Preface

Welcome to the proceedings of EuromedMed 2016, the biennial scientific event which this year was held in the capital city of Cyprus, the island that has always been a bridge to three continents in the world going back to the origins of civilization. It is a place where the fingerprints of several ancient cultures and civilizations on earth can be found, with a wealth of historical sites recognized and protected by UNESCO.

Several organizations and current EU projects (such as the Marie Sklodowska-Curie Fellowship project on Digital Heritage Marie Sklodowska-Curie FP7-PEOPLE ITN-DCH, the Marie Sklodowska-Curie FP7-IAPP 4D-CH-WORLD, the FP7-CIP ICT-PSP EuropeanaSpace, the H2020 Reflective 7 - INCEPTION, the H2020 CSA Virtual Museums ViMM, the Research Infrastructure DARIAH-EU ERIC and DARIAH-CY) as well as the Innovation in Intelligent Management of Heritage Buildings (i2MHB) decided to join EuroMed2016 and continue cooperating together in order to create an optimal environment for the discussion and explanation of new technologies, the exchange of modern innovative ideas, and in general to allow the transfer of knowledge between a large number of professionals and academics during one common event.

The main goal of the event is to illustrate the programs underway, whether organized by public bodies (e.g., UNESCO, European Union, National States, etc.) or by private foundations (e.g., Getty Foundation, World Heritage Foundation, etc.) in order to promote a common approach to the tasks of recording, documenting, protecting, and managing world cultural heritage. The 6th European-Mediterranean Conference (EuroMed 2016) was definitely a forum for sharing views and experiences, discussing proposals for the optimum approach as well as the best practice and the ideal technical tools to preserve, document, manage, present/visualize and disseminate the rich and diverse cultural heritage of mankind.

This conference was held during the mid-term of the new Framework Programme, Horizon 2020, which is the largest in the world in terms of financial support on research, innovation, technological development, and demonstration activities. The awareness of the value and importance of heritage assets has been reflected in the financing of projects since the first Framework Programme for Research & Technological Development (FP1, 1984–87) and continues into current HORIZON 2020 that follows FP7 (2007–13). In the past 30 years, a large community of researchers, experts, and specialists have had the chance to learn and develop the transferable knowledge and skills needed to inform stakeholders, scholars, and students. Europe has become a leader in heritage documentation, preservation, and protection science, with COST Actions adding value to projects financed within the FP and EUREKA programme and transferring knowledge to practice and supporting the development of SMEs.

The EuroMed 2016 agenda focused on enhancing and strengthening of international and regional cooperation and promoting awareness and tools for future innovative research, development, and applications to protect, preserve, and document the

European and world cultural heritage. Our ambition was to host an exceptional conference by mobilizing also policy makers from different EU countries, institutions (European Commission, European Parliament, Council of Europe, UNESCO, International Committee for Monuments and Sites ICOMOS, the International Committee for Documentation of Cultural Heritage CIPA, the International Society for Photogrammetry and Remote Sensing ISPRS, the International Centre for the study of the Preservation and Restoration of Cultural Property ICCROM, and the International Committee for Museums ICOM), professionals, as well as participants from all over the world and from different scientific areas of cultural heritage.

Protecting, preserving, and presenting our cultural heritage are actions that are frequently interpreted as change management and/or changing the behavior of society. Joint European and international research produce the scientific background and support for such a change. We are living in a period characterized by rapid and remarkable changes in the environment, in society, and in technology. Natural changes, war conflicts, and man-made changes, including climate, as well as technological and societal changes, form an ever-moving and colorful stage and a challenge for our society. Close cooperation between professionals, policy makers, and authorities internationally is necessary for research, development, and technologica advancements in the field of cultural heritage.

Scientific projects in the area of cultural heritage have received national, European Union, or UNESCO funding for more than 30 years. Through financial support and cooperation, major results have been achieved and published in peer-reviewed journals and conference proceedings with the support of professionals from many countries. The European Conferences on Cultural Heritage research and development and in particular the biennial EuroMed conference have become regular milestones on the never-ending journey in the search for new knowledge of our common history and its protection and preservation for the generations to come. EuroMed also provides a unique opportunity to present and review results as well as to draw new inspiration.

To reach this ambitious goal, the topics covered include experiences in the use of innovative technologies and methods and how to take best advantage to integrate the results obtained to build up new tools and/or experiences as well as to improve methodologies for documenting, managing, preserving, and communicating cultural heritage.

In these proceedings we present 105 papers, selected from 504 submissions, which focus on interdisciplinary and multidisciplinary research concerning cutting-edge cultural heritage informatics, physics, chemistry, and engineering and the use of technology for the representation, documentation, archiving, protection, preservation, and communication of cultural heritage knowledge.

Our Keynote speakers, Prof. Dr. Antonia Moropoulou (NTUA and Technical Chamber of Greece), Prof. Dr. Dieter Fellner (Director of FhD/IGD and TU Darmstadt, Germany), Prof. Dr. Wolfgang Kippes (University for Applied Arts Vienna and Donau University Krems, Austria), Prof. Dr. Sarah Whatley (Director of Centre for Dance Research, UK), Prof. Dr. Mustafa Erdik (Bogazici University of Instabul, Turkey), Mr. Jean-Pierre Massué (Senate Member of the European Academy of Sciences and Arts/ COPRNM, France), Mr. Axel Ermert (Institute for Museum Research SMB/PK of Berlin, Germany), Mrs. Rosella Caffo (Director of the Central Institute for the Union

Catalogue of the Italian Libraries (ICCU), Italy), Mr. Vasco Fassina (President of the European Standardization Commission CEN/TC 346: Conservation of Cultural Heritage, Italy), Mrs. Maria P. Kouroupas (Director Cultural Heritage Center, US Department of State), Mrs. France Desmarais (ICOM), Dr. Thomas R. Klein (Counsel, Andrews Kurth LLP), Françoise Bortolotti (Criminal Intelligence Officer, Works of Art Unit, Interpol) and Prof. Dr. Markus Hilgert (Director, Vorderasiatisches Museum im Pergamonmuseum Staatliche Museen zu Berlin - Preußischer Kulturbesitz and Project Leader, ILLICID) are not only experts in their fields, but also visionaries for the future of cultural heritage protection and preservation. They promote the e-documentation and protection of the past in such a way for its preservation for the generations to come.

We extend our thanks to all authors, speakers, and those persons whose labor, financial support, and encouragement made the EuroMed 2016 event possible. The International Program Committee—whose members represent a cross-section of archaeology, physics, chemistry, civil engineering, computer science, graphics and design, library, archive and information science, architecture, surveying, history and museology—worked tenaciously and finished their work on time. The staff of the IT department at the Cyprus University of Technology helped with their local ICT and audio visual support, especially Mr. Filippos Filippou, Mr. Costas Christodoulou, and Mr. Stephanos Mallouris. We would also like to express our gratitude to all the organizations supporting this event and our co-organizers, the European Commission scientific and policy officers of the H2020 Marie Skłodowska-Curie Programme, the director general of Europeana, Mrs. Jill Cousins, the Getty Conservation Institute and World Monuments Fund, the Cyprus University of Technology, the Ministry of Energy, Commerce, Industry, and Tourism. Especially the permanent secretary and Digital Champion Dr. Stelios Himonas and Mr. Nikos Argyris, the Ministry of Education and Culture and particularly Minister Dr. Costas Kadis, the director of Cultural Services Mr. Pavlos Paraskevas, the Department of Antiquities in Cyprus, all the members of the Cypriot National Committee for E-Documentation and E-Preservation in Cultural Heritage, and finally our corporate sponsors, CableNet Ltd., the Cyprus Tourism Organization, the Cyprus Postal Services, the Cyprus Handicraft Center, and Dr. Kyriacos Themistocleous from the Cyprus Remote Sensing Society, who provided services and gifts in kind that made the conference possible.

We express our thanks and appreciation to Dr. Nikos Grammalides from CERTH in Greece and Dr. Sander Münster, the Dresden University of Technology, Germany, as well as the board of the ICOMOS Cyprus Section for their enthusiasm, commitment, and support for the success of this event. Most of all we would like to thank the organizations UNESCO, European Commission, CIPA, ISPRS, and ICOMOS Europa Nostra that entrusted us with the task of organizing and undertaking this unique event.

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Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection
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Crowdsourcing Cultural Heritage: From 3D Modeling to the Engagement of Young Generations

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Abstract. Monitoring, digitizing and archiving museum artworks represent an important socio-cultural accomplishment and an overcoming in digital preservation today. Cultural heritage is constantly under threat of terrorist attacks and natural disaster. The high costs related to documentation task have prevented a constantly and massive survey activity. The low cost 3D image based acquisition and elaboration techniques of an object, allow to carry out a 3D photorealistic model in a short time. Therefore, a lot of museum adopted these techniques for the artworks archiving. Crowdsourcing activities can significantly speed up survey and elaboration procedures. If, on the one hand, these initiatives can have a positive impact, on the other hand involve the online user with a marginal role. In this paper we demonstrate how it is appropriate thinking the museum visitor as "museum operator/maker" of the digital model overstepping the outcomes achieved so far.

Keywords: Cultural heritage · 3D modeling · Structure from Motion (SfM) · Museum collections · Crowdsourcing

1 Introduction

Dissemination, conservation and knowledge of cultural heritage are essential elements in its life cycle analysis (LCA), whether it is a museum, archaeological, architectural or urban site. The possibility to schedule the updates on the state of conservation of an artwork, ensures its own preservation for future generations. We could bear in mind cataclysms, earthquakes, terrorist attacks, etc. that endanger the life of a physical reality like a museum and its artworks.

The virtualization of an artwork guarantees the digital preservation and its passing down to future generations. That is, history, identity and culture of a community are strictly related to their cultural roots and signs of the past.

The high costs due to 3D acquisition of an artwork whether it is a sculpture, an archaeological site, an architectural element, have not, so far, allowed a cyclical and scheduled monitoring to guarantee a reliable analysis of the work itself. Several attempts have been put in place to support the delicate and utterly titanic undertaking aimed at 3D archiving and reconstruction of museum collections, e.g. 3D icons project, the latest

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Uffizi museum in Florence 3D digitization ect. [1–3]. On the other hand, today there are praiseworthy initiatives seeking in different ways to engage the online user to a museum site, assigning him tasks to help the museum itself in some important digital goals (Egyptian Museum of Turin, Heritagetogether project). However, the online user often has a role still marginal and it is a small piece in the enormous reconstruction mechanism. Our research tends to overrun the goals achieved so far. The source of cooperation is identified in the museum or site visitor: he becomes the creator of the 3D content, acting as a digital maker rather than a mere spectator.

Building on the results obtained from the state of the art we will demonstrate that through the use of existing low cost 3D acquisition techniques (very easy to use and available on the market) it is possible to create an organized system of a production cycle that starts from the museum, involves the visitor, returns to the museum and moves to the community.

2 The State of the Art

The last years have seen several technological innovations in the field of photogrammetry and computer vision techniques for the creation of useful and accurate 3D models of objects, by combining robust algorithms, powerful computers or cloud computing platforms. Several studies have been addressed to the exploitation of SfM algorithms for the creation of 3D models of cultural heritage objects and sites [4–7]. The power of Structure from Motion (SfM) techniques lies in the low learning curve for the realization of a good dataset and in the totally automatic or semi automatic pipeline for the subsequent realization of the textured 3D model. Furthermore, compact or mobile phone cameras can also be used, with good visualization results.

One interesting project that exploits the power of SfM techniques for 3D reconstruction is 4D-CH-World [8]. The main goal of the project, funded under the VII European framework, is to enable historians, architects, archaeologists, urban planners and affiliated professionals to reconstruct views of historical structures starting from millions of images floating around the web and interact with them. Furthermore, the project foresees semantic enrichment of the end results and their subsequent export to Europeana, the European digital library, for integrated, interactive 3D visualisation within regular web browsers.

On the other side, there is an increasingly attention in the power of crowdsourcing for Cultural Heritage: volunteers called to absolve simple tasks that cannot be carried out automatically by a computer and are time consuming for museums employees. However, dealing with cultural heritage, we could consider this a niche crowdsourcing, due to the cultural skills required to the volunteers [9].

One meaningful projects directly managed by a museum is Micro-Pasts project [10]. The project is co-led by UCL and the British Museum, since may 2016 it involves also a pilot experience at the Egyptian Museum in Turin. The platform's goal is to engage traditional academics, archaeological societies, interested individual members to create new, high quality archaeological and historical data about the human past. The project foresees the engagement of volunteers on line assigning them simple tasks such as

transcription and photo-masking on British Prehistory and British Museum collections. As regards photo-masking, the goal is to create masks that isolate the object, improving the 3D reconstruction (Photoscan).

Another interesting project is Heritagetogether [11]. It uses crowd-sourced digital photographs to produce 3D models of Neolithic and Bronze Age remains from Gwynedd and Anglesey area. It is a collaborative Arts and Humanities Research Council project, with academic partners at Manchester Metropolitan, Bangor and Aberystwyth universities. The inspiration for the project was the prevalence of digital camera use in the UK, not least on mobile phones, to crowd-source archaeological research data and to create fully textured digital 3D models using SfM techniques. Volunteers find on the web site tutorials and a list of available software.

If the previous projects are aimed by a cultural-social instance, Stone Bridge Plaka project and Project Mosul answer to our empathic feeling after a catastrophic event to react and try to reconstruct lost heritage sites in order to preserve, also if virtually, the memory and the identity of a place.

Crowdsourcing the traditional stone bridge of Plaka project [12] was aimed to collect images on a lost heritage with the aim to virtually reconstruct it by means of SfM algorithms. On the 1st of February 2015, the central section of the Plaka stone bridge's unique arch collapsed due to extreme weather conditions. Then a web site has been developed for collecting images and videos by volunteers contributors. They were processed both with free and open source solutions (VisualSfM) and commercial ones (Agisoft Photoscan).

As regards Project Mosul [13], it rises at the end of February 2015 after the shocking news of IS destructions of Mosul Museum. The reaction of heritage community brought to the attempt to digitally reconstruct lost heritage starting collecting pictures and using photogrammetry to carry out this task. It was created a platform to manage crowd-sourced images 3D model generation, giving citizen scientists the tools they needed to undertake this task (tutorial, available software). However, the output is a 3D textured model which lacks of geometric fidelity, but constitutes a valuable source for visualization, memory and documentation. Nowadays the platform has been moved to www.rekrei.org and includes a global focus on lost or at risk heritage.

All the highlighted projects are developed on online platforms, one of the major difficulty is the engagement of the online visitor.

However, our idea detaches from these previous experiences because directly engages a museum visitor on site, changing and enhancing his visit experience, transforming him into a 3D cultural content creator during the visit. As will be described in the following sections.

3 A Simple Idea for Museum Collections

The idea of identifying in the museum/archeological-site visitor, a bottom source aimed at dissemination, enhancement and knowledge of Cultural Heritage, got leverage both from the above described projects and the experimentation results on SfM techniques. Although SfM 3D models have less metric accuracy and geometric precision of laser scanning models - especially if integrated with other sophisticated techniques such as

flood-lighting instruments, X-Ray investigation, etc.-, the SfM 3D model quality improves significantly if pictures are taken according to photogrammetric criteria, paying attention to enlightenment conditions, and it is carried out an advanced pre-processing before 3D reconstruction [14].

The potential of Micro-Past, Heritagetogether, Project Mosul (Rekrei) platforms, let us to verify the practicability of a more arduous idea: to encourage the museum/site visitor to give a personal contribution either through the creation of a data set or the final 3D model.

Nevertheless, it was necessary to test our idea on a first target of young visitors. The opportunity provided by the national event #invasionidigitali (thanks to which the involved museum allows the tablet, camera, cellphone to make photos and videos) allows us to involve our students of Palermo and Catania Engineering Schools.

The students just turned in real "digital 3D invaders", without any cultural and technological difficulty. The professors trained the students with the necessary technical and critical tools on SfM techniques, so they could work on their own. The carried out models showed expertise in the use of these techniques and capacity to investigate. Below are showed the phases of the experimentation.

3.1 Engagement and Students/Visitors Training

At this step, thanks to the visibility provided by the national event #invasionidigitali [15] the students felt involved in a bottom-up system of cultural heritage enhancement through the use of social media (facebook, twitter, instagram). This has facilitated their active participation in our project idea also thanks to the introductory seminars on #invasionidigitali held by Dr. Elisa Bonacini, ambassador for the project in Sicily. In addition, the simplicity and easiness in the construction of the 3D model (from the dataset to the 3D reconstruction) encouraged the student to have a social and cultural role, being aware of the final objective: with a little effort, the student/visitor promotes architectural heritage and co-creates 3D cultural content of great value [16].

3.1.1 #Digitalinvasions

#invasionidigitali (#digitalinvasions) is an Italian bottom up project started in 2013 [15]. This initiative was a reaction to the cancellation, for economic reasons, of the "Culture Week" event that allowed for free entrance to museums. Each 'invasion' is a mini-socio digital event in itself with its own poster, Facebook event and hashtag. Social and digital communication are the key to the invasions: 'invaders' are bloggers, amateur archaeologists artists, photographers, Instagrammers, communication experts, but also common people with a wide range of backgrounds, all with the same desire to promote their cultural heritage through social media. By joining the Manifesto (www.invasionidigitali.it), people decided to support Italy's cultural institutions by "invading" them with cameras, smartphones and tablets and share their cultural experiences through the web and social media.

3.1.2 SfM Techniques

In our experiment, students were free to adopt one of the available suggested solutions (Agisoft Photoscan or Recap360 Autodesk platform). If the first one needs a high performance computer for data processing, the second one use the power of cloud computing to carry out a semi-automatic data processing instead of considerably slowing-down the computer.

A fundamental step is the realization of the photographic network of the object: it is recommended that the angle between one shot and another is about 5–10° so that the overlapping between neighboring frames is of about 70 %; furthermore the images around the object should be taken with different rotations and different heights so as to vary the angle of the shoot.

In Agisoft Photoscan the user can give inputs to the several steps of 3D reconstruction (alignment, dense reconstruction, meshing, texturing) concerning the kind of reconstruction, the accuracy, the number of faces, etc. While using Recap 360 the user uploads the images and waits the service for completing the task. The output is a 3D polygonal textured model that can be exported for further usage in external programs according to different formats (OBJ, Ply).

4 Results at Salinas Museum in Palermo and Civic Museum of Castello Ursino in Catania

The students involved in the experimentation were from Drawing Course of the first year of Environmental Engineering of University of Palermo and from Digital Survey Course of the fourth and fifth year of Building Engineering-Architecture of University of Catania. The students of both classes, consisting of about 80 students, lived with enthusiasm and attractiveness the event.

In both cases students were divided into groups to any one of which was assigned a work of art. The following images show the 3D models made by students, chosen by different typologies and dimensions. They are visualized according 4 different modes: textured, solid, x-ray, wireframe. This choice has been made with the intent to show lack of holes, deformations, etc. and meshes face resolution.

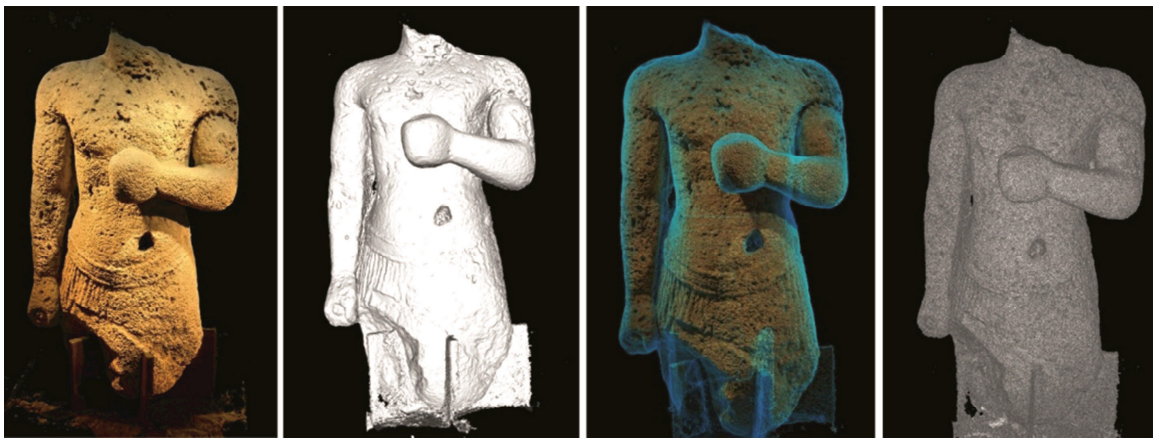

Fig. 1. Torso of the Stagnone (Salinas Museum)

The data set have been made with mobile devices, digital compact camera and reflex camera; the reconstruction resolution variable from low to high values; the data set are made by 40–70 photos (Figs. 1, 2, 3, 4, 5, 6, 7 and 8).

Fig. 2. Statue of Zeus Ourios (Salinas Museum)

Fig. 3. Sarcofago in alabastro: Hasti the dead (Salinas Museum)

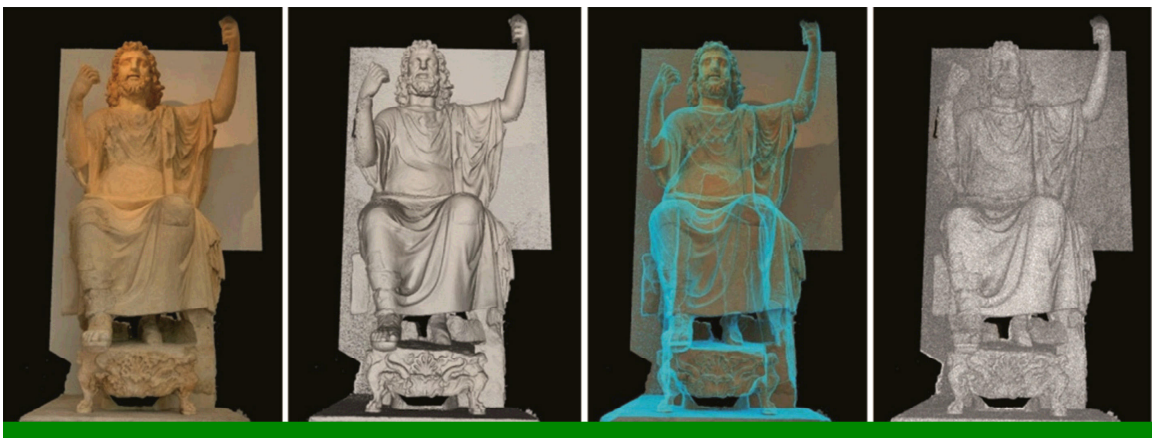

Fig. 4. Statue of Zeus sitting on a throne (Salinas Museum)

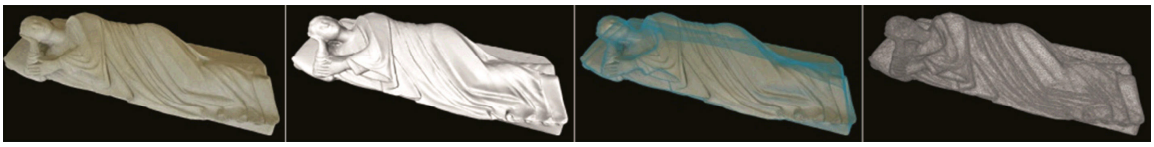

Fig. 5. Sepulchral statue end of XIV-beginning of XV century (Castello Ursino Civic Museum)

Fig. 6. Marble bust Agrippina Maggiore (Castello Ursino Civic Museum)

Fig. 7. Head of Arpocrate (Castello Ursino Civic Museum)

Fig. 8. Fragment of door cornice (Castello Ursino Civic Museum)

5 Discussion and Proposal

The models produced by the students are very impressive and, if you consider that some have also been made with mobile or compact cameras, the result is excellent even under the geometric profile.

Moreover, the heterogeneity of our target (students) in terms of age and cultural background should not be underestimated: those of Palermo attend the course of Drawing which is delivered at the 1st year of degree course in Environment Engineering (18–19 years of age), those of Catania attend the course of Digital Survey which involves students of 4th and 5th year of the degree course in building engineering-architecture (22–23 years of age).

Some of the students involved, especially those of the 4th and 5th year have followed up to the experience within the university courses also in their personal life experience: we refer to students who have produced 3D models of artworks exhibited in European museums (Louvre, Villa Borghese, etc.) visited during personal trips.

The results have given our idea strength aimed at identify a potential creator of 3D cultural content in the young visitor; therefore, visitor, appropriately engaged, becomes an indispensable resource for the development, dissemination, preservation and knowledge of the cultural heritage of society as a whole.

The crucial point is to identify how the results achieved from other crowdsourcing experiences and our experience can find an operational synthesis within an existing museum reality. Below the synthesis of the full process (acquisition, storage, valorization of the models) considering some technical and economic issues:

- **Technical features of the objects/models:** The geometric characteristics of the object do not affect the 3D reconstruction of the model. Problems were found attributable to the material that constitutes the object: for example glass and reflective metals. Particular attention should be paid in the acquisition of objects inside showcases. The features of the model in terms of graphics and metric accuracy are closely related to the resolution of the digital camera. Therefore it would be desirable that the museum could consider as initial investment the acquisition of two–three digital cameras with the same technical specifications.
- **Efforts/time required to the visitors:** It is desirable that on average a dataset does not exceed hundred images, so the time for the creation of a data set takes from 5 to 20 min. The timing of the loading and processing of the data set vary depending on the hardware features/power of cloud computing. Generally, the range is from one hour to five hour.
- **Copyright issues:** In order to guarantee the paternity of the creation of a model, models will be released in CCBY license, that include in metadata the name/s of the model creators.
- **Business rationale:** The business rationale has two main objectives: the first is to realize the 3D cataloguing of the museum collection, the second is to achieve a return in terms of number of visitors due to the media echo both of the initiative itself and of visual/cultural/creative impact of created models.

- **Operational rationale for the institutions:** The digital models will be stored for the conservation and will be disseminated as Open Data by using social media also by video, animations, interactive navigations, etc.; each visitor will have assigned a specific task, so there should not be any possibility of annoyance of the operation during the acquisition process.
- **Overall technical infrastructure and features of the system:** The museum will achieve the following features: digital database of photo archive of the collections items, 3D repository enriched by metadata linked to the objects, a team of experts that will design, check the quality of the models, maintain the technical infrastructure and give tips to visitors. Furthermore, the museum should foresee the use of a laboratory for workstations where the visitor could upload the data set and start the elaboration. And 3D prints of the model should before see.

Below we highlight some of the operational arrangements-to be implemented along the visitor's path so that he can be engaged and turns himself into a creator of 3D cultural content:

- Visitor must feel involved in the role of actor from his first step at the museum entrance: led lighting spots invite the visitor to become the 3D model author, addressing him towards the vision of a video tutorial;
- The video tutorial, following the introductory/emotional part, is divided in three main parts: creation of the data set, upload and configuration of software/platform parameters, upload of the 3D model;
- The visitor, who participate in the digital reconstruction campaign, could get rewarded thanks to compensation package as free tickets to the museum, score recognition, etc.;

To ensure that the integrated system can ensure an effective response from the visitor, it would be appropriate that the museum activates a promotional campaign through social media and involving school students too.

6 Conclusion

The integrated system structured as above, becomes a potential enrichment not only for the museum and the visitor/maker but also for the community and future generations. The museum experiences a continuous updating of its data fed from a cultural, technological and cognitive ferment bottom-driven, according to the ideals of participatory museum. The visitor/3D maker is involved in the enrichment of the digital cultural heritage with a starring role in a continuous upgrade of the 3D acquisition techniques, until then unknown to him, thus contributing to the growth of knowledge.

The community and future generations will benefit from the outcomes of such large archive, knowledge, dissemination and exploitation of artworks whose 3D visualization may solve museums remote reachability problems or, in the future, collections digital preservation. The operating methodological model described so far could also be extended to the works that are conserved in warehouses stock giving them the possibility

to be disseminated and studied; to museum environments; to architectural and civil infrastructure assets, and more generally to cultural heritage.

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