

Project iMARECULTURE: Advanced VR, iMmersive Serious Games and Augmented REality as Tools to Raise Awareness and Access to European Underwater CULTURAl heritagE

D. Skarlatos^{1(✉)}, P. Agrafiotis^{1,2}, T. Balogh³, F. Bruno⁴, F. Castro⁵,
B. Davide Petriaggi⁶, S. Demesticha⁷, A. Doulamis², P. Drap⁸, A. Georgopoulos²,
F. Kikillos¹², P. Kyriakidis¹, F. Liarokapis⁹, C. Poullis¹⁰, and S. Rizvic¹¹

¹ Cyprus University of Technology, Limassol, Cyprus
dimitrios.skarlatos@cut.ac.cy

² National Technical University of Athens, Athens, Greece

³ Holografika Hologrameloallito Fejlesztő Es Forgalmazó Kft, Budapest, Hungary

⁴ 3D Research s.r.l., University of Calabria, Rende, Italy

⁵ Universidade Nova de Lisboa, Lisbon, Portugal

⁶ Ministero dei Beni e delle Attività Culturali e del Turismo, ISCR, Rome, Italy

⁷ University of Cyprus, Nicosia, Cyprus

⁸ Aix-Marseille University, Marseille, France

⁹ Masaryk University, Brno, Czech Republic

¹⁰ Concordia University, Montreal, Canada

¹¹ Sarajevo University, Sarajevo, Bosnia and Herzegovina

¹² Pierides Foundation, Larnaca, Cyprus

Abstract. The project iMARECULTURE is focusing in raising European identity awareness using maritime and underwater cultural interaction and exchange in Mediterranean Sea. Commercial ship routes joining Europe with other cultures are vivid examples of cultural interaction, while shipwrecks and submerged sites, unreachable to wide public are excellent samples that can benefit from immersive technologies, augmented and virtual reality. The projects aim to bring inherently unreachable underwater cultural heritage within digital reach of the wide public using virtual visits and immersive technologies. Apart from reusing existing 3D data of underwater shipwrecks and sites, with respect to ethics, rights and licensing, to provide a personalized dry visit to a museum visitor or augmented reality to the diver, it also emphasizes on developing pre- and after- encounter of the digital or physical museum visitor. The former one is implemented exploiting geospatial enabled technologies for developing a serious game of sailing over ancient Mediterranean and the latter for an underwater shipwreck excavation game. Both games are realized through social media, in order to facilitate information exchange among users. The project supports dry visits providing immersive experience through VR Cave and 3D info kiosks on museums or through the web. Additionally, aims to significantly enhance the experience of the diver, visitor or scholar, using underwater augmented reality in a tablet and an underwater housing. The consortium is composed by universities and SMEs with experience in diverse underwater projects, existing digital libraries, and people many of which are divers themselves.

Keywords: Underwater · Archaeological sites · Shipwrecks · Maritime · Virtual museums · Serious games · Immersive · Holography · European identity

1 Introduction

The area of Virtual Museums, Virtual Guides and Virtual Reconstruction of Cultural Heritage, has a number of past and currently important active projects of this scope (e.g. V-MUST, F-MU.S.EU.M., VENUS, MINERVA, MINERVA PLUS, MINERVA EC, THE MICHAEL PLUS, ATHENA, ATHENA PLUS, ARCHEOGUIDE, 3DMURALE etc.). However, these projects do not address the real challenge of an Underwater Virtual Museum. In addition, projects related to underwater cultural heritage and environments are not engaged with the challenge of Virtual Museums and Immersive Technologies. These projects (e.g. SASMAP, WRECKPROTECT, ARROWS, STACHEM, 3D-UNDERWORLD, NOPTILUS, CURE) are focusing on the development of tools and techniques to survey, assess, stabilize, monitor and preserve underwater archaeological sites using robot systems and scanners. It is important to note that the majority of these projects are not dealing with dissemination and wider public awareness of underwater cultural heritage. In particular, in the Mediterranean Sea where most of the oldest underwater assets exist, are at most in risk due to the marine environment, trawlers, looting and wood degrading marine borers. Hence recording and promoting CH is most important in the Mediterranean Sea than any other place.

1.1 Scope

Project's iMARECULTURE scope is to raise public awareness of European identity by focusing in maritime cultural heritage, which by default brings together different civilizations. In particular, it aims in bringing inherently unreachable underwater cultural heritage, within digital reach of the wide public, by implementing virtual visits, serious games with immersive technologies and underwater augmented reality. Scope of the project is to design, analyze, develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums.

The project combines the two aforementioned groups of research projects into one by merging advancements in VR with the underwater environment. It will accomplish it by using existing technology to create breakthrough applications and digital experiences in the area of Virtual Museums in order to empower different types of users to engage with European underwater cultural heritage digital resources by exploiting reuse and re-purposing of existing data.

1.2 Approach

Submitted in the call 'Virtual museums and social platform on European digital heritage, memory, identity and cultural interaction' (CULT-COOP-08-2016), the projects investigate new ways to personalize the museum visit to a digital of physical visitor, while

support social cohesion and European identity. Virtual museums are particularly strong in visualizing CH that it either intangible, does not exist anymore, it is partially destroyed or it is remotely located. Ancient maritime commerce is a perfect example of civilizations' interaction and cultural exchange, but unfortunately not easily exhibited to the wider public. Ships, shipwreck sites and underwater sites in general, are far from public's reach and understanding. Enabling immersive technologies to allow for content enhanced dry visits of visitors on such sites, it will inevitably raise public's awareness and stir further interest about maritime culture.

The goal is to bring shipwreck sites to the reach of the wider public, so that they can have a personalized and interactive dry visit using VR googles from the comfort of their house. Museum visits could be further enhanced, using immersive technologies, such as VR caves and holographic screens. The latter allow for all visitors to witness an interactive 3D experience of another visitor, while they carry no special glasses or any other equipment, while freely walking around the objects under investigation. Moreover, the project will enhance the underwater experience of diver visitors, as there are submerged archaeological sites, that support such visits. Especially designed underwater tablets using Augmented Reality (AR) will superimpose information about specific finds and architectural designs on the screen of a specially designed underwater tablet. The information will be provided in real time, and on user's demand, in order to avoid overloading the diver.

Following the need to extend any visit, pre- and after- the visit serious games and storytelling, encourage and surrounds the physical visit. As a pre-visit experience, social platform users will be able to participate in a seafaring game, sailing between ancient ports for commerce, trying to confront all natural and human hazards the ancient crew had to face, using the limited resources and limitations of that specific time period. Similarly, as an after-visit experience, the social platform users will be able to partner up for a virtual excavation dive on an ancient shipwreck, with all limitations and problems that such dives have, and enjoy the 'discovery' and surfacing of new artifacts, while appreciate the work done by underwater archaeologists.

Three sites have been carefully selected for project's implementation, based on their ability to support the context of each action, as well as their data availability, so that no assets were to be allocated on data acquisition.

Mazotos shipwreck site: The site [1], when discovered, was virtually undisturbed, so its archaeological importance, as well as the immediate need for its protection, triggered the organization of the first Cypriot underwater archaeological project. The wreck lies at a depth of -44 m, some 14 nautical miles south-west of Larnaca, 1.5 nm from the shore, near Mazotos village. The main visible feature of the site is a concentration of amphorae on a sandy, almost flat sea-bed. Its maximum vertical relief measures 1 m and its maximum dimensions are 17.5 × 8 m. The oblong concentration, almost in the form of a ship, has a north-south orientation and consists of 500–800 Chian amphorae partly or totally visible, which date to the middle of fourth century BC.

Xlendi shipwreck site: The Phoenician shipwreck off Gozo Xlendi, resting at a depth of 110 m, it is probably the oldest ancient shipwreck in the central Mediterranean (700BC). Xlendi Bay is a narrow inlet on the south-west coast of Gozo, close to the island's south-western point Rasil-Wardija and to the capital Rabat, which is 2.5 km away.

Rabat is a hilltop town that is thought to have been the main settlement area throughout Gozo's history. Xlendi lies at the mouth of a valley which runs from the Rabat hill to the coast. The valley is bounded by high rock walls but opens into a floodplain, which is the site of the modern village, before meeting the sea. There is a good, fresh water source in the village of Fontana, on the road between Rabat and Xlendi [2, 3].

Baiae underwater archaeological park: The Baiae site is of particular interest, it was created in 2002 and it is together a Marine Protected Area and an Underwater Archaeological Park. Environmental aspects of this area are related to a peculiar volcanic and deformational history. The submerged area includes part of the territory of the ancient city of Baiae and Portus Iulius, comprising the roman harbour and numerous constructions used as warehouses. The archaeological remains include luxurious maritime villas and imperial buildings, more modest houses, private *thermae*, *tabernae* and all those structures that characterize the cities of the Roman age. The itineraries of "Villa con ingresso a protiro" (selected for this Project) with black and white and white mosaic floors, and *thermae*; the Villa of Pisoni, the Nymphaeum of Punta Epitaffio (with copies of statues of the Imperial families and of Roman gods); the Portus Iulius with the remains of mosaics floor of a republican Villa and a building with a porticos. The Baiae underwater archaeological park will serve also as a demonstration site for the developed Augmented Reality systems.

All actions will be evaluated in order to attain measurable results, and enhanced by appropriate storytelling.

2 Project Approach and Methodology

2.1 Objectives

Being an interdisciplinary project, the first step is the clear definition of targets, goals, test sites and wrecks to be used. Several decisions about the serious games, the age, the era and data to be gathered, will be taken. Discussions about existing VR and AR technologies [4] and implementation will clarify the roadmap towards milestones and goals.

Data gathering and pre-processing phase: Is the fundamental pillar for the project. Both 3D as well as supporting data will be accumulated by partners, from open sites, published journals and books and partner's archives to support storytelling, narratives, 3D models of sites [5–9], ships [10], cargos, probabilistic geospatial analysis about ship routes [11], wreck site formation processes, etc. Having all the necessary information, iMARECULTURE will create and re-use a plethora of 3D models for both the ship wreckages and the amphorae, allowing people to examine the 3D underwater environment and objects on it. Similarly, a site of Baiae underwater archaeological park where a complete 3D model exists [12, 13], will be used for the implementation of the AR supported dives.

Virtual reality phase: This phase offers the users more than underwater tour, at a safe environment. Additionally, this phase offers the enhanced experience of the diver, visitor or scholar, using underwater augmented reality in a tablet and an underwater housing. In VR people around the world can access any environments using immersive

technologies and internet access. Supportive narrative and multimedia tools [14] will provide interactive information about the site and objects allowing for a personalized experience, both in terms of navigation as well as in objects' queries. At the same time, emphasis will be given towards the creation of a universal standard for storytelling presentation [15]. End-users will be in position to interfere/adjust the excavation discovery story, according to their liking.

Serious games in platforms: All the knowledge acquired through this project will lead to the creation of serious games in platforms [16, 17]; actual and high detailed environments will be presented, allowing the gamers to fully explore and interact with them. The main focus will be on the two imperative aspects of the serious games: storytelling and interaction; both of which are essential in engaging the users and inspiring further intrinsic learning.

Additionally, the knowledge base will cover, under a unified framework, a variety of underwater CH sites of different properties and characteristics. Holistic records enable rich and generic characterization of the aforementioned cultural heritage elements into well-defined and structured components and machine-readable formats that allow the utilization of multi-domain information in an automated way. This holistic knowledge is built upon the CIDOC/CRM protocol and it extends the standard to include historic documentation, geometric survey, material survey, as well as critical environmental parameters. Furthermore, the project will extent BIM protocol, which is a process involving the generation and management of digital representations of physical and functional characteristics of places and objects, in order to describe and manage knowledge about underwater sites and CH assets.

Finally, diagnostic schemes for site formation analysis will be bullied by incorporating (i) underwater changes profiling, (ii) non-invasive/non-destructive analysis methods while (iii) documenting the sensor acquired spatio-temporal data and (iv) supporting data aggregation strategies. Protocols developed in past EU projects will form the basis for the project protocols and will be adapted according to specifications.

3 Methodology

3.1 IMARECULTURE Methodology Steps

Figure 1 is presenting the methodology steps adopted for this project. The project starts with the project scenario and use case definition. The cultural heritage items of the three involved underwater cultural sites will be selected in a way that covers all iMARECULTURE challenges. Then, an iterative process is adopted to specify a concrete architecture that can fulfil all user requirements and pilot sites demands. The design is performed at two cycles. The first gives the first form of the algorithms needed to be applied.

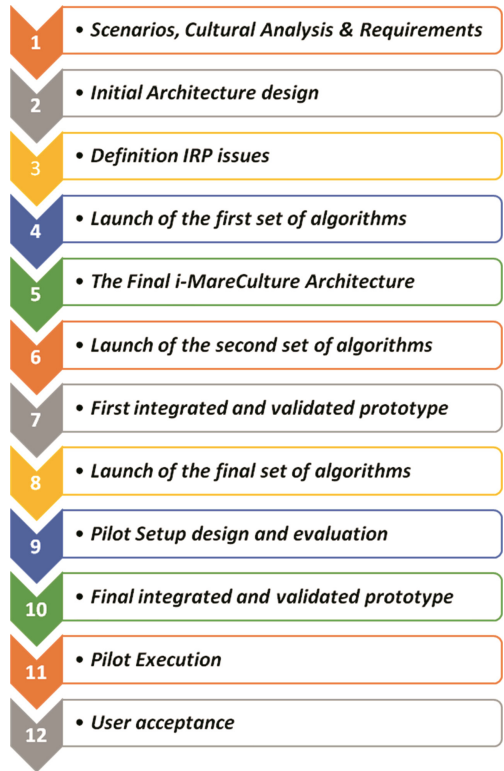


Fig. 1. The i-MareCulture methodology steps

Additionally, are specified and defined the IPR issues involved in the project. Then the first set of algorithms is launched and the updated architecture takes into account results from the previews step. Subsequently the second set of algorithms is launched. At the next step the first integrated and validated is created: All the aforementioned research components are integrated to launch the first initial prototype.

Then we launch the final set of algorithms and we design the pilots and the evaluation frameworks used for objectively assess the performance and acceptance of the architecture. Finally, the final iMARECULTURE platform will be assessed by different types of users.

3.2 Description of “Virtual Sites”

The project exploits 3 different “Virtual Sites” (Fig. 2) (existing sites for virtual and augmented reality applications) in order to implement its multidisciplinary approach and accomplish the described objectives. The proposed sites are representative of different kind of Underwater Cultural Heritage, of different states of environmental and geomorphologic conditions (i.e. water depth) and of different periods, in order to present the users a wide range of the common European maritime culture. Consequently, our

selection of 3 virtual sites includes: (1) Mazotos shipwreck site, Cyprus; (2) Xlendi shipwreck site, Malta and (3) Baiae underwater archaeological park, Italy. These cover the Mediterranean basin from center to east. We have also taken care that these sites cover a wide chronological span from 700BC to 400AD.

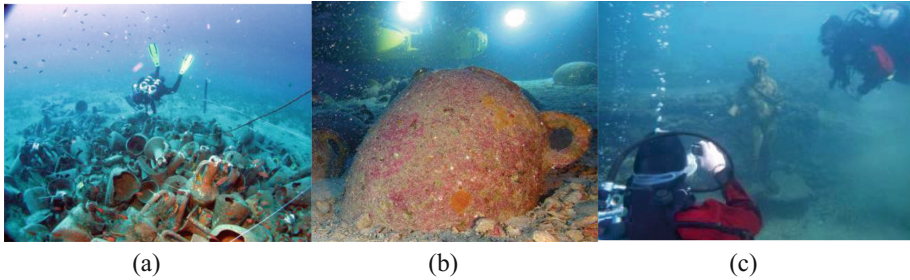


Fig. 2. (a) The main concentration of Mazotos shipwreck site (photo: MARELab, University of Cyprus), (b) Amphorae laying on the seabed at the Xlendi wreck (Photo: The University of Malta/ COMEX/CNRS), (c) The Nymphaeum of Punta Epitaffio

3.3 Description of Demonstration Sites

Thalassa Museum: Thalassa Municipal Museum was opened in August 2005, and it is directed by the Pierides Foundation, in association with the Hellenic Institute for the Preservation of Nautical Tradition and the Tornaritis-Pierides Marine Life Foundation. The Museum is located at the centre of Agia Napa in Cyprus and it has the sea as a subject-matter. It is the first museum of its kind across the Mediterranean region with main principle to present to the audiences, the local and foreign visitors, the impact and the significance of the sea upon the history of the island.

The main exhibit at the fourth level and of the museum itself is the ‘Kyrenia II’ vessel (Fig. 3). A life size exact replica of the ancient ship of Kyrenia of the Classical period (400 B.C.), which was built in 1985 for scientific experimental purposes by the Hellenic Institute for the Preservation of Nautical Tradition of Athens. At the same level the visitor walks on a glass floor where a reconstruction of the old shipwreck is displayed.

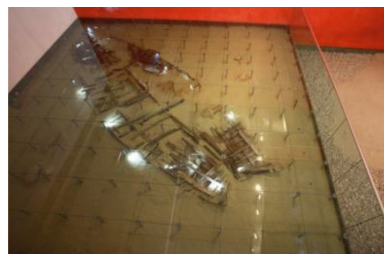


Fig. 3. The life size exact replica of the ancient ship of Kyrenia, the reconstruction of the old shipwreck

4 Specific Innovations

The project connects education, research and industry by supporting and boosting innovative enterprise to develop their technological breakthroughs into viable products in the area of Virtual Museums and Digital Heritage, with real commercial potential. Furthermore, based on the scope and specific aims of the project, significant research will be conducted in

- Developing the outline and short population of a 3D Library as tools for Maritime Archaeology using ontological schemes
- Digitization of naval engineering models and shipbuilding content
- Geospatial analysis of naval routes among main ancient commerce centers
- Multimedia storytelling and interaction
- Underwater Augmented Reality Interfaces
- Hybrid underwater tracking solution based on acoustic sensors and computer vision
- Virtual Reality Interfaces on VR glasses, VR caves and holographic screens
- Serious games through social platforms

The tools will be validated and tested across real-world application scenarios and cases and under a number of different participants. This way, we will prove the innovation potential of our platform over diverse and challenging environments. The serious games platform, the AR/VR interfaces will be assessed in real cases and will include scenarios coming from maritime archaeology research so as to achieve a great mixture between entertainment, informal educational, and underwater/maritime CH understanding. The project supports concrete plans and exploitation activities at certain times to further improve innovation potential.

5 Conclusions

The project iMARECULTURE combines different research disciplines, namely experts in 3D acquisition, Virtual and Augmented reality, serious games developers, geo-statistics and GIS, archaeologists, story tellers, along with technology of underwater tablets, holographic screens, in underwater sites and museums into one group. This way it will accomplish existing technology to create breakthrough applications and digital experiences in the area of Virtual Museums in order to empower different types of users to engage with European underwater cultural heritage digital resources by exploiting re-use and re-purposing of existing data.

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