide range of audiences, including younger ages.

In this work, we propose an approach towards the presentation of both tangible and intangible CH dimensions, through an informal gaming context. This context offers learning potentials through immersion in a virtual setting that enables exploration of the past, the inspection of tangible artefacts, and the engagement in activities that transmit intangible dimensions.

2 Related work

2.1 Representation and digitisation for CH preservation

In the past decades, the evolution of technologies for CH preservation and presentation regarded mainly Semantic Web technologies for preserving knowledge and digitisation technologies for preserving material dimensions. Semantic technologies and ontologies, in particular, are nowadays standard tools in CH. There is a significant history of pertinent approaches in CH, since the pioneering work of Europeana [13], which triggered the model of CH with semantic technologies in 2007 [10]. We distinguish three phases of the adoption of semantic technologies in the CH sector. During the first phase (2000-2010), projects relied mostly on existing approaches to knowledge classification, stemming from the library and archival science. During the second phase (2010-2015), the focus shifted towards richer, event-centric representations, in response to the realization of the drawbacks and scarce utility of object-centric representations (the class Event is one of the basic classes that the Europeana Data Model [10]). Finally, during the third phase (2015, today), we are observing significant changes supported by the development of new representations of CH artefacts, based on new digitization techniques, able to exploit the above-mentioned technological advances [8].

2.2 **Digitization approaches for tangible CH**

Approaches towards the digitisation of CH components initially focused on artefacts and monuments of material heritage. With the evolution of digitisation technologies, in the CH sector, efforts have been made to standardize the digitization process, providing guidelines on how to digitize books and documents as well as objects and monuments of CH [12] [4] [7] [1] [18]. Guidelines regarding file management, digital preservation, online publication, and Intellectual Property Rights (IPR) management can be found through the MINERVA EU funded Thematic Network (IST-2001-35461), whose Website and handbook [23] comprise a valuable starting point for these matters, as well as, the foundation of online heritage repositories, such as Europeana [13]. Digitisation guides and good practice guidelines [11],[4] are now the norm in photographic documentation.

Among digitisation technologies, the most relevant to this work is the 3D reconstruction, defined as the process of capturing the shape and appearance of a physical object. The proliferation of surface digitisation technologies streamlined the 3D digitisation of artefacts and monuments. Digital 3D models of artefacts have a wide range of uses, from conservation and preservation to reunification of dispersed heritage [1]. The capabilities of the individual technologies vary in terms of several criteria that must be considered and balanced when deciding on the digitization strategy [1]. The 3D reconstruction of physical objects has been improved with laser scanning and photogrammetry, which enable digitizing tangible artefacts for cultural heritage and archaeological sites. Each methodology proposes a different approach to face the challenge of digitization for visualization or preservation purposes.

2.3 Advances in the gaming industry

The gaming industry has proposed game genres for creating types of gameplay that could increase the engagement of players with the game scenario. The ultimate goal is the illusion of natural immersion in a way that avails a “sense of place” [19] and provides the context of the targeted experience. One of the most relevant game genres is fantasy role-playing games, which are leisure activities that entail a unique form of play. The game is not competitive, has no time limits, has no score-keeping, and, has no finite definitions of winning or losing. Fantasy role-playing games are not merely for players to play well nor to "win". Instead, the goals are survival, knowledge, skill acquisition, and character development [43]. In the context of role-playing games, the creation of 3D models of real-world scenes has always been an attractive topic in the game industry. According to [28] building virtual 3D scenes has always required talented people with artistic sense, specialized and expensive software, strong computational resources for photorealistic visualization, and significant manual effort. This process includes the acquisition and usage of several visual references such as concept art and photographs [35] [34]. Realistic productions rely heavily on photographs, with higher budget games investing in field trips during the preproduction phase to capture authentic photographs on location [31] [36]. Until recently photogrammetry was only used sporadically in game development as the dense millions of polygons meshes generated by these processes are highly unsuitable for real-time rendering.

The announcement of EA DICE in May 2015 that its new flagship title “Star Wars: Battlefront” would **rely heavily on photogrammetry** to capture the franchise’s acclaimed settings [33] was a **radical change to game development**. Faced with the challenge of capturing the well-established visual style of Star Wars, the team opted for photogrammetry to recreate not only props and outfits previously used in the movies but also the epic locations that are familiar to Star Wars fans [5]. The creation of realistic photogrammetry scans is still computationally demanding, requiring high-end computers and many hours of processing time. Thus, as demonstrated by [2], populating extensive game worlds with photogrammetry assets demands larger-scale solutions. Another consideration is the need to manually post-process photogrammetry reconstructions, including cleaning, re-texturing, etc. [3]. It is foreseen that photogrammetry will be extensively used for creating realistic assets, due to reconstruction realism and reduction of production costs [29]. Furthermore, it is conceivable that 3D art will follow the evolution of painting. In painting, the primary goal of the artists of the past centuries was to create a visually convincing replication of the real world. Then with the evolution of photography, it was made apparent that in the future the work of the painter will be replaced by one of the photographers. This fact resulted in an evolution in art mainly because artists were relieved by the burden of realism and allowed to explore their creativity to create novel forms of artistic expression resulting in the modern art revolution [21].

2.4 This work

In this work, an attempt is made to merge different worlds, the world of scientific representation of CH and the world of the gaming industry. We assert, that the third phase of knowledge representation technologies and 3D digitisation strategies combined with the advances of the gaming industry (new Game Development Engines, usage of 3D reconstructions for gaming, new gaming genres, etc.) can support a new form of CH powered innovation. This could support the creation of appealing demonstrations through an informal gaming context, where entertainment and knowledge join forces to increase our understanding of our cultural heritage. The workflow presented in this research work is rooted in the requirements set by the Mingei Project [27] and follows the defined approach for knowledge representation and presentation [44]

3 The Island of Chios game concept and implementation

The game provides information regarding the historic period of the medieval occupation of Chios and more specifically regarding the socio-historic context of mastic cultivation and the creation of the first settlements resulted in the formulation of the so-called mastic villages. The game is based on the third-person action principles (a third-person game is a game in which the player character is visible on-screen during gaming [46]), and navigation in an open 3D environment where only the restrictions of the sea around the island exist, together with limitations related to the angle of the terrain surface. The proposed, by this work, implementation approach contains the following activities: (a) study of history and definition of a scenario for the game, (b) basic knowledge acquisition & 3D reconstructions of heritage sites, (c) knowledge representation, (d) semantic export and creation of game assets, (e) terrain implementation and (f) implementation of the main game concept and mini-game scenarios.

3.1 Game scenario and objective

The game scenario is built on top of the history of Chios a small island on the northeast side of the Aegean Sea. According to [32], among others, mastic was always a great asset of trading for the rulers of Chios. During the Byzantine Empire (4th – 13th century) mastic monopoly was under the emperor's rule. From 1349 to 1566, Chios was under the rule of the Republic of Genoa. At that time, a trading company was founded, which was called Maona. Mastic was a monopoly of Maona and as a company, it had a very strict program regarding the production of mastic. Maona kept contracts of three, six, eight, and ten years with companies from Genoa, Armenia, Cyprus, Istanbul, Alexandria, Greece, and Syria. The transportation of the product was taking place using vessels that transported crates with mastic that were called 'mastic boats' and they could transfer fifteen to thirty crates. From the 16^{th} to the 20^{th} century, Chios was under Ottoman rule. The Ottomans had also the monopoly of the mastic trade but they allowed some facilitations for the mastic communities. Based on this order, various settlements were created, houses were built to a specific architecture, while the social life of mastic growers was adapted to it as well. First, the "castra", the square towers in the centre of fortified rectangular courtyards, were created. Later, probably within the framework of a wider defensive plan, it was decided that settlements would be fortified with a surrounding wall equipped with round towers in the corners and with gates at the points where the wall met the basic roads. Most probably, the walls also enclosed undeveloped land, which was built later [16].

The main storyline of the game starts with the appearance of the player to an unknown world in the middle of the forest. The game involves exploration of the Chios landscape to access historic information regarding the medieval occupation of the island and through exploration learn about the cultivation of mastic and the significance of this product for the local population. Furthermore, the game scenario includes exploration of mastic villages each of which reveals its unique architecture, decorative patterns, house structures, etc. In this journey, the main ports of the island are presented, the transfer and export of mastic, the mastic field as the dominant cultivation of the island, etc. The storyline of the game is not linear and relies on the exploration decisions that the player is making following the principles of open-world gaming. In video games, an open world is a game mechanic of using a virtual world that the player can explore and approach objectives freely, as opposed to a world with more linear and structured gameplay [3].

3.2 Knowledge acquisition & 3D reconstructions

PIOP is a cultural heritage stakeholder that has created a museum dedicated to Chios mastic with the cooperation of the Chios Gum Mastic Growers Association. Extensive historical, environmental, social, and craft knowledge was collected for the creation of the museum and is now part of PIOP's archive. Knowledge acquisition for the specific game was carried out through PIOP's archive which also includes the Chios Gum Mastic Growers Association archive on the trade and industrialization of mastic. Archival material included scientific essays, audio recordings of local oral traditions, audio-visual documentation of craft and industrial processes, as well as digitized historical books. For the collection of new assets audio-visual material was produced, as well as 3D scans of the museum's items, the mastic tree, and open spaces such as the Chios Mastic Museum and mastic villages.

The 3D reconstructions of the villages are part of the game assets and were acquired through on-site aerial 3D reconstruction. Their characteristic structure reveals fortification against pirates and storage buildings at the centre of the village to guard mastic (see Fig 1, section 1). To do so, a dataset was created containing aerial images acquired via a UAV overlooking a village. In the results (see Fig 1, section 2), building structures are reconstructed with fidelity and alleys, streets, and village squares are clearly outlined (see Fig 1, section 3). Furthermore, reconstructions of additional rural environment elements and mastic cultivation tools were made, including 3D modelling of some of the tools and were further post-processed to be converted to 3D assets.

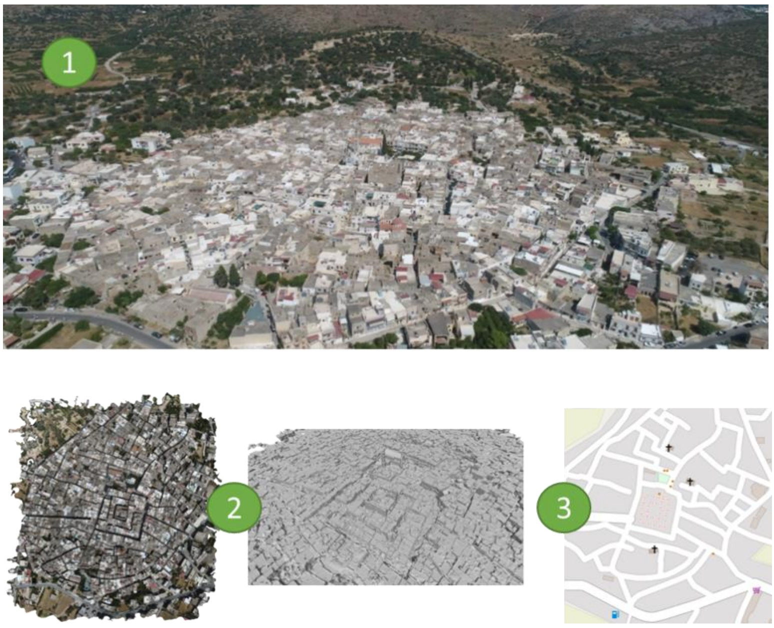

Fig. 1. Aerial photograph of a village (1), 3D reconstruction results (2) map view of the same village (3) (street map retrieved from [30]).

https://youtu.be/adPDVx7RGVc https://youtu.be/15NcRlg3360 https://youtu.be/9xNlrGSBfIE

Fig. 2. Videos showing the 3D reconstruction of three mastic villages.

3.3 Knowledge representation and authoring

The representation of knowledge was facilitated by the Mingei Online Platform (MOP), which has been developed based on the Research Space (RS) [26] platform, enriched with features for representation, digital preservation, and dissemination of this content. MOP offers seamless treatment of heterogeneous data and implements a repository of content created in the project, inherited as a legacy from archives, as well as links to knowledge and assets created by third parties, and are available online. The Mingei Crafts Ontology (CrO) [22] was used to represent the collected knowledge on mastic cultivation and the relevant socio-historic context.

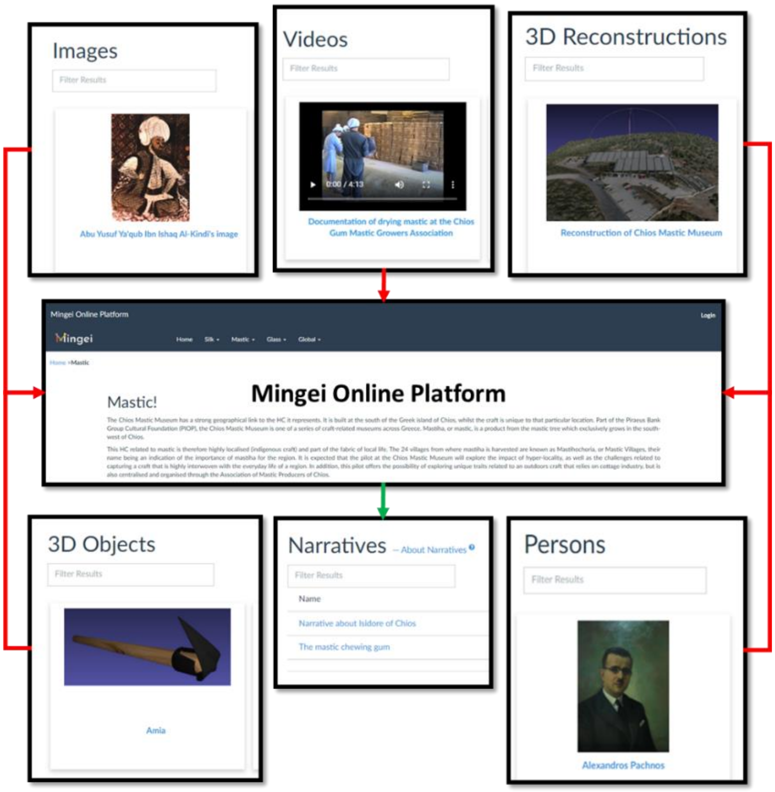

Fig. 3. Mastic knowledge representation in MOP.

To provide **access to the authored knowledge**, two routes were explored (a) runtime access to and (b) offline access. The first route poses several limitations mainly because all assets used in Unity3D should be precompiled and, thus, creating a runtime compilation feature for Web-based URIs could pose extra development effort. In this work, the second solution was preferred. In this solution, digital assets were exported from the MOP in a structure JSON based format. The JSON file includes metadata of assets and the URIs, where assets are located on the Mingei Online Repository (see Fig. 4). Furthermore, it provides the relations between digital assets for the needs of the game and allows the game to reference digital assets from the Asset Bundle. An Asset Bundle is an archive file that contains platform-specific non-code Assets (such as models, textures, prefabs, audio clips, and scenes) that Unity can load at run time (see Fig 5). Asset

Bundles can express dependencies between each other; for example, a material in one Asset Bundle can reference a texture in another Asset Bundle [42]. From the export, game assets were collected and pre-compiled in the form of Asset Bundle files imported to the Unity3D project. Grouping was used to organise assets in bundles e.g. textures and layout data for a User-Interface screen, game scenario and texts, textures and models for pieces of the scenery, etc.


```
{
  "head" : {
    "vars" : [
      "subject",
      "name",
      "source"
    ]
  },
  "results" : {
    "bindings" : [
      {
        "subject" : {
          "type" : "uri",
          "value" : "http://www.mingei-project.eu/resource/be3dfc7b-d4af-4328-ab25-46003800445d"
        },
        "name" : {
          "type" : "literal",
          "value" : "Reconstruction of Chios Mastic Museum"
        },
        "source" : {
          "type" : "literal",
          "value" : "http://139.91.186.146/media/recon-viewer/index.html#53"
        }
      },
```


Fig. 4. A JSON formatted response from the MOP.

3.4 3D game implementation

For the generation of the game terrain, a terraforming tool [38] was used to prepare a height map of the Island of Chios (see Fig 5, Section 1). A height map is a raster image where each pixel stores elevation data, for display in 3D computer graphics, typically after conversion into a 3D mesh. This map was imported into Unity3D as a 3D mesh. In this process, several iterations and tests were made. Each test included editing resolution, terrain size, and maximum altitude in conjunction with the size of the reconstructions. The output of this process is the development of a terrain structure that although similar to the one of Chios, can be experienced as a game terrain (see Fig 5, Section 2). To this end, the final terrain is scaled down in terms of dimensions to be played “on foot” by a single player and at the same time have a logical distance between action points that can be easily covered by the player either “on foot” or using several portals that transfer the player in several places of the terrain. Furthermore, the game terrain and the player avatar are deviated from reality to enhance the “play” characteristics (e.g. less gravity or zero gravity areas, increased player speed, increased climbing capabilities, etc.). Other post-processing activities include the creation of game planes such as roads, hills, harbours, etc. Then, the 3D reconstructions of the villages were integrated into the terrain considering the dimensions of the terrain, player, and reconstructions. Fig 5, section 3, presents the placement of the Olympoi reconstruction in the terrain. The placement included terraforming of the surrounding to the reconstruction areas to eliminate any overlapping between the terrain and the reconstruction.

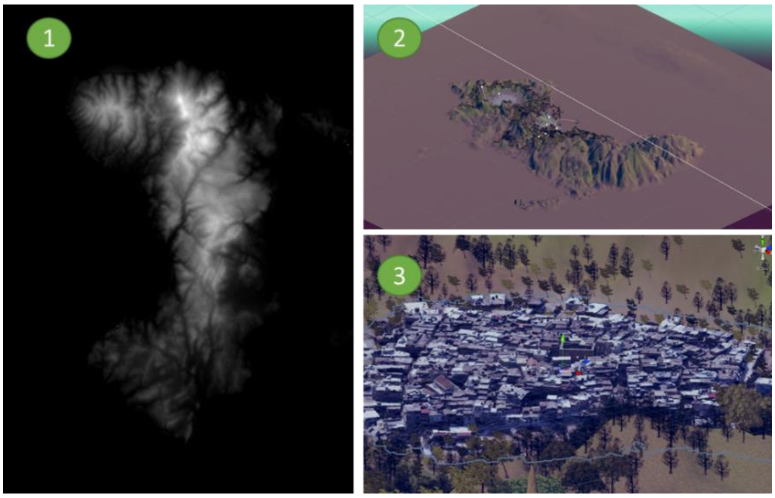

Fig. 5. A height map (image source [15]) for the Island of Chios (1), 3D Chios game terrain (2), Placement of Olympoi in the game terrain (3).

3.5 Gameplay implementation

Gameplay implementation was based on “The Explorer: 3D Game Kit” which is a collection of mechanics, tools, systems, and assets for third-person action games [39]. Based on this framework several components of the kit related to character animation and rendering, terrain navigation through teleports (see Fig. 6 left), areas unlock, etc. were reused. The implementation was initiated through the formulation of the main game environment and routes within the environments and then moved to the 3D modelling of specific areas of the landscape. These areas were created with imaginary scenery build with assets from the Unity3D asset store [41] and reconstructions of (a) mastic villages, (b) rural sceneries, (c) mastic trees, and (d) mastic tools. In the case of 3D reconstructions, Level of Detail (LOD) post-processing [20] was performed to ensure that game assets do not pose extremely high GPU rendering prerequisites.

For demonstration purposes, a scenario was created and recorded following the path of a user from game start until the discovery of two main points of interest (a) the mastic field and (b) the village of Olympoi to experience its architecture (see Fig. 6 right).

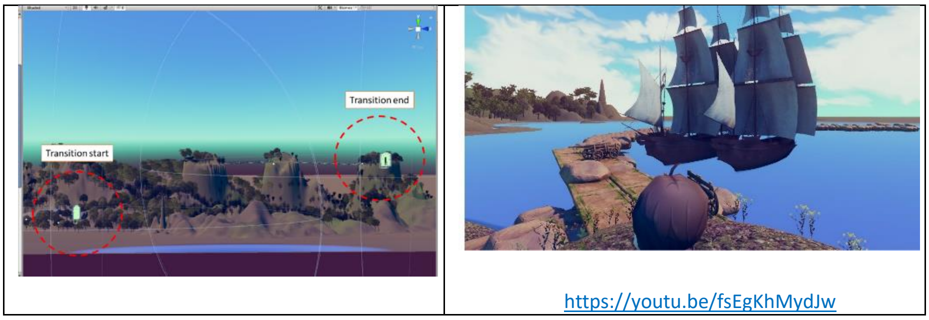

Fig. 6. Setting transition points through teleports (left), mini video from the main game plot (right).

4 Discussion and future work

In this work, we provided evidence regarding the exploration of the third era of knowledge representation technologies and 3D digitisation strategies combined with the advances of the gaming industry to support a novel form of gaming experiences powered by tangible and intangible CH. To this end, the creation of the Chios exploration game was presented which is a fantasy role-playing game situated at the medieval island of Chios infused with 3D reconstructions of CH sites, validated and semantically represented knowledge and enhanced immersive experiences. During game creation, state of the art technologies from the CH sector and Gaming Industry were used and thus the game heavily relies on 3D game platforms and game building tools, 3D reconstruction technologies for content regarding places of historical significance and traditional terrain building and gameplay concepts. At the same time, the semantic representation of knowledge provided ready to use structured knowledge representations that made easier the integration of knowledge in the form of precompiled asset bundles thus enhancing traditional approaches considering that content authoring is happening in an external platform accessed by anyone including scientists and curators.

Regarding future work, the prototype will be first evaluated by experts employing not only traditional usability evaluation guidelines, such as Nielsen's heuristics [25] but also domain-specific guidelines for games [6, 14]. The expert-based evaluation will be followed by user testing, aiming to assess not only usability but the entire user experience, thus studying issues about game enjoyment and flow [37], as well as the overall learning experience an aspect of particular importance in serious games [9]. This game is a technology exploration created in the context of the Mingei H2020 project and it is a candidate for its inclusion in the pilot setup of the project in the Chios Mastic Museum. An additional research direction that could be pursued would certainly include the concept of a multiplayer online role-playing game, which are video games that combines aspects of role-playing video games and multiplayer online games. In such a game context, multiple users could be spawned in different parts of the island and competitive collaborative learning experiences could take place. This, of course, requires further development and effort but it is foreseen that will contribute to the educational value and exploitation potential of the presented concept.

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