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Emerging Geospatial Technology Trends in Relation to City and Building Information Modeling - An Application Specific Analysis

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Abstract: ***The exponential growth of population demands accelerated growth in urbanization which challenges the susceptibility of environments and human life. Geospatial technology attempts to document all the happenings on the surface of the earth. Usability and accuracy of this documentation with respect to real-world applications and scenarios are directly related to the methods of obtaining this information and use of different type of sensors used in the acquisition of data.***

Author has attempted to illustrate methods of Geospatial technology to acquire suitable data for City Information Model(CIM)/Building Information Model(BIM) to use in various applications as per the challenges on the real ground scenario and to establish an analogy between the real world and its documented models produced by Remote Sensing, Photogrammetry, LiDAR, and 3D laser scanning methods and ascertain suitability of this models in various applications. Finally, Compare and contrast application versus LOD and LOD verses method of data acquisition and outputs with respect to the scope of the model use.

Index Terms: City Information Model, Building Information Model, Photogrammetry, LiDAR, 3D Laser Scanning, Level of Details(LOD).

I. INTRODUCTION

The motivation behind the emergence of new geospatial technology is because most of the earlier data acquisition and mapping technologies are practically difficult in present-day scenarios due to the size of the instruments, processing time and handling capacity of multiple data types at the same time. With the advent of digital technology size of the instruments has drastically become small, data collection at very high resolution, advanced data storage and retrieval methods, the faster processing power of the systems became the miracle of the latest geospatial technology.

In this paper, the author attempted to illustrate latest trends in mapping/documentation of geographic features using geospatial technology i.e. GIS, RS, Photogrammetry, LiDAR and 3D laser scanning especially related to Building Information Modeling (BIM), City Information Modeling (CIM).Since this paper focuses on the graphical representation of an object the term LOD refers to Level Of Detail instead of Level of Development (LOD) which explains graphical representation and information(properties) of the object [4-6].

II. PHOTOGRAMMETRY

A. Data acquisition

The technology of obtaining 3D data through photogrammetry has evolved many folds. From hardcopydiapositives to high- resolution digital images. It has transformed into user-friendly and automatic procedures from the strenuous procedure of earlier methods.

Digital planimetric data, digital orthoimagery and digital topographic (elevation) data require certain accuracies depending on RMSE thresholds. Film Based aerial photographs can be described using a scale, whereas digital images with Ground Sampling Distance (GSD). To identify the required system to produce data as per the project requirements to a specific purpose can be calculated using the relation between flying height divided by contour interval equal to c-factor [7] with equation 1.

$$\text{c-factor} = \frac{\text{flying altitude}}{\text{contour interval}} \quad (1)$$

In most of the photogrammetric projects follow one-third of the contour interval as the accuracy of the project. That means if a project is proposed at 1m contour interval is having all the feature on the earth surface which are bigger than 33 cm [1] as shown in size Table I.

Table I:

Metric system		
Map scale	**Contour interval (CI)**	**Min. Object Size**
1:500	0.5 m	17 cm
1:1000	1.0 m	33 cm
1:2000	2.0 m	67 cm
1:5000	5.0 m	1.67 m
1:10,000	10.0 m	3.33 m

Primary thematic outputs from a digital photogrammetric workstation (DPWS) are:

1. Planimetric data
   a. Transport features
   b. Structures
   c. Hydrology
   d. Vegetation &
   e. Utilities

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2. Topographic data
   a. Breakline
   b. Mass points
   c. Spot heights

Among the categories listed above topographic data is used to create Digital Elevation/Terrain Model which is one of the prime inputs to represent terrain under the structures in city modeling. The planimetric themes rest on the ground and above ground. Together they both represent a real city in a 3D perspective scaled model of the city.

B. Data processing

The data processing is performed in two stages. First, the data will be edited as per the ASPRS specifications [2] to match the topological rules in GIS. Usually, this data is in CAD format and will be converted either into shape or database format. Second, the data will be verified for correct linking of the attributes and spatial reference of the project area.

C. Display

Depending on the type of sensor/camera and flying height one can calculate scale and in turn contour interval and the minimum size of the object that can be displayed in the model. Sample LOD [6] from this method is illustrated in Figure 1.

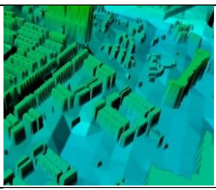
Satellite Photogrammetry (Data compiled from 1m Ikonos satellite stereo images)	LODO	
Aerial Photogrammetry (Data compiled from medium scale (1:10,000) aerial photographic stereo pair	LOD 0	
Large scale Photogrammetry and Drone photogrammetry (Photo rendered model)	LOD 1	

Figure 1: Level of Details

III. TERRESTRIAL PHOTOGRAMMETRY

Terrestrial and close-range photogrammetry complements Building Information Modeling (BIM) engineers in creating very large scale model for reverse engineering, documentation of historic monuments and to document very typical/successful engineering structure to study further and to repeat that successful model elsewhere as a template.

IV. LiDAR

A. Data acquisition

LiDAR stands for Light Detection and Ranging. It uses an infrared band of EMR spectrum. These systems can be used at any time of the day as they send their own source of energy to collect information about physical objects and phenomenon. Depending on the type of carrier of these sensors they named Mobile Laser Scanning (MLS), Aerial Laser Scanning System (ALS) and Terrestrial Laser Scanning (TLS) systems. All of these contribute specific kind of data as per the suitability of the project (problem). ALS is suitable to collect building roof and ground elevation data. MLS is mainly used to document transport related features and TLS to collect quantity analysis and building wall documentation. TLS and ALS complement each other to create more detail model of the city. The basic principle of this method is shown in equation 2.

$$\text{Distance} = (\text{Speed of Light x Time}) / 2 \qquad (2)$$

B. Data processing

LiDAR data processing usually performed in two stages, preprocessing and post-processing. Preprocessing is carried out immediately after the data collection stage so that the data is correct in all xyz directions as per its geolocation using pre-marked GPS points on the ground. Latest GPS technology is enabling the system to deliver preprocessed geo-corrected and flight line matched data. However, post-processing is the key to LiDAR data processing. This process also called point classification. Though there are software algorithms available to perform automatic classification human verification will only give 95% confidence of the final quality of the data.

Point classification adheres to standard ASPRS specification [1]. Basic classes are shown in the Figure1. To save time manual classification is followed by automatic classification.

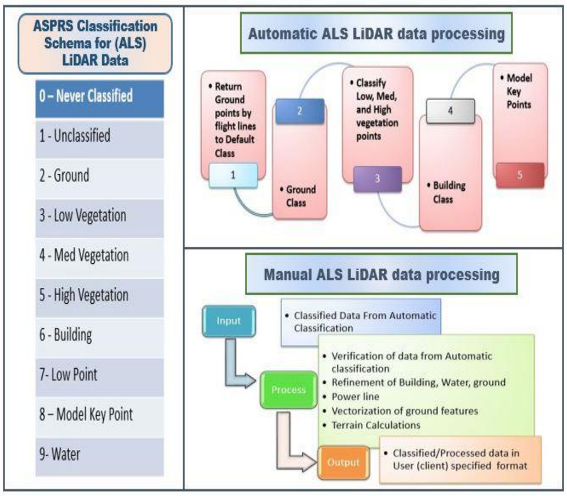


Figure 2: LIDAR Data Processing (ALS)

C. Display (Output)

As per the application of the data, it is possible to display (Figure 3) and save individual classes so that one can display only ground(DEM), only houses (House model),

only vegetation or combination of the classes like ground and buildings without the hindrance of other feature like vegetation, power lines etc.

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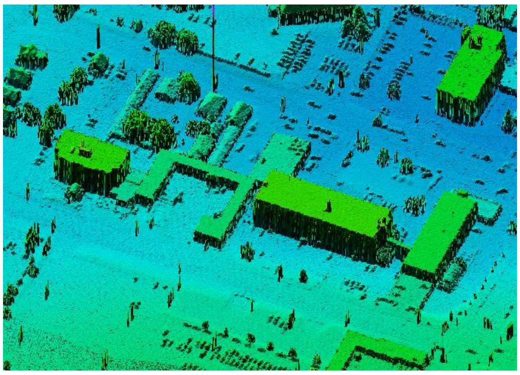

Figure 3: LiDAR Point Display

V. REMOTE SENSING (ISFAR)

Leaders in Geospatial technology are gradually accepting elevation data produced from Interferometric Synthetic Aperture Radar (IFSAR). The production cost of the DEM produced from Photogrammetry and LiDAR can be brought down by complementing airborne ISFAR elevation data. It is an active system and can penetrate through the cloud as it is using microwave sensor, 3cm wavelength, x-band so independent of light and weather. It is more preferred to Shuttle Radar Topography Mission (SRTM) data on resolution grounds.

Low confidence areas due to the obscurity of vegetation, non-available GCP areas and cloud cover can be supplemented as per the ASPRS standards 2014 [1].

VI. GEOGRAPHIC INFORMATION SYSTEM

GIS is a very good tool in the transformation of vector data into true scale scenic city models. GIS stores attributes of the feature in the database linked to its corresponding vectors. This enables GIS analyst to query as per their demand. Once the City Information model is ready it will be a powerful tool for urban agglomeration planning, Navigation, transport planning, especially at the times of special events and hazards, happen. Overlaying, join and relate database kind of tools further enhance GIS in the geospatial domain.

VII. DRONE SURVEY (UAV)

Entry of Unmanned Aerial Vehicles (UAV) into geospatial technology brought revolutionary changes not only especially in BIM/CIM but also in Building information development. Drones are providing the data to enable 4D functionality of BIM.

VIII. 3D LASER SCANNING

This method is by far the most accurate (up to 2mm) and very large scale at building level detailing projects. The pulsed laser beam is used to collect 3dimention locations of the entire model. These locations are called point cloud. These points are loaded into CAD environment to vectorize the model and further to render to view realistic view of the complete model with the measurable, navigable facility. This process follows stringent specifications of Federal Geographic Data Committee (FGDC), Global Spatial Data Infrastructure (GSDI), National Cartographic Standards for Spatial Accuracy (NCSSA).

IX. SUMMARY

Emerging advancements in geospatial technologies (Figure 4) such as Photogrammetry, Remote Sensing, LiDAR, 3D Laser Scanning, Terrestrial and close-range photogrammetry and UAV are enabling construction, city planners, environmentalist and decision makers to make better decisions as accuracy and resolution, ease of use, accessibility to the difficult places and automation became practical reality.

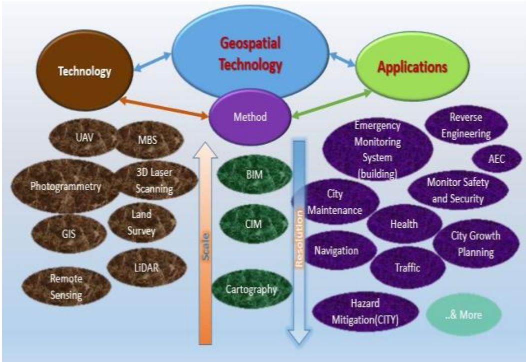

Figure 4: Components of Geospatial Technology

It is becoming easy to achieve more accuracy and more meaningful models by using multiple technologies together (Figure 5) and transformation of the specification from [4] to [1]. As technology advances, progress in level of details becomeevident [3]. Dimensions in geospatial modelling are levelling up from basic 3D models to 4D and beyond.

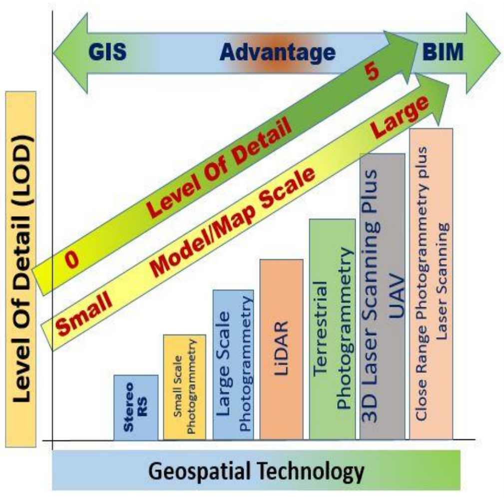

Figure 5: Geospatial Technology Trends

X. CONCLUSION

Insummary, keeping the view of emerging trends in Geospatial Technology, a modest prognosis can be set that in near futures one can assume all the BIM/CIM will be attributed, photo-textured and geocoded so that the use of this model in navigation enables true replica of the real ground. Use of this technology along with specifications in transforming existing cities to future smart cities will be a meaningful journey.

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REFERENCES

1. ASPRS_Positional_Accuracy_Standards_Edition1_Version100_November, 2014.
2. American Society for Photogrammetry and Remote Sensing (ASPRS), 2013. ASPRS Accuracy Standards for Digital Geospatial Data (DRAFT), PE&RS, December 2013, pp 1073-1085.
3. Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy Federal Geographic Data Committee(FGDC), FGDC-STD-007.3-1998
4. American Society for Photogrammetry and Remote Sensing (ASPRS), 1990. ASPRS Accuracy Standards for Large-Scale Maps, URL:
5. http://www.asprs.org/a/society/committees/standards/1990_jul_1068-1070.pdf (last date accessed: 22 January 2015)
6. https://bimforum.org/wp-content/uploads/2013/08/2013-LOD-Specification.pdf
7. Wolf, P. R., & Dewitt, B. A., “Elements of photogrammetry with applications in GIS”, fourth edition, Vol. 3, McGraw Hill, 2000, pp. 467-468.

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