

Archaeological Syrian Heritage Memory Safeguard By Low Cost Geomatics Techniques

Gabriele Fangi¹, Wissam Wahbeh², Eva Savina Malinverni¹,
Francesco Di Stefano¹, Roberto Pierdicca¹

¹ Università Politecnica delle Marche – Ancona, Italy,

² University of Applied Sciences and Arts Northwestern Switzerland FHNW – Muttenz Switzerland

gabrielefangi@gmail.com, e.s.malinverni@univpm.it, r.pierdicca@univpm.it;
wissam.wahbeh@fhnw.ch, francy89disty@gmail.com

KEY WORDS: Spherical Photogrammetry, 3D Modeling, Documentation, Open Information System, GIS, Syrian Cultural Heritage.

In 2010, just before the war, professor Fangi made a trip in Syria and it was the occasion to make a fast documentation of some Syrian Cultural Heritage monuments. Most of the images were not taken properly to make a survey, but rather as a photographic report. Nevertheless, the images represent an important source of data, which can be processed in a rigorous manner, following the 4x4 CIPA rules, to obtain a 3D modelling by Spherical Photogrammetry. These surveys could be useful in case of reconstruction and in case of lack of a suitable alternative of metric documentation. Then, with the realization of an open access database it was possible to organize and collect all available data information supporting the documentation and preservation of Syrian monuments, sites and identities, and finally to share this documentation on different web platform.

I. INTRODUCTION

During the Arab Spring and the Syrian civil war the fighting various fronts reshaped Syria in different control areas. Beyond being a tragedy for the civil population, the conflict represented and represents even now a threat to the artistic and cultural heritage (CH) that underwent huge damages from military actions, clandestine excavations, illegal civil constructions and illicit trafficking of antiquities, but also acts of vandalism (some examples are depicted in Figure 1). During the civil war, almost 300 (UNITAR, 2016) heritage places of Syria have been raided. The research presented in these pages consists on the documentation of Syrian Lost Heritage (SLH), made possible thanks to the precious contribution given by prof. Fangi who took so many photos (almost 17,000) to most of Syrian CH monuments during his touristic trip in 2010, before the civil war began. [14]

The selected monuments for this project are 32, listed below according to the cities where they rise: Aleppo: al-Halawiye Madrasa and its mirhab, Minaret of Umayyad Mosque, Khan al-Wazir, al-Madina Souq, Citadel walls, Ayyubid Palace, Bab al-Faraj Clock Tower; Church of St. Simeon Stylites; Apamea: Roman Temple of Tyche; Bosra: Nabatean Arch and the Roman Theatre; Crac des Chavalier and Hall of Knights; Damascus: Umayyad Mosque, Azm Palace, Darwish Pasha Mosque, al-Sibaiye Mosque-Madrasa, Tekkiye Mosque, Minaret of al-Qali Mosque, Gateway of Qasr el-Heir al Gharbi, Hejaz Railway Station; Hama: Minaret of al-Nuri Mosque; Palmyra: Great Colonnade, Triumphal Arch, Temple of Bel, the Roman

Theatre, Tower of Elahbel; the dead city of Serjilla; Shahba: Filipeion and the Roman Theatre. Some of these monuments included the Syrian UNESCO heritage and all of them are inscribed on the ‘List of World Heritage in Danger’ in 2014. [14]



Figure 1. Examples of war destructions in Syria: collapse of Minaret of Umayyad Mosque in Aleppo (above), bombs hit the Temple of Bel in Palmyra (below)

Given the above, the aim of this research is to build a technological platform based on low cost digital techniques and open source tools, becoming a valid contribution to recover the lost heritage for a cultural rebirth and to give back the identity of Syrian population.

The Spherical Photogrammetry (SP) solves the first step of acquisition; the relational database collects and organizes all the information in a structural way producing some reports. The other improvement is the export of the database in a desktop Geographic Information System (GIS), to localize on the world satellite map the Cultural Heritage data to display the related data sheet or multimedia data, activating some hyperlink. Finally, the dissemination process is performed relying on the Web, using for example the *Google Earth* platform.

Our research is focused on the development of methods and technologies for the construction of 3D models digital library, representing architectural artifacts, in order to have access to information in real time on off-line or web-based systems. Analyzing different scenarios, satisfying standard and quality requirements, developing procedures, we provide the integration of different types of data and the knowledge of selected artifacts.



Figure 2. Examples of spherical panorama: Hall of the Knights, Crac des Chevalier (above) and the Roman Theatre of Palmyra (down)

In general, as the panoramic images are omnidirectional, it facilitates the operator in the field by freeing him from the constraint of the fixed field of view, inherent in the traditional camera. So it makes this acquisition method more affordable and cheaper than other surveying approaches, for cultural and architectural metric documentation. Panoramic images look impressive (see Figure 2), but to be suitable for measurement they must fulfill some rigid geometric conditions (Fangi 2007, 2010, 2013).⁷ The SP works by means of an analytical approach based on spherical images to realize 2D and 3D CAD modeling products (restitution and modeling phase can be seen in Figures 3 and 4). [2,3]

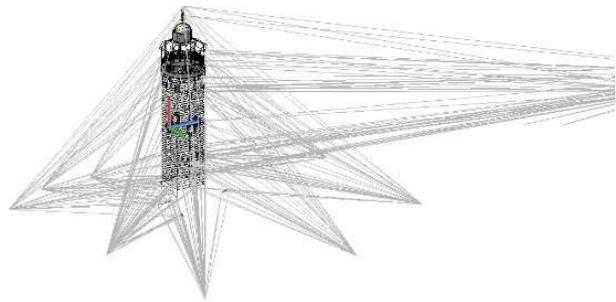


Figure 3. Restitution from panoramic images by SP and CAD 3D wireframe of Minaret of al-Nuri Mosque, Hama

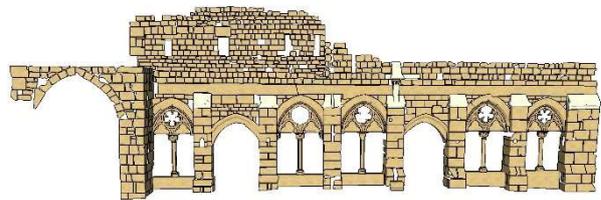


Figure 4. The 3D model of outdoor façade of Hall of Knights, Crac des Chavaliers (by F. Di Stefano)

Then, all the processed data have been organized by means of a database to retrieve quickly the information, useful for different purposes: historical analysis, architectural knowledge, promotional aspects and current states. According to the philosophy to use as soon as possible simple and well-known solutions we implemented the database core in Microsoft Access. This platform is useful to manage several records, each of these referred to a single object characterized by many attributes/features. [14]

II. CULTURAL HERITAGE INITIATIVES OF SYRIA

In line with recent research trends related to the Syrian Heritage, this work acts as a further enhancement of knowledge for the organization of information related with highly damaged buildings (or even no more existing). In fact, in the international panorama, CIPA organization is forwarding a similar approach (see, e.g., Ardissonne and Rinaudo, 2005, Lönnqvist and Stefanakis, 2009) with open access possibilities.

CIPA is not involved in targeted recording and documentation in Syria at the moment but will be first primarily using the existing data held by the CIPA members (images, metric and historical records, like maps, drawings and textual descriptions, as well as reports of archaeological studies) and to organize the data into a database structure useful to the conservators and restorers beside archaeologists and architects. [13]

The main aim of the CIPA project is concentrating on a specific goal: to provide the restorers and conservators with all the available data that CIPA has and provide links

which will allow the design of future actions. The second aim of the CIPA effort is to collect the existing data from other stakeholders to offer the possibility to transmit worldwide knowledge of this universal patrimony. [13]

The first step of the CIPA project is the data collection, and it is organized by following two different strategies. The first action is the description (by using the metadata structure described in the following paragraphs) of the data collected from the CIPA members, and in future the data collected from other providers. The second step is to attach the metadata for the data and to store the accepted data to allow the downloading it to the interested parties. All the collected data will be described in a synthetic way. At the end as the third step, it will be possible to design a database structure to be implemented inside a GIS (Geographic Information Systems) platform. [13]

Within this framework, the steps described in these pages cope with the same issue, enhancing the state of art with the final step consisting on the dissemination of all data archived by means of an experimental web shared system to gather, visualize, and share data on-line using the *Google Earth* platform. [14]

III. METHODOLOGY

Spherical Photogrammetry

The photogrammetric reconstructions are based mainly on SP even if there are many variables in the workflows due to the possibilities to integrate various techniques. The advantages are the high resolution, the FOV up to 360°, the low cost, the completeness of the information and the high speed of takings photos. On the contrary, the plotting and the orientation are, up to now, fully manual. Nowadays more accurate and efficient tools and instruments are available for CH recording, such as laser scanning, and dense multi-view 3D reconstruction. The following examples are created with different workflows using SP, sometimes in combination with other surveying technologies.

It was mainly conceived and designed for cultural and architectural metric documentation. It was introduced by Fangi [9,10] subsequent to the research carried out by Luhmann and Tecklenburg (2004) and by Schneider and Maas (2005). [12] Since then it has been tested on several projects, performing the orientation of multiple panoramas and manual 3D object reconstruction. SP performs the bundle block adjustment (Fangi&Nardinocchi 2013). [7]

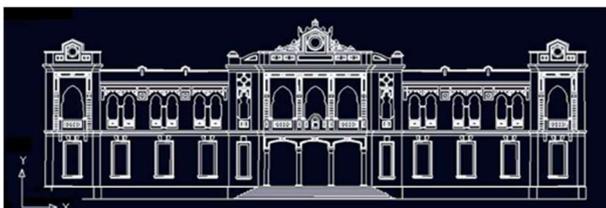


Figure 5. Damascus - The Ottoman Railway Station (by C. Olimpio)

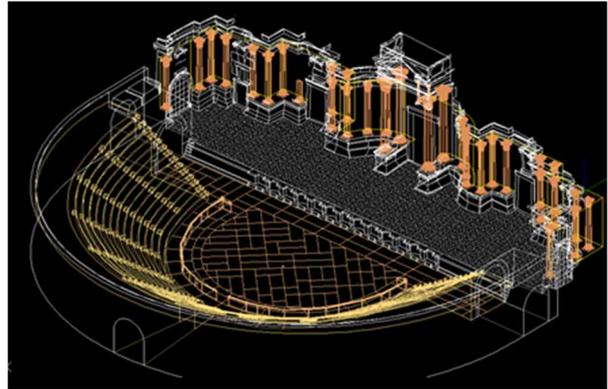


Figure 6. Roman Theatre of Palmyra (by E.Ministri)

Starting from the SP orientation, is possible to use the 3D modeling tools to create the 3D models basing on the rules of the projective geometry with a method called panoramic image-based interactive modeling; this technique is suitable for the architectural survey because it is a “point by point” survey (conversely to dense matching techniques which produces point clouds) and it exploits the geometrical constraints of the architecture’s geometry to simplify the 3D modeling process (see Figures 5 and 6). [4] Therefore, the surveyor has to comprehend the geometry of the architecture before modeling it. In this approach, the modeling methodology is based on the use of texture mapping techniques in a generic modeling software as virtual projector of an image, and thus to be used to model an architectural object (see Figures 7 and 8). If the projection centre and the orientation are fixed in the 3D virtual space, objects could be created, moved and modified to match the projections. [8] Objects therefore take the right shape and location in the virtual space of the surveyed elements. It is an interactive modeling technique because the interaction between the modeled objects and the projection of the images is visible in real-time. As well, the quality of the model could be verifiable in various interactive ways. [12]



Figure 7. The Minaret of the Omayyad Mosque (by Aboufaires, Wahbeh)



Figure 8. Bel Temple (by W.Wahbeh)

Data Archiving

This research sets the objective of creating an Architectural Heritage cataloguing by means of an Information System (IS), to access, in simple way, to different types of multimedia contents (images, drawings, 3D geometric models, animations, videos, descriptions, localizations, and so on).

The knowledge and the documentation are essential and very important to protect and to promote the CH documentation to a wide public. The cataloguing in standard format of every available data allows deciding the priorities and the type of actions for the monument maintenance and restoration.

Due to an efficient action of protection and enhancement of cultural and environmental heritage it is useful a creation of a basis of knowledge. In this way, the methodology of work continues with the creation of a digital data archive dedicated to the achieved heritage of Syria, making easier the management of their information, also updating time by time all the data collected.

Among the available DBMS (DataBase Management System) softwares, *Microsoft Access* allows to organize complex and basic database based on a conceptual model, easy to manage, that can produce a final report in automatic way too.

Every investigated CH is stored in each record of a unique table (see Figure 9) and consequently the possible type of relationship is one-to-one, recording some special information applied to a specific product, so the table share a common column or columns, useful to search, in a simple query, the information. [1]

ID	Project	Location	Country	Region	City	Neighborhood	Area	Style	Material	Builder
1	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
2	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
3	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
4	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
5	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
6	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
7	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
8	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
9	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
10	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
11	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
12	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
13	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
14	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
15	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
16	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
17	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
18	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
19	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
20	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
21	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
22	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
23	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
24	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
25	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
26	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
27	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
28	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
29	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
30	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
31	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine
32	Palmyra	Syria	Syria	Palmyra	Palmyra	Palmyra	Palmyra	Byzantine	Brick	Byzantine

Figure 9. Some records of the 'Object Table' (Microsoft Access)

A big opportunity is that the report is filled automatically, retrieving the information from the Object Table fields and displays them in an attractive and informative layout for printing or viewing on screen. It can be updated immediately when you update the 'Object Table' fields. Grouping and presenting data in many different ways make it a meaningful tool.

Reports provide a way to distribute or archive snapshots of your data, either by being printed out, converted to PDF or XPS files, or exported to other file formats suitable for the web sharing, such as XML files (see Figure 10). [5]

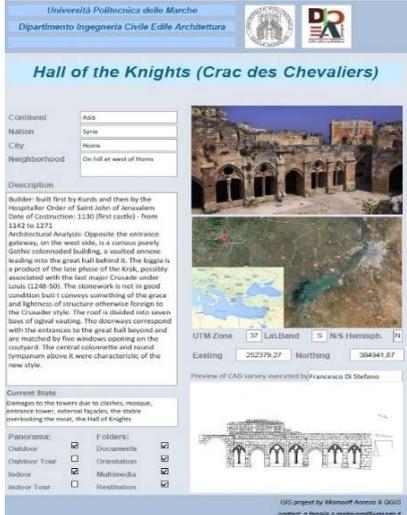


Figure 10. The report in form of data sheet summarizes the information of an architectural heritage stored in the database

It is well known that in a rigorous database design the metadata structure is essential to understand the real content of the data themselves. The proposal is to start with a simple metadata structure in order to be able to clarify the real information contents of the collected data. Following in the third step of the project a more rigorous attribute and metadata structures can realize a real database for a GIS platform.

Data dissemination

'Heritage information is the activity and products of recording, documenting and managing the information of cultural heritage places should be not only an integral part of every conservation project but also an activity that continues long after the intervention is completed. It is the basis for the monitoring, management, and routine maintenance of a site and provides a way to transmit knowledge about heritage places to future generations.' (Timothy P. Whalen) [6]

Maybe the most important factor for the protection and preservation of the monuments is the recognition of their value by the local people. And so people assign value to

the monument, you need them to know you and know your history.

Nowadays, the best way to promote the knowledge of the CH is using the web applications. Therefore, the dissemination of the monuments' information is an essential part of this project, once this diffusion of the CH contributes widely for its recognition and value assignment.

Regardless of immediate applications that led to the execution of the survey, once data is produced, it needs to be indexed, stored and preserved for later use. And to ensure that these data can be used effectively they must be disclosed, published and retrieved. That closes the cycle that encompasses planning, gathering, processing, indexing, storage, publication, dissemination, retrieval and use of data and information on buildings and architectural ensembles.

In this new approach, the result of this research is related to the dissemination of the CH database by means of the *Google Earth* platform. At the moment we have tried to use an experimental data visualization web application to gather, visualize, and share bigger table data on-line: *Spreadsheet Mapper* (*Google Docs* template). [14]

First step it was to identify all monuments analysed with a *placemark* on the *Google Earth* map using the coordinates recorded in *Microsoft Access* table. [14]

Then we have uploaded the data table from spreadsheet or CSV file and then filtered and displayed it on satellite map; successively we shall customize the layout according to our necessity. All the data are stored in *Google* or it will be possible to use other web spaces. The updating of any new table is very easy by means of the merge function that generates a single visualization including both sets of data and showing the latest value too. Exporting the KML file you can view it in *Google Earth* or providing a dynamic link to *Spreadsheet Mapper*, any changes to the data online are reflected in *Google Earth* and share it to the community. The data can be shared at different levels and discussed with others, or to find public data combining with yours for a better visualization of all information in one place. [5]

To give more completeness, it is possible to 'lay' on the *Google Earth* map also the CAD survey realized by the SP, the modeled and edited 3D view. Software *SketchUp* allows to create a file format that make visible the 3D object directly on the map (see Figure 11). [14]

You can share only what you want, keeping some of your dataset private and publishing a subset of rows or columns according to own share permissions. This makes it a powerful tool when you want to diffuse and promote the knowledge of the building heritage on the World and their current state. It is as a big community that works together.



Figure 11. Dissemination on web by Google Earth

IV. RESULTS

Our plan of work is appropriate to show the achieved results. From many simple photos, we arrived to reproduce the lost heritage through 3D or 2D model for their documentation, using the SP. A technique of survey that lends a complete and flexible method and gives a metric and scale levels of precision of the analysed objects, that helps a possible future reconstruction of the damaged monuments.

We have collected all the data into specific folders to make order and, for a first archiving of information, we have designed a table. We got the best result creating a relational database (*Microsoft Access*) thanks to multidata management system, fast information input and efficient final reports ready to be consulted. Beyond representing a form of dissemination, the database can be updated adding or modifying information giving a dynamic and current state of the objects.

The web shared system allows to publish all the results through the *Google Earth* platform showing templates and edited CAD models directly on the on-line map, and so to facilitate the data access and become a powerful tool for interdisciplinary communication. Moreover, it's possible to consult these results on ARCHDBWORLD, an Heritage Information System patented by members of Università Politecnica delle Marche to share information, e.g. spherical panorama, database and reports, of CH around the world documented by Fangi. [5]

IV. CONCLUSION

As a conclusion, we can state that the documentation process for architectural and urban sites, because of the amount of variables involved and resources allocated, is a complex and multidisciplinary activity, involving traditional disciplines such as architecture, design, survey methods, history and art history and strongly combining digital microelectronics, computer science and information science, involving significant technological, financial and human resources.

The documentation can't protect physically the

buildings, but can provide information for their restoration in case of any accident. However, in case of the building completely wracked, the multimedia database could preserve its memory for the future generations and educational purposes. We are witnessing to the increasing awareness, by all the actors involved in the preservation process. This show that it is worthwhile to make all these information public and, moreover, to share among the research community these priceless sources of data. For instance, the storages, archives, museums, datasets and databases of DGAM (Directorate-General of Antiquities and Museums of Syria) are central in saving the cultural heritage of Syria. Apart from the initiatives of UNESCO (the United Nation, Organization for Education, Science and Culture: UNESCO Observatory of Syrian Cultural Heritage and the project Safeguarding Syrian Heritage at www.unesco.org), ICOMOS and ICORP (International Committee on Risk Preparedness, www.icorp.icomos.org) organizations under UNESCO are specialized in safeguarding the cultural sites, the latter especially in the case of catastrophes. ICCROM and ICOM under UNESCO are active in conservation, restoration as well as storing artefacts. UNITAR (www.unitar.org) under UN with its UNOSAT program has collected satellite data of the damage at heritage sites in Syria. The World Monuments Fund is also supporting the site preservation in Syria. SHIRIN International (Syrian Heritage in Danger: an International Research Initiative and Network at www.shirin-international.org) and EAMENA (Endangered Archaeology in the Near East and North Africa at Oxford University, www.eamena.arch.ox.ac.uk) are organizations working to save the Syrian heritage based in Europe. [13]

Through the public divulgation of this architectural heritage database, we hope to contribute for historical sites preservation by promoting their knowledge. The valorization of these urban sets is an effective way to protect them and call the attention for the urgency of a heritage protection policy and the risk they are submitted continuously. By the end of this project, it is expected that all this data and information will be available at the project website on the internet.

REFERENCES

- [1] Amorim, A. L., 2011: Methodological aspects of architectural documentation. In: Proceedings of XXIII International CIPA Symposium, Prague
- [2] Fangi, G., 2007. The Multi-image spherical Panoramas as a tool for Architectural Survey. In: ISPRS International Archives, Vol. XXXVI, Part. 5/C53, CIPA Archives, Vol. XXI, pp. 311-316.
- [3] Fangi, G., 2010. Multiscale Multiresolution Spherical Photogrammetry With Long Focal Lenses For Architectural Surveys. In: ISPRS International Archives, Vol. XXXVIII, Part 5, pp. 228-233.
- [4] Fangi, G., Pierdicca, R., 2012. Notre Dame du Haut by Spherical Photogrammetry integrated by Point Clouds generated by Multi-view Software. International Journal of Cultural Heritage in the Digital Era, Vol. I, n. 3, pp. 461-478.
- [5] Gabrielli, M., Malinverni, E. S., 2007. Multimedia Database for the Heritage Information System of the Ancyra Project. In: Proceedings of XXI CIPA International Symposium "Anticipating the Future of the Cultural Past", Athens (Greece), pp. 323-417.
- [6] Letellier, R., 2007. Recording, Documentation, and Information Management for the Conservation of Heritage Places: guiding principles. The Getty Conservation Institute, Los Angeles.
- [7] Fangi, G., Nardinocchi, C., 2013. Photogrammetric Processing of Spherical Panoramas - The Photogrammetric Record
- [8] Fangi, G., Wahbeh, W., 2013 The Destroyed Minaret of the Umayyad Mosque of Aleppo, The Survey of the Original State, European Scientific Journal
- [9] Fangi, G., 2007, The Multi-image spherical Panoramas as a tool for Architectural Survey, 21th CIPA Symposium
- [10] Fangi, G., 2009, Further Developments of The Spherical Photogrammetry for Cultural Heritage, 22th CIPA Symposium
- [11] Luhmann, T. Tecklenburg, 2004, 3-D object reconstruction from multiple-station panorama imagery, ISPRS Workshop on Panorama Photogrammetry
- [12] Wahbeh, W., Nebiker, S., Fangi, G., 2016, Combining Public Domain and Professional Panoramic Imagery for The Accurate and Dense 3d Reconstruction of the Destroyed Bel Temple in Palmyra, ISPRS Prague
- [13] Rinaudo F., Silver M., 2016: The CIPA database for saving the Heritage of Syria. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B5, 2016, XXIII ISPRS Congress, Prague
- [14] Di Stefano F. , 2016 – Il patrimonio perduto della Siria, documentazione e archiviazione – GraduationThesis, Università Politecnica delle Marche, Ancona