“iMMS approach for construction monitoring and geospatial applications: new prospective and near future developments”

Giorgio P. M. Vassena, University of Brescia

8th International Workshop 3D-ARCH
Bergamo – 6-8 February 2019

WE ARE JUST AT THE BEGINNING OF THE 3D DIGITAL REVOLUTION

3D strategies in construction and cultural heritage are becoming standard
Forensic field work by students of the University of Brescia
2017 - 2018

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LiDAR technologies in construction

A lot has to be done
TO CLOSE THE 3D DIGITAL WORKFLOW

Surveying instruments as we were used

UAV (Unmanned aerial vehicle)
"iMMS (indoor MMS)"

Several points: Less accuracy

Few pts: High accuracy

Quantità punti

10,000,000
1,000,000
100,000
10,000
1,000
100
10

GENERAL VIEW OF THE MAIN EXITING
OPEN ISSUES AND HOW WE ARE FACING IT
AS SURVEYORS

About drone mapping
EVERYONE IS USED TO UAV MAPPING BY
DIGITAL PHOTOGRAMMETRY
Several companies worldwide provide 3D UAV mapping and sharing 3D point cloud data on the web services.

Innovation?
Fast lightweight Autonomy (FLA)

Mobile Mapping System
MMSs need to track GNSS signal

And what about indoor mapping?

we need a mobile system to speed up 3D surveying also in urban canyoning, in indoor sites, underground mines...

What do we need?

HIGH ACCURACY, NO TARGET, FAST, REAL TIME, OUTDOOR/INDOOR, EASY...
Innovative solutions for indoor mapping have been developed

We call these systems iMMS (Indoor Mobile Mapping System)

Every system has a different approach

Different instruments for different projects?

In iMMS makes the difference

Wheeled mobile systems

Hand Held systems

Back-packed mobile systems

Courtesy of
https://www.navvis.com
https://www.trimble.com

Courtesy of
https://www.Leicageosystem.com
https://www.gexcel.it

Courtesy of
https://www.kaarta.com
https://www.goslam.com
Wheeled mobile system

Back-packed mobile system
Hand-held mobile system

Almost all the system are based on SLAM approach, almost all the system have almost the global accuracy

BIG DIFFERENCES FOR THE LOCAL ACCURACY/RESOLUTION and IMAGES QUALITY

- More mobility imply less camera resolution
- More weight imply more camera resolution
Know we consider iMMS as no-GNSS devices

"SLAM addresses the problem of a robot navigating an unknown environment. While navigating the environment, the robot seeks to acquire a map thereof, and at the same time it wishes to localize itself using its map. The use of SLAM problems can be motivated in two different ways: one might be interested in detailed environment models, or one might seek to maintain an accurate sense of a mobile robot's location. SLAM serves both of these purposes." Sebastian Thrun, John J. Leonard

At the moment the iMMSs have great differences based on the software and it means on the application field where these instruments are focused

iMMSs are still in a developing stage
How we proceed now indoor?

STATIC SCANNER

What you can get with LiDAR and what you can improve/loose moving from static approach to Indoor Mobile

- Scanning/surveying time
- Accuracy
- Geolocalization and use of targets
- Models update
- Large sites surveying
- Data elaboration efforts
Scanning time at its best can be equal to walking time!

Mode: Walking, outdoor/indoor
Surveying Time: 1:15h
Survey length: around 900 mt
Software: HERON® Desktop and JRC 3D Reconstructor

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Hospital mapping

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Test made by iMMS JRC research Group

Accuracy

How to increase the accuracy?

• CLOSING THE LOOPS
• WITH DIFFERENT TECHNIQUES
  AS GLOBAL OPTIMIZATION

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How to geolocalize without GNSS?

THE USE OF TARGETS OR CONTROL POINTS IS USUALLY MADE BUT THIS APPROACH SLOW DOWN THE MAPPING PROCESS

Time consuming topographic activities for targets geolocalization
FOR EVERY POINT CLOUD 3 TARGETS REQUIRED

DRIFTS? CPs ARE JUST FOR GEOREFERENCING
HOW TO MANAGE ACCURACY?
The progress of the quality of the automatic pre-registration tools is providing an unexpected productive approach.

AUTOMATIC PRE-REGISTRATION / ICP APPROACH

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Automatic pre-registration and ICP

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Automatic pre-registration

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Automatic pre-registration and ICP

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Automatic ICP

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Automatic ICP

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Automatic registration - Quality check

We have tested an important quality improvement of the automatic pre-registration / fine registration tools, also with 20% - 30% overlap between scans.

THE TOOLS FAIL WHEN POOR GEOMETRY IS PRESENT (CONCRETE TUNNELS, REGULAR STAIRS,...)

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Vassena’s "iMMS approach for construction monitoring and geospatial applications: new prospective and near future developments"
IMMS FOR GEOSPATIAL APPLICATION

Finally the iMMSs can be profitable used for geospatial data acquisition and
Easy to connection between indoor mapping and outdoor mapping.

THE APPROACH BECOMES VERY FLEXIBLE AND THE LIMITATION OF DRIFTS CAN BE KEPT UNDER CONTROL

Accuracy and resolution only where needed.
Street evaluation and underground detection

APOSA UNDERGROUND RIVER (BOLOGNA, IT)

A iMMS mapping has been carried on

Courtesy of Gexcel
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Result of the iMMS mapping

Courtesy of Gexcel

Test of an innovative procedure
AUTOMATIC REGISTRATION WITH STATIC SCANS
CANNOT SOLVE THIS PROBLEM

After the SLAM process, drifts are present
More than 50 cm

Courtesy of Gexcel
Static scans as constraints

To correct an iMMS SLAM based indoor/outdoor mapping it is possible to use as constraints, in the SLAM process, portions of point cloud data coming from

Selection of UAV point cloud data
Selection of MMS point cloud data
Selection of static scan data

A point cloud coming from a BIM model of a project or from a SCAN to BIM process can be used

How would we proceed for Venice 3D Mapping using iMMS

Courtesy Ramses Venezia

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iMMS SLAM mapping can be constrained to static scans or mobile / UAV point clouds data.

OR VIRTUAL SCANS CAN BE GENERATED IF AT LEAST 3 GNSS POINT ARE AVAILABLE

3D mapping

3D Digital documentation
Scan to BIM
To get a good BIM model from iMMS, a quality pointcloud is needed.

Data filtering

No Filter VS Filter

What you can get with LiDAR

Monitoring

"As built" vs "As designed"
Real time mapping Process of construction
“As built” vs “As designed” is becoming more and more popular using static scans.

iMMS have lack of accuracy for accurate as built as designed projects.

But can be very useful for geometry check or installation errors.
Accurate “as built” “As designed” has to be carried on using tripod scans but iMMS can be used extensively to highlight construction problems as installation errors (ONE PART IS POSITIONED IN A WRONG POSITION OR HAS NOT BEEN INSTALLED)
Software are now capable to match point clouds models with existing BIM models. Automatically it is possible to monitor the existence of parts of the building and to allow to manage digitally the monitoring and the control of a construction site work advancement.
To manage a construction site work advancement using 3D static scans it is too time consuming and expensive. INDOOR MOBILE MAPPING SYSTEMS ARE PERFECT FOR THESE APPLICATIONS.
The problem is that the 4D BIM CONSTRUCTION SCHEDULING & PROJECT MANAGEMENT SOFTWARE are not at the moment capable to be synchronized with the results of the LiDAR based processes for monitoring and control of construction site work advancement.

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With the almost real time approach, means that we can access to the surveying results in almost the same time of the surveying process.
The case study is a fast on the field evaluation if a site has the characteristics to host a concert.

Are the basic geometric characteristics of the site capable to make the site eligible for the organization of a public event?

Data elaboration can be very fast.
The existing project is compared with the 3D iMMS survey.

What you can get with LiDAR:
- Real Time:
  - Localization and Real time Change detection
  - Real time Geospatial data acquisition

We have to consider that always more iMMSs have real time tools, very interesting for different applications.
SLAM

- This means that if a 3D point cloud or BIM model is already available, automatic localization can be run
- If the system is capable to recognize its position, can in real time to display the difference between reference model and reality

AUTOMATIC LOCALIZATION
HOW DOES IT WORK?

- Load the point cloud / BIM reference model
- System localize itself
- Change detection in real time can be run
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WHAT IS IT FOR?

Large models updates.
Where differences are observed static high resolution scans are made.

IMMS FOR GEOSPATIAL APPLICATION

Finally the iMMSs can be profitably used for geospatial data acquisition and...

What you can get with LiDAR

Geospatial

Preogress of a construction site
IMMS FOR GEOSPATIAL APPLICATION

Finally the iMMSs can be profitable used for geospatial data acquisition and...

Data from Unibs Test sites can be managed with ORBIT platform

The iMMS acquire also RGB data that can be used both to:

- Colorized point cloud
- To be used with spherical images
Example: Martes museum

3D Survey

3D Point Cloud colorization

Fast 2D Map
360° Spherical images navigation and 3D measurement

WEB APPROACH

Every object can be recognized in the image (in the back ground the 3D information and coordinate are present)
This data can be shared in the web

Real time data than can be acquired on the field directly from the surveyor on the field

Data connected to the sensor location (quality of the floor of the room)

Objects could be recognized in the image and tagged on the Control Unit in real time

Lighting staff DB
Objects could be recognized in the image and tagged on the Control Unit in real time.

Various sensors are connected with the iMMS by WiFi:
- QR Code
- High res Camera
- Hand Held Scanner
- Colorized point cloud

THANK YOU!

Giorgio Vassena
giorgio.vassena@unibs.it