Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 223 (2016) 555 – 560
Procedia
Social and Behavioral Sciences

2nd International Symposium "NEW METROPOLITAN PERSPECTIVES" - Strategic planning, spatial planning, economic programs and decision support tools, through the implementation of Horizon/Europe2020. ISTH2020, Reggio Calabria (Italy), 18-20 May 2016

Laser scanner for the architectural and cultural heritage and applications for the dissemination of the 3D model

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Abstract

The development of new technologies surveying has allowed great strides to acquire spatial data for various applications. Among these, it the scanner technology is one of the methods That Allows for rapid and detailed acquisition of date. Particular and interesting application Concerns The Importance of cultural context as in the surveying of buildings, statues and artifacts and dissemination through Android apps, augmented reality and Webgis thus putting at the disposal of technical and historical information community through the use of new technologies.

Peer-review under responsibility of the organizing committee of ISTH2020

Keywords: Laser Scanner; Heritage; webgis; Augmented Reality; cultural.

1. Introduction

In recent years Cultural Heritage Studies have attracted an increasing interest by the scientific community, which has found a support in the detection field. In particular, the major agencies and authorities in the field of cultural heritage have focused on digital realization of high accuracy of archaeological site, the historical centre, building complex of historical and archaeological importance and artefacts. From here, the idea that the knowledge of a good is not only made of an artistic nature, but have to include geometrical features, position and shape. For this reason, it was proved that Geomatics was subjected to a deep innovation and a huge evolution. Thanks to the help furnished by

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Peer-review under responsibility of the organizing committee of ISTH2020
doi:10.1016/j.sbspro.2016.05.342

electronics and information technology, it is possible to obtain innovation prospects in every application relating to detection. The Cultural Heritage is the most appropriate filed to this new approach, more than other, due to the interest brought by these new techniques and technologies always in continuous development.

These new techniques and digital technologies give the possibility to configure new products, not only from the relief activities, but also in its representation and visualization, in order to have a clear description of the area, the structures, buildings and finds. They represent a powerful instrument for the analysis of the artefacts, in order to help their reconstruction and restore. Moreover, the process of acquisition and realisation of data have to follow some appropriate methodologies, taking into account the features of every technique in terms of inherent capacity (precision, accuracy and data format) and for the purpose of mutual integration in order to insert all products in a useful database: divulgation, research, structural stability, etc.

2. Practical and operative phase of relief

To make an analysis through the relief laser scanner it is necessary to proceed step by step. At the beginning, it is made an acquisition of the architectural resource by scanning, in order to can obtain as many data as possible. Successively it is made an alignment of the collected scans, by using software furnished by the manufacturer. In particular this study brings to obtain an algorithm to use on Matlab in order to effectuate the alignment. To record the clouds and generate the sames, each time was used the ICP algorithm (Interactive closest Point) [1] implemented in the Matlab environment.

The ICP algorithm iteratively applied a rigid roto-translation in one of the two clouds, considered to be mobile, so that overlap in the best possible way to another cloud, considered fixed.

Given a point cloud V^j and a point cloud V^i to align with each other, for each y_i point of V^j, exists at least one x_i point on the cloud V^i, said corresponding point, which is the closest to y_i compared to all other points in X.

The algorithm is an efficient method to tackle rigid registration between two point sets. Its goal is to find a rigid transformation, with which Y is registered to be in the best alignment with X, that is, let T of Equation:

$$\min_{T,\, j\in\{1,2,\ldots,N_x\}} \left(\sum_{i=1}^{N_y} \left\| T(\vec{y}_i) - \vec{x}_j \right\|_2^2 \right) \tag{1}$$

be rotation and translation transformations, hence the rigid registration between two point sets is

$$\min_{R,\vec{t},\, j\in\{1,2,\ldots,N_x\}} \left(\sum_{i=1}^{N_y} \left\| \left(R\vec{y}_i + \vec{t} \right) - \vec{x}_j \right\|_2^2 \right) \tag{2}$$

s.t. $R^T R = I_x$; $\det(R)=1$

In an iteration, ICP assumes that the closest points correspond, computes the absolute orientation and applies the resulting rigid transformation to V^j. In practice, at step 1 for each point of mobile cloud (V^j set), are sought, within the fixed point cloud, the points (closest point) contained in a sphere of a certain radius (multiple of a parameter introduced by user) belonging to V^i set. The closest of these will be held and considered the corresponding point.

$$C_k(i) = \underset{j\in\{1,2,\ldots,N_x\}}{\arg\min} \left(\left\| \left(R_{k-1}\vec{y}_i + \vec{t}_{k-1} \right) - \vec{x}_j \right\|_2^2 \right) \tag{3}$$

With these matches found, in step 2, the algorithm computes the incremental transformation (rotation matrix $R_{i,j}$ and translation vector T and solving the absolute orientation) by applying it to the elements of V^j; If the mean square error is less than a certain threshold, the iteration terminates otherwise return to step 1;

$$(R_k, \vec{t_k}) = \underset{R^T R = I_m,\, \det(R)=1,\, \vec{t}}{\arg\min} \left(\left\| \left(R\vec{y}_i + \vec{t} \right) - \vec{x}_{c_k(i)} \right\|_2^2 \right) \tag{4}$$

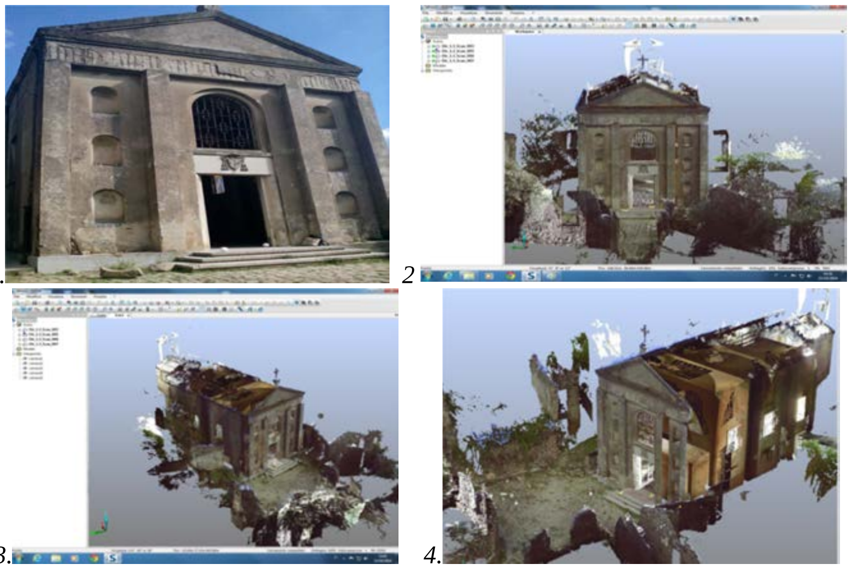
The principle on which is based this algorithm is that the alignment between the two point clouds corresponds to the minimization of the quadratic error of the minimum distances between the two objects. In fact, Besl and McKay demonstrated that the algorithm converges to a local minimum of the error (Fig. 4).

$$e = \sum_{I=1}^{N} || x_i - (R_{y_i} - T)||^2 = mine = \sum_{I=1}^{N} || x_i \text{-} (R_{y_i} \text{-} T)||^2 = \min \quad (5)$$

$$C: V^j \to \frac{V^i}{\forall y} \in V^j \; \exists \; x \; such \; that \; min \; distance \; (y, x) < \sigma \quad (6)$$

3. Practical relief by using laser scanning

The use of laser scanning was useful to make a survey of S. Salvatore Church. In particular, it have been made different scanning from different perspective and then they have been aligned using the software Scene and Reconstructor. The result was a 3D model faithful to reality, from which it have been obtained the dimension of the building, moreover with different viewpoint. The above-mentioned abbey is settled in the main square of Africo vecchio, a small town in the province of Reggio Calabria, that was founded in the IX century. In 1951 and 1953 this town was hitten by floods, which have tragically destroyed the built-up area and the population was forced to search for shelter. When the town was definitely abandon, it was not reached yet by the passable route and it was connected by a path.



1. 2 3. 4.

Figs. 1,2,3,4 – Views derived from the 3D model of the church of S. Salvatore – Africo (RC)

The application of this technology was useful to make the relief of Santa Maria Tridetti Church, settled in the town of Staiti, in province of Reggio Calabria. The building was declared National Monument and it date back to the Normans, around XI century, but it was built on a Greek frame, because of it was dedicated to a Greek ritual.

In the presbytery of Santa Maria Tridetti can be noticed the fusion between Byzantine and Normans architectural typology. Among the endured walls of the ancient Church, can be deduced elements of the Greek architectural technique, as well as its position with the three apses toward the East and the facade toward the West.

5.

6.

7.

8.


Figs. 5,6,7,8 – Views derived from the 3D model of the church of S. Maria Tridetti – Staiti (RC)

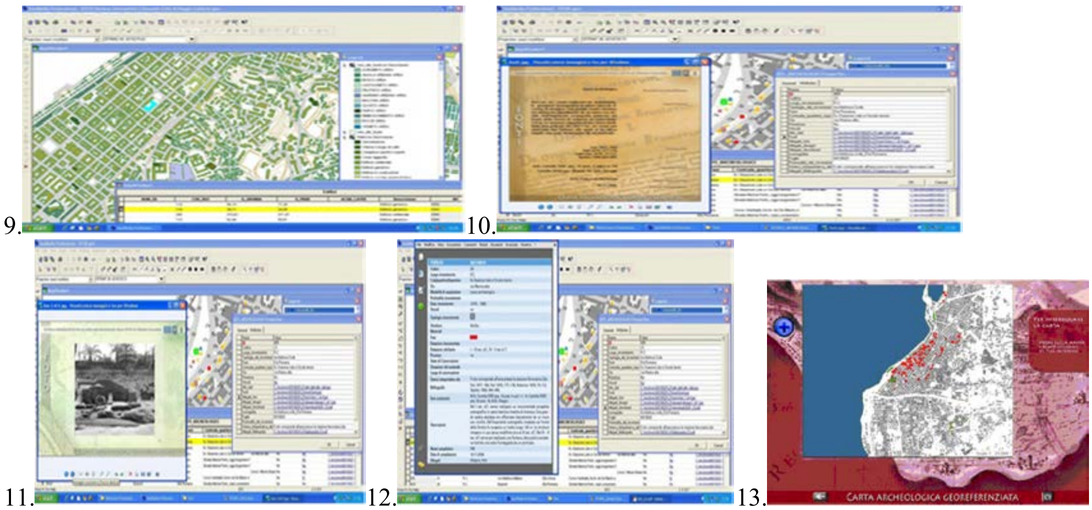
4. Web-GIS

The spread of data obtained thanks to the laser scanning, that is the realisation of the 3D model, it can happened by using the Web GIS, through which it is possible to realise this model by using an open source program. Thanks to this program, it is possible to spread the information on the web, on the mobile phones and devices, which use the operating system Android in order to allow to every user to find these information everywhere. It is an online platform freely available for users, that was born with the purpose of furnish information about geography, historical and cultural places and buildings, through a clear localisation on the map by using point of interest and multimedia content (photos with digital geographic information, text, etc). The information are usable from mobile phones, palmtop and tablet, also when these devices are used as gps.
The software is made up of a complete GIS platform, which is developed around the framework Mapserver with frontendp script, mapper in PHP on the web server Apache.
the cartography is linked to its database and it permits a representation of territory with multisensory data, for example through association between geometric and alphanumeric data.
The GIS Web permits to consult, ask and print all the information that the system administrator makes available to users, through the favourite browser.

Data can be organised in three areas, according to its descriptive nature:

- The first area includes all the essential information, which represent the website calling card: the identification code (master key); the identification place data; the localisation.
- The second area is reserved to description, historical information, bibliography etc.
- The third area concerns the photography research, drawings, illustrations and the results of reliefs with LS.

In the case of Archaeological site, the database includes information related to the discovery phase, evaluation about the conservation status, the material that has been found, TV documentary and the historical relationships.



Figs. 9,10,11,12,13 – Example of Screens made WebGis

5. Application for Android System

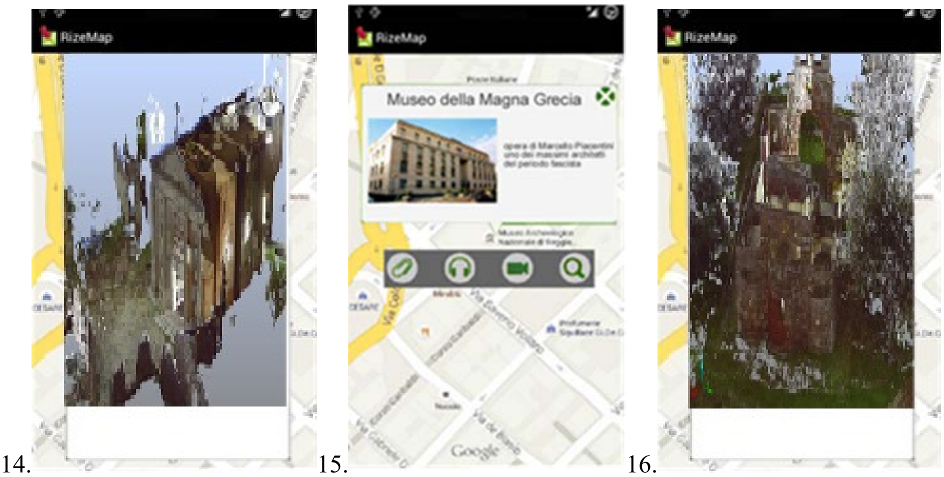
The technological progress allows the application of new models by using multimedia contents, which consider the new mobile phones system as 3.9G/4G.

The development activity concerns the planning and the consecutive realisation of a InfoMobility platform, which allows to make available archaeological, artistic and cultural information.

The purpose of this platform is to promote the knowledge of the country, by making available the required information and guaranteeing a rapid and intuitive rediscovery.

Used on a smartphone or tablet, the Infomibility Platform should make the visualisation of POI (Point of Interest) in the proximity of the user easier, through digital geographic information given by the map based on an open source cartographic system.

Every POI present on the map can be selected by the user and it allows to display a descriptive window, which contains the information related to the selected POI. With the description, it is visible an image related to the POI and the results of the reliefs made with LS are available too.



Figs. 14,15,16 – Example of the Android app screens made

6. Augmented Reality

An interesting thing could be the association of the diffusion of this 3D models obtained from the laser scanning with the augmented reality. This technology permits the combination between the real world and the 3D virtual objects, which are integrated in the user visual field and with which it is possible to interact in real time. This method can be integrated on devices used daily, thanks to the apps installed on it. The augmented reality, to operate correctly, it uses some sensors that we can find on the modern smart-phone and tablet as the accelerometer, the gyroscope, the gps, the magnetometer, the proximity and light sensor. Particular attention is focused on the tracking, that is the localisation of the user, considering that wherever he is, he could accesses on the app and he can have all the information related to the place. Moreover he can make some overviews, thanks to the 3D model, which will use the accelerometer and the gyroscope available in the devices.

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