

A DATABASE FOR THE ARCHITECTURAL HERITAGE RECOVERY BETWEEN ITALY AND SWITZERLAND

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ABSTRACT:

The purpose of this paper is to show some results coming from the international Interreg-AlpStone project, a research whose main aim is the protection and valorisation of a rural Cultural Heritage, theme of recent growing interest. In particular the background of this contribute is the traditional stone architecture placed in the territory between Italy and Switzerland, while into the foreground is put the method to right document, archive and analyse information about the objects of study. The response comes from BIM technologies (acronym of Building Information Modeling) which objective is the creation of a dynamical and interoperable system allowing the share of information through a unique database. If these methods have been largely employed on new constructions, they still haven't been enough tested on the field of historical architecture. In order to fill this gap, the paper suggest a method leading to the creation of a Cultural Heritage information system, which arise during the survey phase and continue through the detection of different building information, the proposal of recovery solutions, the asset georeferentiation on the territory and finally the moment of sharing information on a web platform. The creation of an architectural database is made possible by a survey based on point clouds. The latter constitute then the input data for the creation of a 3D model made with a parametric software allowing the increase of various kind of information. The future work plans will complete this project by locating the Cultural Heritage models on a webGIS.

1. INTRODUCTION

The field of rural architectural heritage protection and conservation is nowadays an issue of growing interest: a cultural awareness toward an endangered asset that finds its roots in traditions and customs characterising a certain area is increasingly drawing the attention of both professionals and local people.

This will of revitalising the past is well supported by the improvement of the nowadays technologies and ways of communication.

In particular, what is interesting is not just the practical tools employed for the protection and valorisation of the heritage, but, first of all, the methodology and the setting out of the work.

It is in this sense that thinking in terms of "database" should mean a great step forward concerning the efficiency of information exchange, work in team and continuous up-to-date. This approach is increasingly entrenching in the field of new constructions but it isn't yet enough developed in relation to the intervention on historical heritage.

Some researchers have however already effectively begun to explore, even if from different points of view, the way to make use of the advances in digital technologies in order to intervene on an "as-built" architecture.

A study developed by Tom Maver (Maver, T., 2001), whose main objective was the understanding and preservation of some Scottish assets, is the possibility to create virtual 3D models of the Cultural Heritage. In this way the important buildings can be explored and interrogated by tourists, professionals and students. Analogous researches (Kwon, Y-M. et al., 2001, Vlahakis, V. Et al., 2001) demonstrated how 3D models can be managed through a web service in order to permit a

transcontinental exchange and to promote a cultural education (with a 3D cyber museum for example, as exposed byKwon, Y-M. et al., 2001). A little bit different approach is visible in researches made by the University of L'Aquila (Centofanti, M. et al., 2011; Centofanti, M. et al. 2012). Their studies mainly focus the attention on the management of different information in a database whose users won't necessarily be tourists, but, above all, professionals and technicians who plan processes of restoration, maintenance and management of the cultural heritage. With this aim they give a more global view, stressing the necessity of defining a geo-referenced information system integrated to digital 3D models of historical architecture.

However, it still doesn't exist a consolidated method that put together the different aspects raised by the authors mentioned with the intention of creating an interoperable and dynamic database of historical Heritage exploitable by both the professionals and people interested in such an architecture. This broad theme is at the moment fringe research and the purpose of the present paper is to explore, at least in part, some possible solutions by suggesting a methodological process. Our need of creating an interoperable archive of Cultural Heritage has its origins in the Interreg-AlpStone project, a research oriented to the protection and valorisation of the rural traditional architecture widespread in the area between Italy and Switzerland.

The first essential step has been the definition of a work methodology and a general scheme where the information will be placed. As the achievement of the objective requires the contribution of operators having different kind of knowledge, it needed a tool permitting a high level of interoperability. The response necessarily comes from the BIM process.

This approach permits a good management and data sharing too.

The present paper is consequently organised in way of showing the BIM methodology applied to the Cultural Heritage at the different scales required by the research: from definition of virtual 3D graphical models and related data tables till information about the territory (given by a GIS).

Since the research is still in progress, some items are just presented as future plans and will presumably be object of future publications.

2. METHODOLOGY

The current investigation has involved an important theoretical phase focused on the setting-out of the work and, at a later stage, a phase of practical experimentation of such a process.

The macro-objective of the Interreg-AlpStone research is the protection, valorisation and management of the traditional stone architecture placed in Ossola Valley (Italy) and Canton Ticino (Switzerland). The essential condition in order to achieve this aim is the availability of many documents and consequent elaborations. With the purpose of realising a functioning Cultural Heritage information system employable by several professionals, the best solution is to use just one meta-model able to manage data of different nature. The intermediate goal, the one investigated by the paper, is therefore the determination of the most efficient instrument able to collect, analyse and easily interrogate the huge quantity of data related to the buildings. In other words, it is necessary that the different tools employed during the research have a common denominator that permits them to easily communicate. The project is therefore articulated in the following moments:

1. A knowledge moment, which aim is to have a first approach to the asset by both an historical documentation (archival documents, chronicles, etc.) and an accurate geometric survey (morphology, metrical data, etc.);
2. A critical study moment, when an analysis is required from several points of view, as for example the constructive building technologies (materials, structures, etc.), the conservation conditions (structural problems, signs of decay, pathologies, etc.) and the detection of characteristic components (finishing and decorative elements, frescos, etc.). During this step a possible way of taking advantage of the BIM technologies is given by working with 3D interrogable models;
3. A proposal moment, defining hypothesis for a restoration planning;
4. A sharing moment, when the information is made available to an extended number of people. This step, still in phase of development, will include the use of web platforms, easily interrogable and in some cases modifiable by different kind of users.

All this phases are thought with a background made up of territorial geo-referenced data in order to properly collocate every piece of information in its specific area.

The will is indeed to integrate the 3D digital models with webGIS: in this way the interoperability and exchange of data should be extended not just to different professionals working on the same area but also to people studying physically distant architectures.

Next paragraphs explain in a more detailed way the methodology used during each of the previously mentioned moments.

2.1 Knowledge moment

The tools employed during the knowledge phase have to be chosen with regard to the kind of object to be surveyed and the target of the study.

Since the paper focuses the attention on historical heritage (where every element is different from the others and possesses its own value) and the aim is to create a dynamic database (that find, as seen, a synergetic support in tridimensional models), the most efficient way to have geometrical data is to make a survey whose output is a point cloud.

This goal is nowadays achievable through different techniques and the choice is made in function of survey conditions, time, costs and expected precision.

In particular, we have tested the laser scanner and photo-modelling techniques.

The first one is expensive but, in a very short time (few minutes) is able to create very dense and precise point clouds (millions of points), which can be also geo-referenced (figure 1). On the other hand the photo-modelling, a technique based on multiview camera images, is cheap and more easily applicable in case of inaccessible buildings; it however requires longer time for the snapshots and the precision is a little bit lower.

Others techniques could anyway support and integrate these two methods.

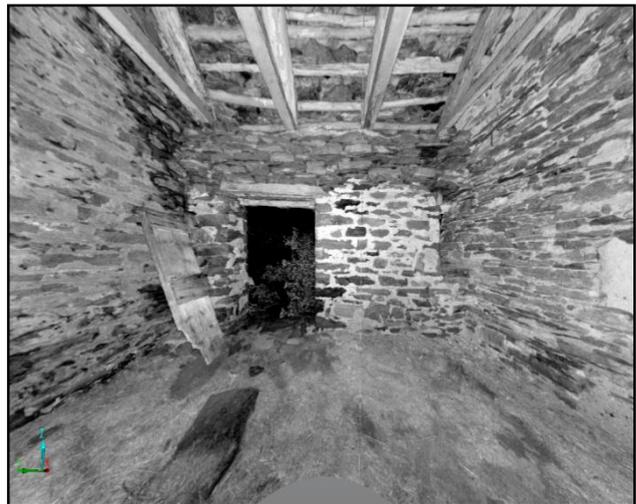


Figure 1. Laser scanner survey of a Veglio (Piedmont, Italy) interior building

2.2 Critical study moment

This is a central phase, where probably the competences of more than a person will contribute to the collection of information about the Cultural Heritage object of study.

It is indeed in this phase that the use of BIM technologies becomes of fundamental importance in relation to the work methodology.

It has however been unavoidable the obstacle represented by the same philosophy of the BIM, which is expressively conceived for the architectonic projects. The parametric software belonging to BIM process do not refer anymore to basic object as lines, spline or geometric surfaces, but to complete components as windows, doors, walls, etc. Every element can be modelled so that it owns functional relationship and associated properties. These concepts make slightly problematic the use of BIM to historical architectures, where every element differs from the other and often has not sharp-



Figure 2. Typical Alpine stone building

cut geometries: it is sufficient to have a look to the irregular stone walls of Ossola Valley buildings (figure 2) to understand how a parametrisation for every single component would be clearly unthinkable.

The challenge is therefore to find the way to best fit the potentialities of BIM to the necessities of the Cultural Heritage.

This paper wants to suggest a possible compromise over the issue, letting however opened the dialog with others researchers in order to perfect always more the techniques.

Since the inputs coming from the building survey are, as stated before, either data from laser scanner or photos, the first step is to manage a point cloud that, for its nature, is well inscribed on the BIM methodology in reason of the possibility to easily communicate with some parametric software.

For both the survey tools there are appropriate information technologies permitting the visualisation, the management and the post-process of data. The tools experimented by the research are in particular the following ones:

- Faro Scene and MeshLab for laser scanner data
- Autodesk 123D Catch, Agisoft Photoscan and MeshLab for models created from multiple snapshots.

Point clouds can besides be transformed into meshes, which means surfaces having the geometry of the real object.

At this point, the choice of our study has been to import both the point clouds and the meshes on Autodesk Revit software. It is important to keep in mind that while the point cloud can't have any parametric properties, the related modelled surfaces can be increased with other kind of information (and therefore become part of BIM). Well conscious of Revit limits (concerning in particular the difficulty of this program to think in terms of "as-build", as underlined also by the University of L'Aquila in Centofanti, M. et al. 2012), we have judged this parametric tool a good compromise if looking to the finalities of the research. Indeed, if it is true that creating a model on Autodesk Revit, will necessarily decrease the precision and fidelity to the reality, it is also true that the mesh and the point

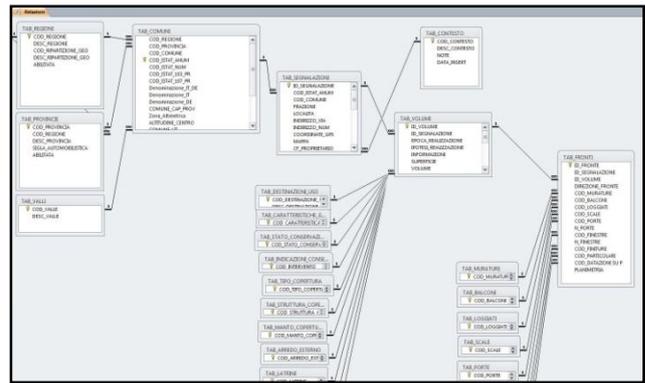


Figure 3. Access relationships

clouds are still present in the same file. In other words, with the awareness that the recreated model will necessarily be an idealisation and won't include information about the irregularity, for example, of openings and fallen walls, the users will however have the possibility, in every moment, of switching on the mesh in order to visualise and measure it.

Accepted this compromise, it is now possible to take advantage of the potentialities of the software: different kind of information about the building analysis can be associated to the objects in a dynamic and interoperable way by different people. The 3D model will become even more "interrogable" by associating table data to graphical information. For this reason the research has focused the attention also on the development of Microsoft Access tables that step by step support the user starting from the survey moment till the database interrogation. At this point of the research two types of Access tables have been developed:

- A general database concerning the surrounding where the Cultural Heritage is located. The professional has to give information about the kind of environment (mountain, hill, lacustrine, etc.), the geographical localisation, the basic cartographical documentation, etc.
- A more specific database containing information about the building (classification of every door, window, wall, roof, etc.)

Figure 3 shows Access relationships determining the connection between different kind of information of a same building.

Access tables are dynamically integrated in the Autodesk Revit model, so that the user who needs to extrapolate information can utilise, according to his necessities, either the graphical model or the table data.

In addition to the Access tables, each professional who increases the 3D model will automatically create a series of alphanumeric data dynamically joined with the graphical visualisation.

As a consequence this unique database will progressively become richer in heterogenic information ranging from the materials to the structures, from the pathologies to the finishing elements. Moreover, the user can decide what to visualise, add or modify at every moment.

2.3 Proposal moment

At this stage of the study, the Cultural Heritage is therefore well defined and analysed from different points of view. It is so possible to project the protection and valorisation of the building.

For example the Interreg-AlpStone research has focalised on the standards update (structural improvement, thermal insulation, intervention on *piode* roofs, balconies and modillions reinforce) without compromising the traditional values.

The utilisation of BIM technologies becomes now the natural continuation of the previous step: people who work at this stage will intervene on the same database created before, adding layers that increase the state-of-the-art information with data concerning the intervention moment.

In this case the BIM tools are therefore employed a bit more in their classical way, that means as a project instrument.

2.4 Sharing moment

The last step is the sharing of information in a web platform. This point is, at the current state of the research, still in progress of development. The objective is the creation of an extensive Cultural Heritage information system which provides different levels of accessibility according to the kind of user. That means that people who are effectively working on historical buildings will have some credentials letting them the possibility of increasing the platform by adding, integrating or modifying the data. On the other hand, people who don't have the competences or the needed authorisations will just be able to consult the information collected in the web platform.

This platform will therefore be studied in line with the BIM principles of interoperability, letting the users move from the tridimensional model to the data tables.

In order to make this plan feasible it is necessary to integrate the platform with territorial information, meaning the creation of a 3D geo-referenced GIS where the building models can be right and easily collocated.

The Interreg-AlpStone research will focus on the area between Italy and Switzerland, but the base idea is to extend this concept to a much wider zone, in way of maximising the interoperability and exchange of information. In other words the project wants to create an architectural information system where the user can surf on the territory and progressively come closer to the Cultural Heritage just varying the scale of visualisation till the reaching of the modelled building, containing the information of the database.

3. RESULTS

Since the main aim of the research is the definition of solutions able to valorise and protect the spontaneous architecture located between Italy and Switzerland, it has firstly been necessary to find and choose some significant villages to study. Veglio, hamlet of Montecrestese (Italy), is one of them and is the place hosting the examples showed in this paper. It is indeed a little village abandoned from its habitants about 60 years ago in reason of an avalanche risk: its typical stone buildings lie now in a state of degradation due to the lack of maintenance.

3.1 Veglio castle

The first case study has been the castle of Veglio, made up of a XIII century square tower and a XV-XVI century rectangular construction (Osello, E., 2012). Unfortunately the gable *piode* roofs have fallen down and the building presents clear signs of decay.

The study has been a chance for thinking in terms of BIM, starting from the first phases of knowledge till the 3D modelling.

Similarly to the procedure followed by Lo Turco M., 2012, the survey has been carried out with a laser scanner: 12 scansions, 9 outside and 3 at the interior of the building, allowed an exhaustive definition of the asset geometry. In order to successively join the point clouds and in view of the implementation of the survey on a GIS system, it has been necessary to predispose the georeferentiation of the building. For these reasons it has been created an internal planimetric network connected with a GPS sampler, which is able to supply the exact geographic position and altitude. It has firstly been necessary to place the GPS, which, connected to the Domodossola station, has furnished the benchmark useful to link the point cloud and the scansions. In order to allow the connection between scansions and planimetric network it is necessary to place some visible markers on the building and close objects that will be scanned. After that, the vertexes of the planimetric network (where the total station will be placed) have been located in way of surrounding the castle.

A step of data elaboration has then been necessary in order to get the correct coordinates of the planimetric network vertexes: this operation utilises the Bessel rule, which takes into account the right and left readings of the total station. These coordinates constitute the input information for the net compensation executed by Starnet software, which also permits the exportation of a local network image consisting of vertexes and markers (the markers coordinates will be fundamental for the point clouds georeferentiation).

The scansions are then opened in Scene software, where the georeferentiation is proceeded through the association of the coordinates -coming from Starnet compensation- to each of the marker before placed on the building and close trees (as showed in Figure 4).



Figure 4. Point cloud georeferentiation through the markers (Osello, E., 2012)

The georeferenced point cloud is at this stage exported in .PTS file, the unique available format compatible with Autodesk Revit software. It is now possible to start with the tridimensional modelling, that, as stated before will forcedly be a simplification of the scansion (Figure 5).

In Autodesk Revit every professional is enable to associate properties to the objects: the Veglio Castle Revit file owns indeed information about materials, structures, pathologies and data linked to Access tables easily interrogable.



Figure 5. Creation of a parametric 3d model of the castle from the laser scanner point cloud (Osello, E., 2012)

3.2 Residential and rural buildings in Veglio

Besides the castle, Veglio is a village made up of simple stone buildings, which original destination was either residential or rural (e.g. barns, mangers, etc.).

Since a goal of the Interreg-AlpStone project is to study and valorise this local traditional Cultural Heritage, a survey of the village is in progress. At this moment of the research this work is still a step behind if compared with the castle one because it lacks the georeferentiation.

However, 20 scansions with laser scanner provided the model of 15 interiors and 5 external sights.

Moreover, it has been the occasion to test the photo-modelling technique as a cheaper alternative method to be eventually exploited for other already planned surveys.

It consists in taking a series of photos with some criteria allowing the software to right model the object. Indeed, the images have to be shoot with a digital camera in good conditions of light, few contrasts, no shining or moving objects and have to be taken always with the same focal length and approximately orthogonal to the facade. Respecting these rules and comparing the 3D output of photo-modelling with the analogous laser scanner point cloud, we have proved that the precision decreases of 2-3 cm in a wall of about 50 m² if compared with the laser scanner model (Figure 6).

This is a satisfactory result if we take into account the

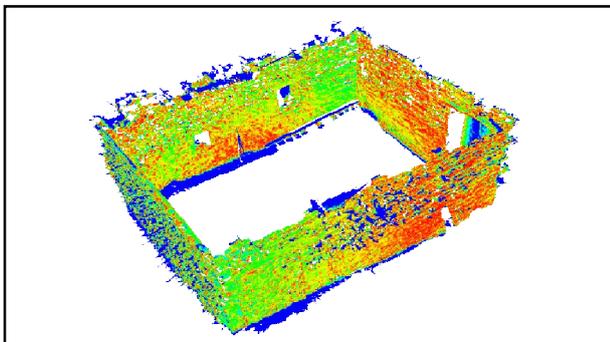


Figure 6. Comparison between laser scanner and photo-modelling 3D models: from red (indicating a minimal distance) to blue (maximum distance, set to 5 cm)

irregularity of the stone elements and low costs of the technique. The software employed for the creation of the 3D model and its post-processing are AgisoftPhotoscan, Autodesk 123D Catch and MeshLab.

Once the 3D point cloud has been obtained, the following goal concerned the modelling of the room. Since the strong irregularity of the walls will affect several aspect of the future recovery (e.g. thermal insulation, positioning of hydraulic lines, structural behaviour), it was necessary to model the walls with a discrete level of precision: in this case, indeed, the approximation with vertical walls would not have been functional. The challenge has been to find a way to draw irregular 3D walls capable of storing parametrical information. This objective has been achieved in Revit by drawing (with 4-5 points) some vertical profiles of the wall as “local mass”; they have then been jointed with the command “create form”, obtaining in this way a surface that can be transformed in wall and consequently become a parametric object. Figure 7 illustrate the model of the irregular walls.

3.3 Future work plans

The study conducted till now is projected to the realisation of a GIS system where placing the georeferenced tridimensional models of the Cultural Heritage.

The idea is to test the importation of the database coming from Autodesk Revit and Microsoft Access in software as ArcGIS or City Engine, both of ESRI.

A particular attention will be probably necessary in order to guarantee a right transfer of information and communication between different software. As find in the literature (Centofanti, M. et al., 2011), it will probably be necessary to add an intermediate step with another software (e.g. 3D Studio Max), being careful not to have data losses.

Once the GIS will be operative the following step is the creation of a web platform permitting a dynamic sharing of information. This Cultural Heritage information system could indeed be increased by professionals studying assets localised in areas different from the one between Italy and Switzerland (thinking for example at the work made by the University of L’Aquila).

At the same time another important goal of the research is the definition of solutions for a good intervention on the Cultural Heritage object of study. These aim will involve knowledge of technical architecture and will necessarily talks the BIM language.

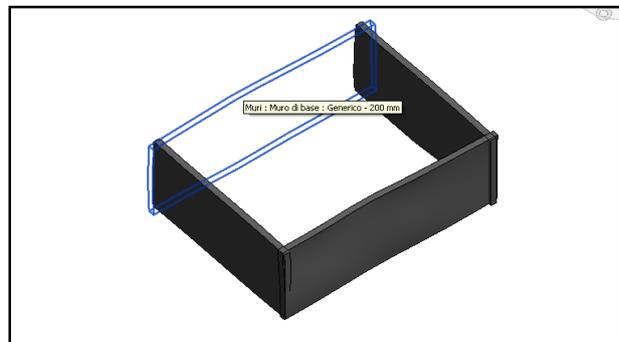


Figure 7. 3D Revit model of irregular stone walls

4. CONCLUSIONS

Prior researches have documented a new effort and attention in the field of Cultural Heritage. Indeed, new techniques are born in order to document, archive and preserve historical buildings. The technology improvement is going in the direction of 3D virtual models (Vlahakis, V. et al., 2001, Maver, T., 2001, Kwon, Y-M. et al., 2001) and GIS implementation (Centofanti, M. et al., 2012, D'Andrea, A., 2000), with the aim of permitting an easy dialogue between several operators. However, these studies often consider just some steps of the work and a global and interoperable methodology is still missing.

This paper follows the goal of suggesting a methodological approach involving all the phases, from the moment of survey till the sharing of information and begins to furnish some practical possible solutions.

The employment of BIM technologies in the field of Cultural Heritage is indeed possible and desirable: the interoperability will facilitate works in team, support the exchange of information and limit errors of transfer (there won't be transfers because the information is stored in a unique database). Moreover, the sharing of data on a web platform will allow an easy documentation about the historical heritage. The phases analysed in this paper show how a step toward the interoperability is offered by the possibility of shaping the Cultural Heritage with a point cloud, which can then be imported in a parametric software allowing the integration of different kind of information. These tools could be utilised for any object of cultural importance from different people and in different areas.

Nevertheless, some improvements are still possible: a limitation lies for example in the inevitably process of simplification from the point cloud to the 3D model and in the communication between software. Future research should therefore follow-up work designed to find a solution to these issues and improve even more the interoperability and sharing of data.

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