Fast Mapping and Geospatial Data Acquisition by Innovative Indoor Mapping System

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Key words: Mobile Mapping System, 3D survey, spherical images, point cloud, indoor database, SLAM, survey multiresolution approach.

SUMMARY

The increasing demand of 3D spatial information is nowadays there for all to see and it is involving all the branches of the economy, coming out of the traditional civil and environmental sector. Smart cities implementation, facility management, real time as built "as designed" verification, modelling of existing building and neighborhoods, are becoming crucial and challenging activities, to carry out with new survey approaches (Marinelli et al., 2017; Schmitz et al., 2015, Barsanti et al.; 2012; Lauterbach et al.; 2015; Khashayar et al, 2018; Boavida et al, 2012). Moreover, those process involve various professionals with different background so unequivocal data and compatibility of procedures must be guaranteed. Thanks to the continuous and recent technological progress, innovative instruments are now available in the market, making sustainable fast mapping acquisitions, also of indoor environments. This paper as first investigates how the latest indoor Mobile Mapping System (iMMS) Heron, based on SLAM (Simultaneous Localization and Mapping) algorithms was effectively used to acquire 3D data and high-resolution images especially in indoor environments. As second, the case study investigates how sensors with different characteristics and peculiarity have been exploited in order to carry out a multiresolution survey, being able to satisfy both the need to have detailed models and large amount of data.

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1. INTRODUCTION

The need of large, dense and fast 3D data acquisition in the field, is becoming more and more crucial in all the life of buildings and infrastructures, starting from the design, construction and/or renovation phases, until the short and long-term maintenance procedures. The continuous innovation in the 3D mobile mapping technologies makes now possible to acquire, at reasonable costs and in a fast way, dense point clouds of construction sites, with an accuracy ranging from 2 to 10 centimeters and enriched with high-resolution RGB images. While Outdoor Mobile Mapping Systems (MMS), usually installed on vehicles and based on a combination of GNSS, odometer and IMU to solve the positioning problem, have been reached their maturity, recent and various other solutions have been developed instead, to solve the problem of 3D mapping in indoor environments when GNSS signal is not available. In fact, outdoor MMS are based on the use of the GNSS signal to geo-reference the trajectory of the vehicle. Nevertheless, lack of signal and "canyoning" problems makes GNSS based systems ineffective in indoors and narrow environments and different mapping solutions must be adopted. The development of innovative indoor mapping systems needs to introduce also a different real time and post processing workflow, composed by different surveying strategies and different processing software. The result is that to fully map a construction site or a city model a combined use of vehicle-based MMS, indoor MMS and classical static scans acquisitions is often needed.
The paper investigates and describes how a 3D survey carried on with an Innovative Indoor Mobile Mapping System, based on SLAM approach, has been effectively integrated with acquisitions coming from an Outdoor Mobile Mapping System mounted on a vehicle, static scans from tripod laser scanner and point clouds coming from a hand-held laser scanner device. The paper describes also how this multiresolution and multiplatform data have been managed in the way to realize a model characterized by an increasing level of detail. The goal of this approach is to test the right procedure to be able to provide to the final stakeholders a 3D model with dense and large amount of information, with a variable level of detail diversified in function of the real needs.

2. METHODOLOGY

1.1 Data acquisition

The test site of the data acquisition has been chosen as the engineering Campus of the University of Brescia and in the surrounding areas and buildings. Different instruments have been used in order to create a full indoor/outdoor model of the University district and some indoor environments. The main streets around the campus have been mapped thanks to a

MMS mounted on a car and the point cloud model have been geo-referenced mainly thanks to the GNSS mounted on the instrument. The model acquired with the MMS has been used as reference frame for the 3D acquisitions carried on with different sensors. In fact, in order to acquire indoor environments a iMMS based on SLAM algorithm with a RGB camera has been used. Further indoor details have been mapped with a static scanner and specific details with an hand-held lased scanner. What made interesting and innovative this test has been the systematic use of automatic registration tool for the registration between the variuos point clouds acquired with different instruments. Only the registration between static scans and hand-held laser scanner data has required the use of common targets.

1.1.1 Mobile Mapping System (Teledyne Maverick)

To map the University district roads a Teledyne Maverick platform have been used. This compact MMS uses a robust and consolidate mapping approach (Teledyne, Maverick, 2018) enriched by some very useful tools able to speed up the control of the system, as the application that allows the surveyor to use a smart phone to drive and control the functionalities of the Maverick platform. The use of system is quite fast; once installed on the vehicle (Figure 1), the system just needs a short calibration before to start the data acquisition, driving for some minutes along a fast drive road. At the end of the calibration process, a 3D acquisition has been carried on, setting at 5 meters the distance between two consecutive RGB images shoots. In less than 10 minutes, three kilometers of streets have been acquired.

Figure 1:Particular of Maverick MMS

1.1.2 Indoor Mobile Mapping System (Heron)

As Indoor Mobile Mapping System, the SLAM based Heron (Gexcel, Wearable Mobile Mapping, 2018) (Ceriani et al., 2015) (Figure 2), has been used in order to survey some indoors environments of the faculty of engineering building and of a Sport shop positioned close to the University campus. Heron provides a 3D point cloud with a local accuracy and resolution of 2 cm, synchronized with a full resolution RGB camera. The characteristics of an iMMS as Heron is the capability to carry out fast 3D surveys just walking with a backpack or an instrumented trolley along the surveyed site. To geo-reference this kind of indoor mapping survey, it cannot be proposed the use of geo referenced targets; this accurate but time-consuming approach would contrast with the need of a fast and affordable approach. For this reason, the indoor acquired point cloud has been overlapped with the point cloud acquired by the Maverick system. The registration has been carried on using the automatic tools present in the post processing software. To optimize the surveying time and, consequently the amount of raw data acquired, the indoor mobile mapping procedures have been organized planning acquisition sections of 5-10 minutes.

Figure 2: Heron survey at a shopping center located close to the University Campus

1.1.3 Static laser scanner (Faro Focus 3D X 330)

The same fully automatic registration tool available in the post processing software (JRC 3D Reconstructor), have been successfully applied to geo-reference the high-resolution static scans, using Faro Focus 3D scanner (Faro, Faro Focus 3D X 330, 2018). In this way the iMMS survey (already geo-referenced on the Maverick one) is used, inside the building, as the reference frame to geo-reference the high resolutions scans acquired by the Focus scanner.

1.1.4 Hand Held scanner (Dot product)

Some more details, of a portion of the indoor site, acquired with the Faro scanner, have been 3D mapped, with very high resolution and accuracy, using the Dot Product hand held laser scanner (Dot product, Handheld 3D capture solution, 2018). This instrument allows to acquire high resolution point clouds starting from images, with a maximum range of three meters. The system requires the use of various typologies of targets, and these same targets must be visible in the Faro scans to connect the hand-held 3D point cloud data with the Faro ones. In fact, in this case study, test have been carried out with the available automatic registration algorithms but failed when trying to connect tripod scans with the point clouds acquired with hand-held laser scanners.

Figure 3: particular of the target used (April tags, survey tags)

1.2 Data elaboration

The post processing data elaoration have been carried on using a a portable workstation with an Intel Core i7-6700HQ quad core 3.5 GHz processor, 16 GB DDR4 RAM and a graphic card Nvidia GTX 960M with 4 GB GDDR5 installed. The data of the Indoor Mobile Mapping Systems have been post processed in a specific software where the trajectory quality is improved with specific procedures and the final point cloud and panoramas views are generated. All the point clouds models have been managed in the JRC 3D Reconstructor software (Gexcel, JRC 3D Reconstructor, 2018) where the automatic pre registration tools and ICP algorithms are available. As already mentioned, the 3D point cloud model from the Maverick Mobile Mapping System has been georeferenced by GNSS and used as skeleton to geo reference all the point cloud models coming from all the other instruments. The overlap between the point clouds is crucial to run the automatic pre registration process. The final model has been moved in the cartographic reference frame EPGS:32632 (WGS 84/UTM zone

32N). Finally the high resolution point clouds coming from the hand held scanner have been registered on the static laser scanner ones, thanks to the presence of common 2D targets. The static scans, the Heron data and finally the Maverick ones have be registred automatically.

1.3 Data visualization and Features extraction

Once all the models have been merged together and moved in a common cartographic reference system, a top view map called "Blueprint" have been automatically generated. These top view map (Figure 4) can provide a fast overview of the surveyed area; it is easily measurable and exportable in AutoCAD script, giving back the surveyed area state of the art. Moreover, it is possible to directly investigate the iMMS dataset in an effective way, thanks to a dedicated navigation tool (Blueprint Navigator), that allows to simultaneously visualize the high-resolution images overlapped on the point cloud acquired. The datasets coming from the Mobile Mapping Systems have been also organized and exported according to the "Orbit" Templates. A mobile mapping run has been created for each Mobile Mapping System acquisition and then, merged together in the same project (Figure 5). In Orbit Feature Extraction Standard, a worldwide well-known platform for mobile mapping data visualization and facility management applications, point cloud and images have been investigated thanks to the possibility to open more than one view and to simultaneously extract spatial and geometric information. Moreover, it is possible to fill an already organized database coming, for example, from platform as QGIS, ArcGIS etc. or directly to create a new one inside Orbit.

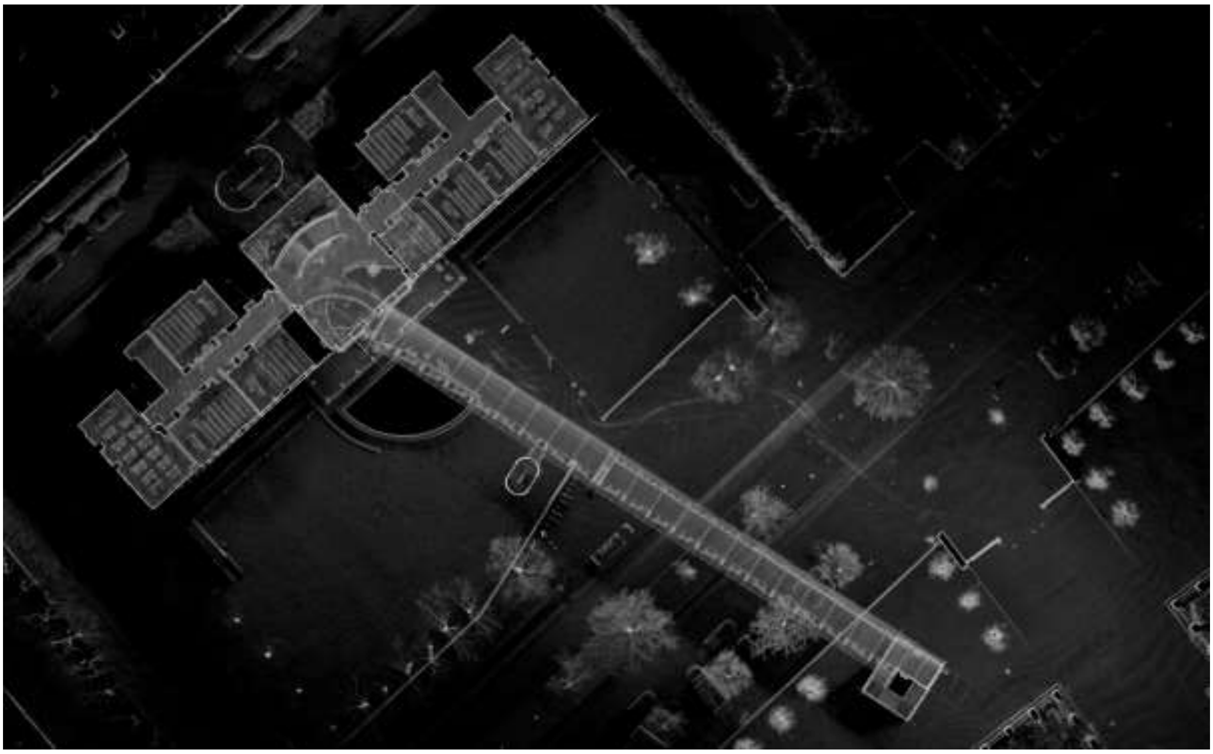

Figure 4: particular of the blueprint generated

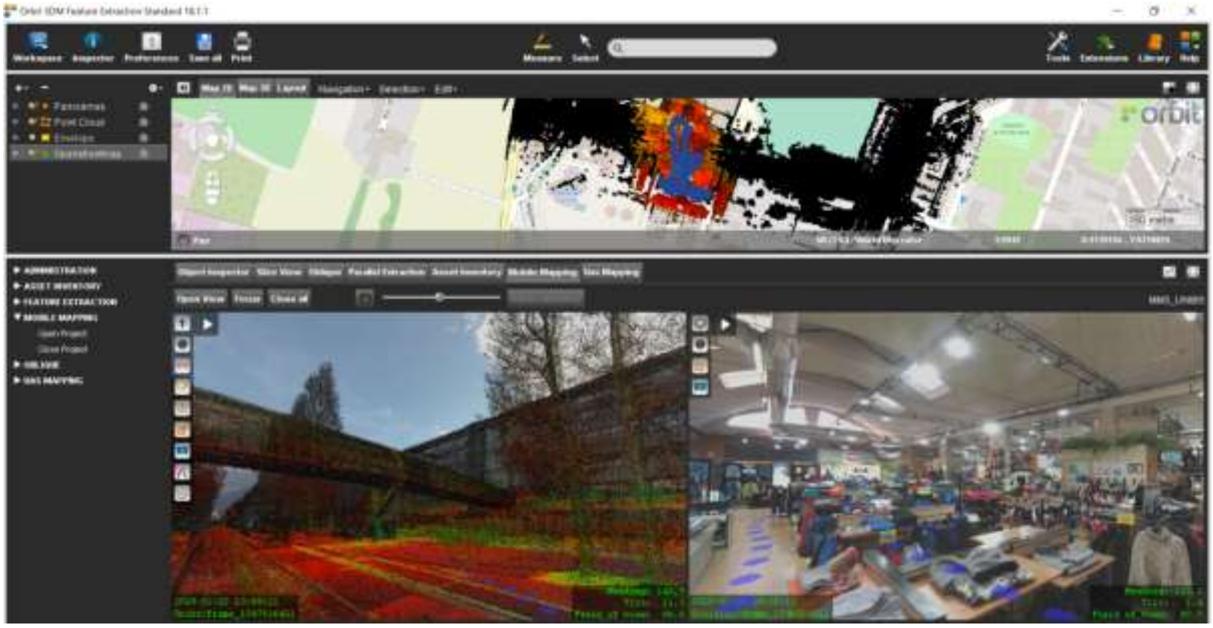

Figure 5: Project visualization in Orbit Feature Extraction

CONCLUSION

This case study shows how the use of various 3D surveying instruments, with different resolution, accuracy and formats can be merged in the same platform. It is possible to create a full 3D model of construction sites and urban areas, thanks to the performances of available tools of automatic registration between point clouds.

3. AKNOWLEDGMENTS

The authors would like to acknowledge Gexcel and iMAGE-S for providing the used instruments, software licenses and technical support during the data processing.

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