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XV to XVIII Centuries

Giorgio VERDIANI (Ed.)

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BasiliCastle: the digital Atlas of Castles in Basilicata (Southern Italy)

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Abstract

The Institute for Archaeological and Monumental Heritage of the National Research Council, in cooperation with the Italian Institute of Castles - section of Basilicata, has designed and developed the digital Atlas of Castles of Basilicata. This Atlas, named BasiliCastle, aims at being a concrete contribution to the knowledge, fruition and promotion of the fortified architectural heritage of Basilicata. It includes a WebGIS and an App. The WebGIS is based on free geographical data and it is shared and supported by OpenStreetMap platform. The App provides users with a detailed geographical data, the historical and architectural description, pictures and 3D models of the castles. BasiliCastle has been developed using an Open Source environment and allows to share all the data which are fully available to users.

Keywords: Digital Atlas, Conservation, Historical Heritage, Fortified Architecture

1. Introduction

The aim of BasiliCastle project is to support fortified heritage study projects with innovative methodologies and integrated technologies for its fruition and promotion but also for conservation. Actually the use of new ICT technologies and applications in addition to support the study and sharing of data on cultural heritage can also give a strong contribution to our purpose. In this regard, BasiliCastle [Masini *et al*., 2014] is an open WebGIS that contains the essential information on the castles of Basilicata with particular reference to history, architecture, restoration works, accessibility. It is based on free geographic data (without copyright conditions) and supported by OpenStreetMap platform. The Atlas also consisting of the BasiliCastle App for smartphones, which

provides the user-visitor the same information of WebGIS and in addition of some 3D castle reconstruction.

Other Digital Atlas experience focused on the architectural heritage exists: some of this use Open Source software (Grass) and add 3D model reconstruction but the content is not available online [Ippoliti *et al.* 2011]; instead in some online catalogs the built heritage information frequently represents only an additional layer as part of the broader issues, such as that relating to the risk [Lanza & Lazzari 2010].

Fig. 1- BasiliCastle Atlas: home page.

2. The case study and the methodology

In the Basilicata region there is a dense network of about 170 fortifications, testifying to several centuries of history, architecture and archaeology of this area [Santoro, 2014]. The oldest structures date back to the XI century and were built *ex novo* by the Normans or on preexisting structures (Lombards or Byzantines). In this period, it begins to form a defensive system throughout the region, in order to control territories, rivers, valleys. Between the XI and XII century many castles and fortified settlements in Basilicata underwent military sieges that destroyed them partially or totally: new fortifications were built, or the old ones were repaired. In the XIII century Frederick II Hohenstaufen and Charles I of Anjou had been completing the the defense system in the region, strengthening and building castles. The Aragons built several coastal towers for sighting and communication along the coast of the kingdom of Naples, in order to stem the Saracen and pirate incursions. Most of them are well preserved [Licinio, 1994; Masini, 2006; Santoro, 2014].

Towers, castles and city walls were transformed over the centuries according to the geographical and historical context, to the present day. The current challenge is the knowledge but also the preservation, interpretation and dissemination, for a total restitution of heritage to the community and to posterity.

The ICT includes technologies (components, systems and software programs) and Applications (virtual reality, 3D) and their use for Cultural Heritage knowledge and protection is widespread [Gizzi & Masini, 2015].

With regard to the format of the contents, the use of Open Data is essential: they are fully accessible (without restrictions) and reusable (respecting license, imposed by those who produced them) [OKF, 2016]. They are key to sharing content and global participation for the cultural heritage knowledge or study activities but also for its protection and fruition. From this point of view, the possibility to develop a webGIS, through the union of the web programming languages and of the GIS, is fundamental.

A webGIS is a digital platform based on geographic information that could be completely consulted and explored simply with a browser and is an excellent instrument to spread information, to share data and to support decisions.

The applications for tablets and smartphones have come strongly in our lives. The use of these APPs in digital enhancement and fruition of cultural heritage, offers a large range of opportunities and ability to communicate and interact with the cultural object [Fritz *et al.*, 2005; Arduini, 2012; Bonacini, 2014; Gizzi *et al.*, 2013; Gizzi & Masini, 2015]. At the same time, they allow the divulging to a wider audience and not defined, to a variety of

possible users, increasing and encouraging the virtual and real contact with the cultural heritage. Possible uses of APPs for iOS or Android systems are several: from the thematic investigation of a particular artifact to guides into an archaeological park, from the exposure of a virtual exhibition to the display of multimedia content. The apps are flexible platforms which allow to explore different contents including also 3D models which are very used tools for the visualization of cultural heritage [Caprioli & Scognamiglio, 2009; Vetrivel *et al*., 2015; Pecci *et al*., 2015]. Fixed rendering and virtual movies allow enjoyment, engaging and immersive visualization, and virtual tours of the cultural object. We can re-create spaces or landscapes within which to move, interact with the environment, access to information sheets with text and images or media content. 3D models that may be of historical reconstructions of the cultural object in its specific historical period or a reproduction of his current state.
The integration of the technologies mentioned above has made possible the design and implementation of the BasiliCastle Project.

3. BasiliCastle: Project phases and results

3.1. The Castles of Basilicata: census, study, classification

The first phases of the work realize a census and a classification of the castles according to the period of construction and architectural features. Four typologies have been distinguished: the castle tower type, the defensive walls, the fortified palace and the castle with courtyard.
The tower type of castle includes independent structures used as observation points and also towers remaining part of a larger fortification. The primary role of these towers was to observe and to control the territory, but also as fire signal post and guard-posts. With their characteristic compact footprint size, these structures were tall and usually higher than the castle. These towers had a massive walls structure and were divided into many overlapping levels. Their walls usually had arrow loops, and the tops could have hoardings or be crenelated roofed. The defensive walls type includes all the external structures enclosing the castle. They were almost always masonry structures, made with stone or brick and with stone around their bases. Construction quality of this type was very high and the materials worked in them was brick or stone. They were disposed according to the topography of the area in order to protect the included castle or the settlement. The castles type itself may be divided into palace, castle with towers and castle with courtyard. The first architectural and historical derivative of the castle is the palace. This fortified palace with a space planning solution had internal spaces including some rooms for habitation. These fortified structures presented a complex and organic lookout and defence system (such as observation towers, fortified towers and other lower structures). The second type is the castle with towers. Sometimes these towers have been built in four angles of the castle, such as the Castle of Venosa, or they were placed at intervals along the external walls of the castle, such as the Castle of Melfi. Thus, these towers can have a rectangular, square, round or multifaceted shape [Santoro, 2014]. The last type is the castle with courtyard. The spaces of these castles include many buildings often with an irregular shape located over the perimeter of the area and also an internal courtyard, such as the Castle of Lagopesole that has a rectangular perimeter the involves two different courtyards [Masini, 2006].
Almost all of these castles were located on the rocky hill in order to control the territory and they were constructed with high quality and resistant materials in order to resist to the enemies attack. The results of our classification reveal that castles are the most abundance (70%) in Basilicata region. The towers (18%) are in the next rank, and in the last rank are the defensive walls (12%) [Santoro, 2014].
The cards created for each fortified structure are composed of the following items: localization; description (historical and architectural overview); chronology; technical data relating to construction techniques and materials; state of the monument

conservation and the eventual restoration; legal status; sources and reference documents. It is considered appropriate to include in the cards also items relating to construction techniques and the restorations carried out over the years. In addition, they were included items related to the reuse of the monument and the current legal status, of the same castles are legally belong to the state, others belong to private citizens. Each tab, finally, collects a bibliography of all the material published consulted. The cards obtained (Fig. 2) represent and provide the structure and the contents at the base of the digital Atlas.

Fig.2- An example of the Atlas card (Castle of Cancellara).

3.2. The BasiliCastle WebGIS

One of the BasiliCastle Project products is the WebGIS (Fig. 1, 2, 3, 4). The BasiliCastle team pays special attention to freedom and dissemination products and information that develops, so the Atlas:

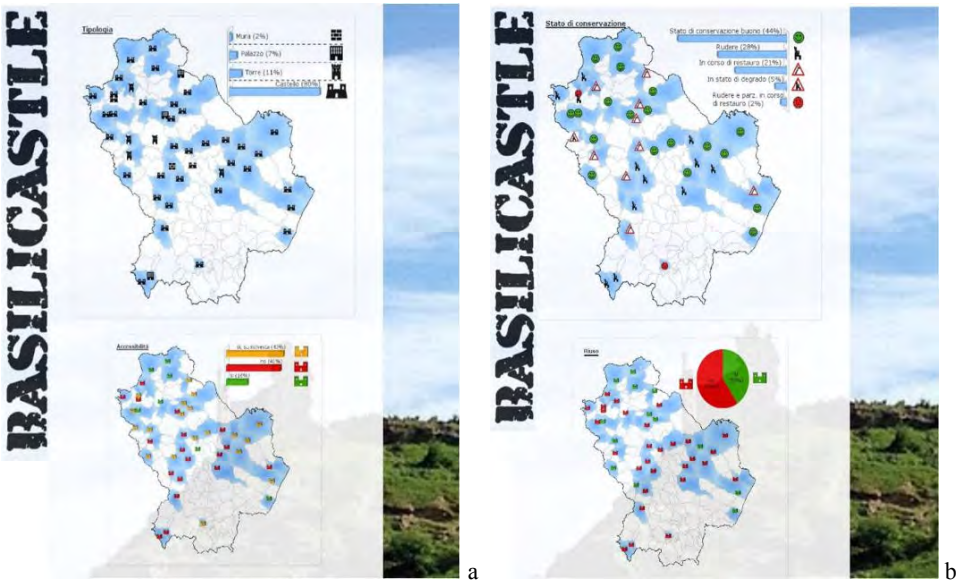
- has been developed using an Open Source environment, (with OpenLayers), and it is compatible with international standards of the Open Geospatial Consortium, which is based on free geographic data;
- it enables the sharing of data, so our content is fully available to users. They can be freely downloaded from the OpenStreetMap platform, in which it was included in the first phase of the project, but is also able to download from the webGIS page (www.basilicastle.it).

The data on fortified heritage are protected by Creative Commons 4.0 (License Free Culture), that is a copyright that allows free reuse, prior quote, of the material used, even for commercial purposes, provided that the resulting product is shared under the same conditions. From the homepage http://www.basilicastle.it it is possible to gain access to a bibliographic section, to a web page containing some infographics on the data related to the Atlas (Fig. 3) and obviously to the webGIS (Fig. 4). In this image it is possible to see the web interface of the Atlas. At the top left there are the instruments for the navigation of the map (1), while at the top right there are some buttons useful to download the data (2). By clicking on the single points it is possible to visualize some quick information about the castles. Finally, at the right of the page there is a mask (3) useful to query the internal database and to gain access to some more detailed information, inserted in a dedicated form.

3.3. The App for tablet and smartphone

Upon completion the Atlas, to enhance the dissemination of data on the forts of Basilicata and to make the information on castles everywhere, it was made the App for smartphones BasiliCastle. "Leafing" BasiliCastle the user-visitor will have the geolocation, the historical and architectural description and typological, some curiosity and the castles of Basilicata. At the time BasiliCastle is downloadable from Android devices. The app for Android devices

"Basilicastle" was realized using free platform "App Inventor 2"[1] [Wolber *et al.*, 2011; Sanchez, 2014]. This suite is equipped with quick and simple interface for the realization of very complex applications and also does not require knowledge of programming languages. Once created the graphics and added content we proceeded to the building of the basic logical pattern that allows operation.



a b

Fig.3-Thematic maps of the castles of Basilicata related to their typological features and accessibility (a), conservation state and reuse (b).

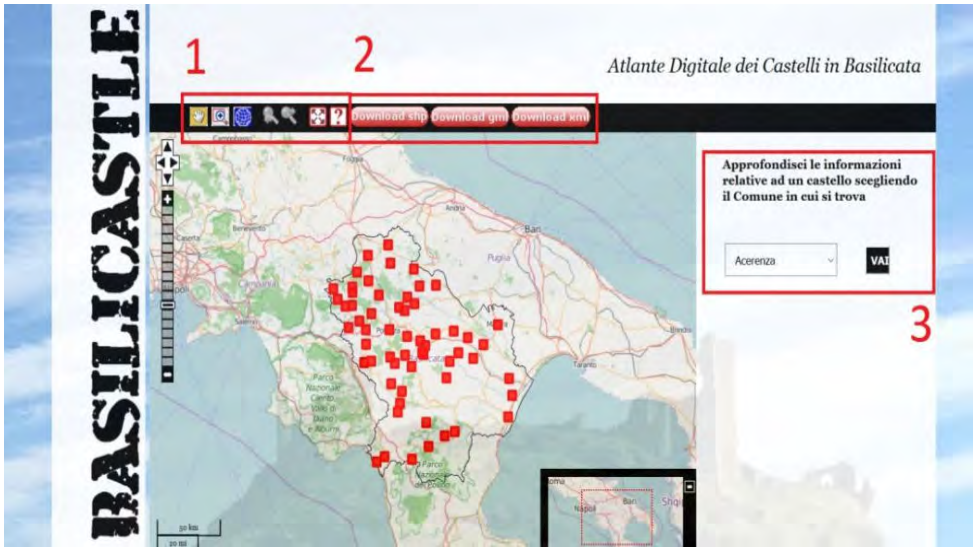


Fig. 4- The BasiliCastle webGIS.

3.3.1 3D Model Reconstructions

Finally, the addition of 3D model reconstructions greatly enriches the App and improves the user experience.

The BasiliCastle team realized some 3D model reconstruction through photogrammetric acquisition performed by a low cost drone (Dji Phantom Vision 2 Plus) and the processing data performed by Agisoft Photoscan Professional software.

The photogrammetric acquisition is conditioned by the topography of the site, the presence of potential hazards such as electrical cables, buildings, etc., the weather conditions and the stability of the flight deck. In our case, and according to our configuration, the movement of the drone are monitored on smartphones and controlled in real time. The shots are automatic by setting the time-lapse feature to 3 seconds.

Planned flight and prepared the APR[3] we proceeded with the flight and in the acquisition of the images. For a complete and detailed photogrammetric coverage, the drone shot zenithal (at a constant height of 30 meters above the ground) and nadiral photos around the entire castle. Subsequently, the photo shoots to get the point clouds were processed, the mesh and finished products such as textured 3D model with Agisoft PhotoScan software. This program is characterized by user-friendly interface and is based on a flow of highly automated and comprehensive work (manages the entire work phase, the orientation of the picture until the creation of the outputs).

The 3D models made were uploaded on Sketchfab[2] website. For example, UAV surveys, performed for the Castle of Valsinni aimed at providing a 3D model of the entire castle, including some archaeological excavations, with a very high detail enabling us to analyze building techniques and decay patterns of masonry. Fig. 5 shows the 3D model of the castle, obtained by processing two datasets of images. In order to provide a detailed survey of the Castle two flights, in automatic and nadiral mode at 40 meters of height and in manual, oblique and nadiral mode at a height from 10 to 15 meters (Excavated courtyard) were made.

The digital images were loaded in Agisoft Photoscan Professional software. In order to create the 3D model, the usual Photoscan workflow was followed. For the first flight (named Castle) the first stage was the automatic alignment of the 450 selected images. Then a sparse point cloud (442K points) and a dense point cloud (16.7 M points) with the matching points in the images was obtained. The second stage of the pipeline was the mesh (2.2 M faces and 1.2M vertices), so the model geometry was built, resulting in a first 3D surface. The last stage was the textured model that allows a photorealistic visualization (Fig. 5). The same workflow was followed for the second flight (named Excavated Cortyard) and the details of the two models are summarized in Table a.

4. Discussion

This work demonstrates that an essential part of a larger conservation process is to merge heritage knowledge with the use of information and communications technologies (ICTs) to support oriented to accessibility, sustainability and the active citizen dynamics.

The BasiliCastle approach has led to the creation of open source products (webGIS, App, 3D model reconstructions), and promotes the use of innovative low cost technologies for the growth of a cultural identity of local communities.

The BasiliCastle contents are available on line (the user has also the possibility, through OSM, to cooperate) and completely open; their fruition is user friendly, also for mobile users. Regarding the interaction between local communities and ICT the importance of mobile technology is constantly growing because it facilitates the access and interaction with citizens information and encourage their participation [Han *et al.* 2016; Gizzi et al. 2013]. For this reason, we intend in the future to increase community participation by making

interactive the existing BasiliCastle App.

Moreover, among the future developments we mention the production of other data for a complete, loadable and interoperable system, which converge on regional and institutional websites.

Notes

[1] https://ai2.appinventor.mit.edu/

[2] Sketchfab is a website designed and developed by Cédric Pinson the beginning of 2011. This web platform allows you to share and view 3D models online through a 3D viewer based on WebGL, a technology that allows you to observe the 3D model of mobile web or pc desktop. The viewer can also be embedded on third party websites. https://sketchfab.com/

[3] For the purpose of our investigation we used a low cost drone Dji Phantom Vision 2 Plus equipped with a 2-axis gimbal very stable and mounting a Dji camera which can shoot video in Full HD and take photos in 14 megapixels.

Fig. 5- Processing of aerial images captured from drone. (a) Dense cloud of 3D model; (b) mesh wireframe of 3D model; (c) textured 3D model.

Datasets	Number of images	Sparse Point Cloude	Dense Point Cloude	Faces of Mesh	Vertices of Mesh	Texture (pixel)
Castle	450	442.320	16.666.336	2.236.195	1.121.684	15.000X15.000
Excavated courtyard	418	1.124.359	42.365.131	5.684.314	2.851.273	15.000X15.000

Table a- Details of the two models processed for the 3D reconstruction of the Castle of Valsinni.

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