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Urban Morphology Assessment through Close-Range Photogrammetry: A Case Study of Garhi Cantonment Street, Dehradun City (Uttarakhand)

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Abstract

Photogrammetry is the science and technology for obtaining reliable 3D geometric and physical information about objects and the environment from photographic images. Practically, photogrammetry allows 3D measurements of geometric information of objects (e.g., positions, orientations, shapes, and sizes) from photographs. In the last decade the demand of 3D models for objects and places has been increasing drastically for visualization and interpretation purposes. Most professional 3D software is expensive, however for the present study we have used TRIVIM open-source software to make 3D modeling. This paper mainly focuses to generate 3D street modeling using the principle of close-range photogrammetry and to assess urban morphology through 3D Visualization and data query. Our study area is the buildings along the Garhi Cantt road (New Cantonment Road), near Indian Institute of Remote Sensing (IIRS), Dehradun, India. Present paper highlights that Trivim Software would provide a visualization and decision support tool by creating georeferenced, photorealistic models attached with attribute data base for variety of applications.

Keywords: *Close Range Photogrammetry, Trivim, Camera Calibration, Georeferencing, 3D Modeling.*

Introduction

Advancement in computer vision and photogrammetry is changing human perception to examine and analyze objects in 3D virtual reality. Evolution of computer vision and photogrammetric technology has introduced flexibility and efficiency in the creation of 3D realistic models. In addition to this, easy availability of cheap hardware and software has driven development in the field of computer vision and digital photogrammetry in the technology sphere. Close range photogrammetric applications have made it possible to create 3-D realistic reconstructions of heritage buildings, archaeological monuments and other objects of interest (Chetan Katoch, 2013).

Photogrammetry is the science and technology for obtaining reliable 3D geometric and physical information about objects and the environment from photographic images (ASPRS, 1998). Practically, photogrammetry allows 3D measurements of geometric information of objects (e.g., positions, orientations, shapes, and sizes) from photographs (Wu, B. 2021). Photogrammetry is the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images, patterns of electromagnetic radiant energy and other phenomena. Photogrammetry produces coordinates of real world points of objects, Maps or Plans like topographic maps, Ortho-rectified images, Digital Terrain Models (DEMs) without contacting the surface to be measured and at a predetermined accuracy. Accuracy is mainly determined by the scale of the photograph.

Close Range Photogrammetry is Terrestrial photographs having object distances up to about 300m, collection methods can be both ground or aerial-based and camera is close to the subject and is typically hand-held or on a tripod. 3D modeling is the process of developing a mathematical representation of any three-dimensional surface of an object via specialized software (Meenakshi, 2016). The software which is used in this project is TRIVIM, developed by Indian Institute of Remote Sensing (IIRS), Dehradun, India. Foregoing analysis reveals that a high end geo-tagged camera is pre-requisition for the use of TRIVIM software which is may costly. So, we recommend that mobile based app must be developed by the IIRS.

Study Area and Data Set

Dehradun, the capital city of Uttarakhand, is a vibrant blend of natural beauty, cultural heritage, and spiritual tranquility. Nestled in the foothills of the majestic Himalayas and flanked by the sacred rivers Ganga and Yamuna. Our case study area is the buildings along the Garhi Cantt road (New Cantonment Road), near Indian Institute of Remote Sensing (IIRS), Dehradun, India (Fig.1). Its planimetric extensions are 30.34074°N 78.050847°E to 30.342175°N 78.049635°E.

The complete length of the street for 3D visualization is 176 meters taken into consideration.

Objectives

1. To generate 3D modeling using the close range photogrammetry.
2. To assess urban morphology through 3D visualization and data query.

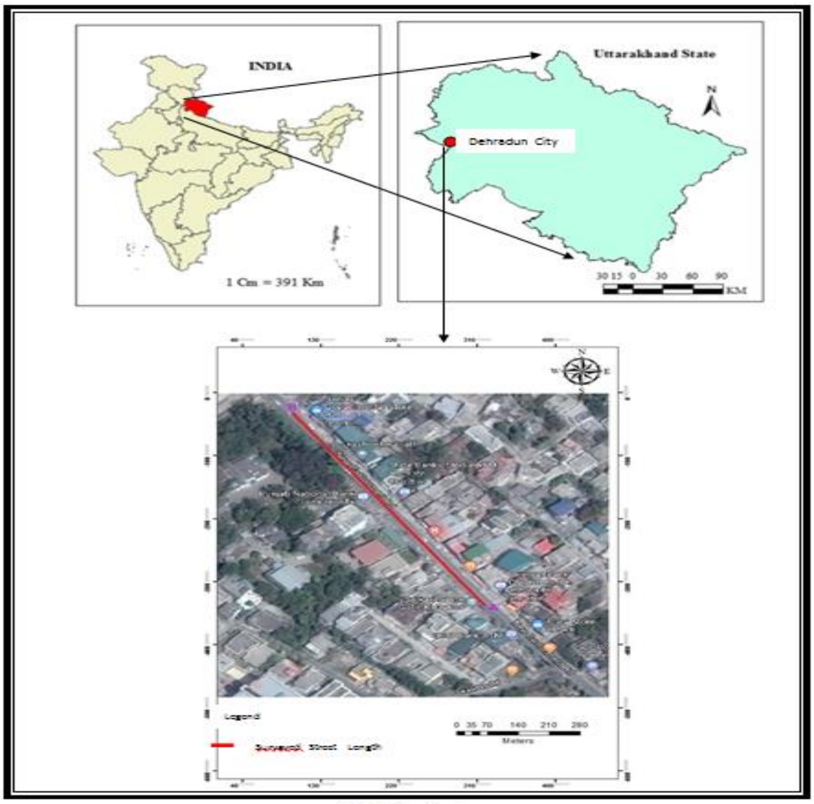

Fig.1 Study Area

Methodology

A distance of approximately 1 meter was taken at every consecutive photograph to maintain a 60-80 per cent overlap between the photographs. 356 photographs have been snapped in field which of them 177 were found suitable for this project. 123 shorted photographs are being used to generate the right hand side view of the street, while remaining 54 photographs has been used for left side street visualization. The steps are shown in following flow chart (Fig.2).

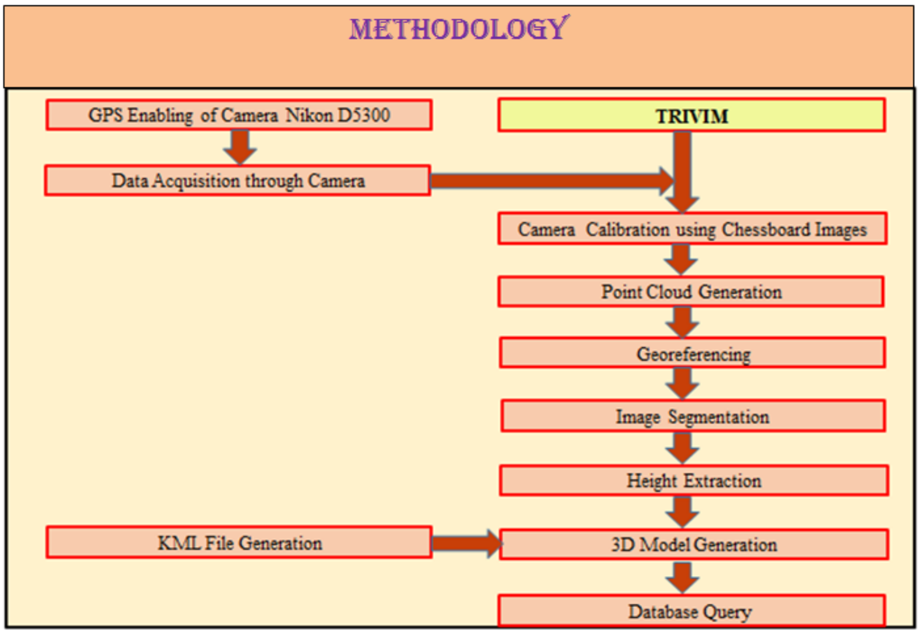

Fig.2 Flow Chart

Result and Discussion

Generate 3D Model using TRIVIM software

The following steps are used for 3D streets scenario.

1. Creating a new project

Create a new project first of all with a desired name in the Trivim software and choose that folder that give databased entry name or can load the already saved folder (Fig.3).

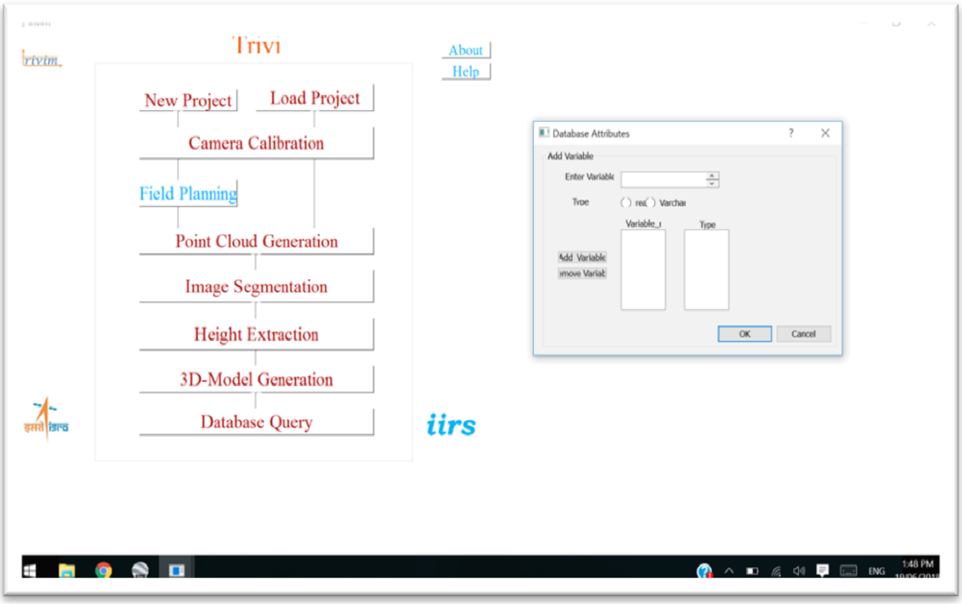

Fig.3 Creating New Project with Database Attribute

2. Camera calibration

In this step one must calibrates the camera and estimates the interior orientation parameters. Grey images of the chess board have to be taken with same camera and focal length as was taken to click photographs of the area (Fig.4). the use of calibrated cameras is preferred since even small calibration inaccuracies can have a significant impact on the precision of the generated point cloud (Fathi & Brilakis, 2011).

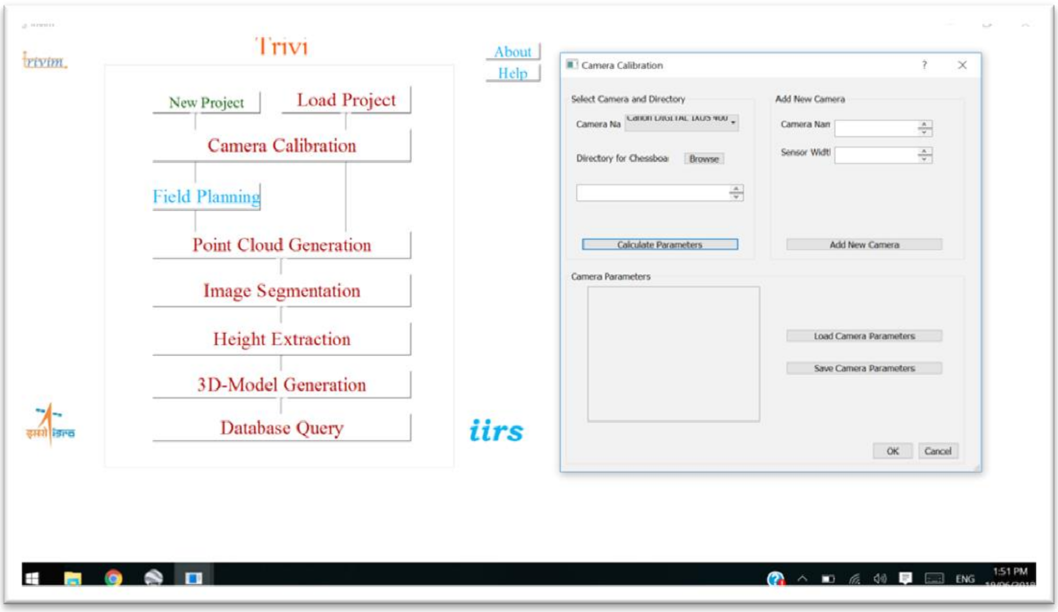

Fig.4 Camera Calibration Process

3. Field planning

The user should plan about the time required for image take, number of photographs needed. This is an optional field.

4. Point Cloud Generation & Georeferencing

After completion of above II/III stage, 3D point cloud from the set of two overlapping 2D images has been made. After the completion of point cloud generation, we must have to georeferenced this point cloud (Fig.5).

5. Image Segmentation & Generation of KML files

It is used to capture the texture of various buildings. For this one must select particular image and crop the buildings of each floor and enter its attributes. This step is repeated for all the buildings and all the floors of the building.

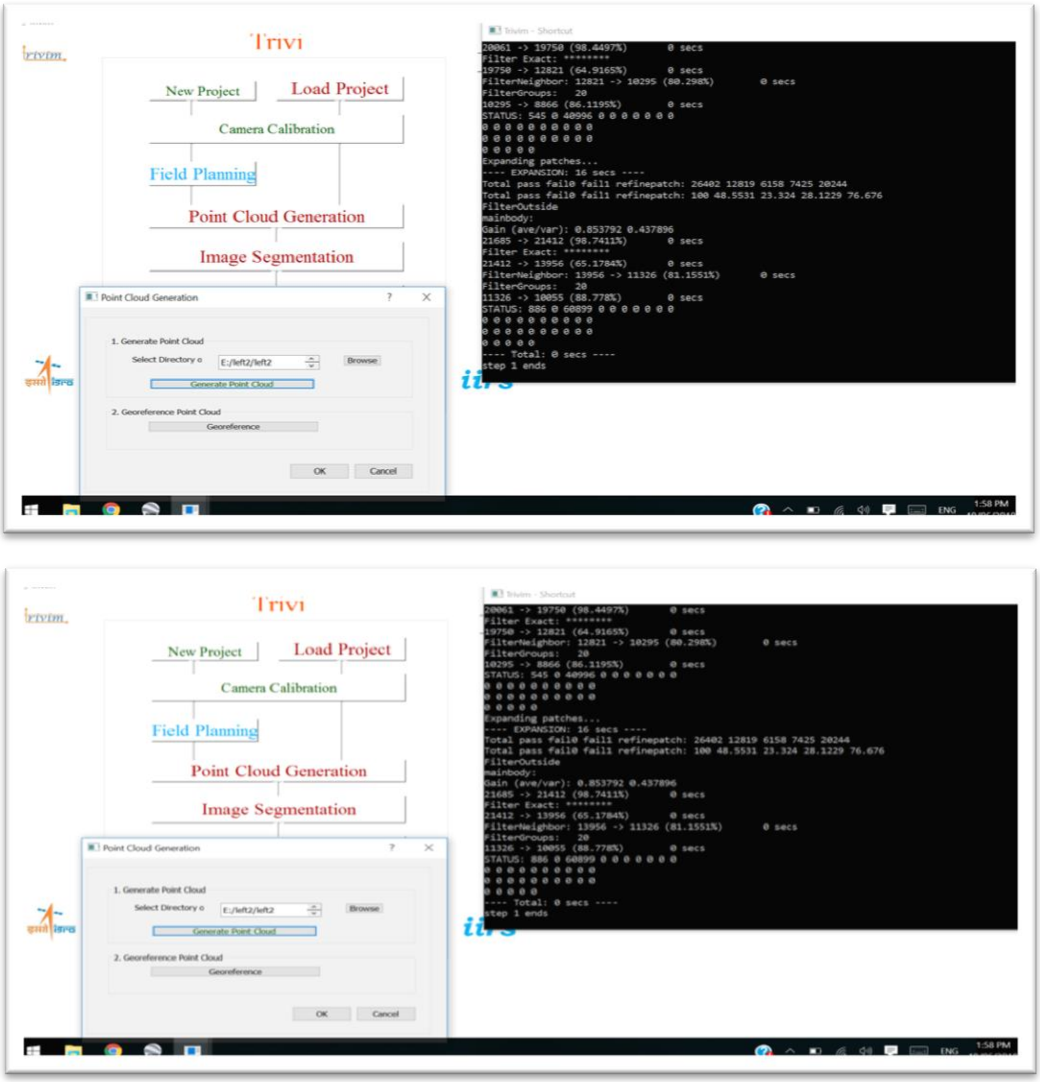

Fig. 5 Point Cloud Georeferencing

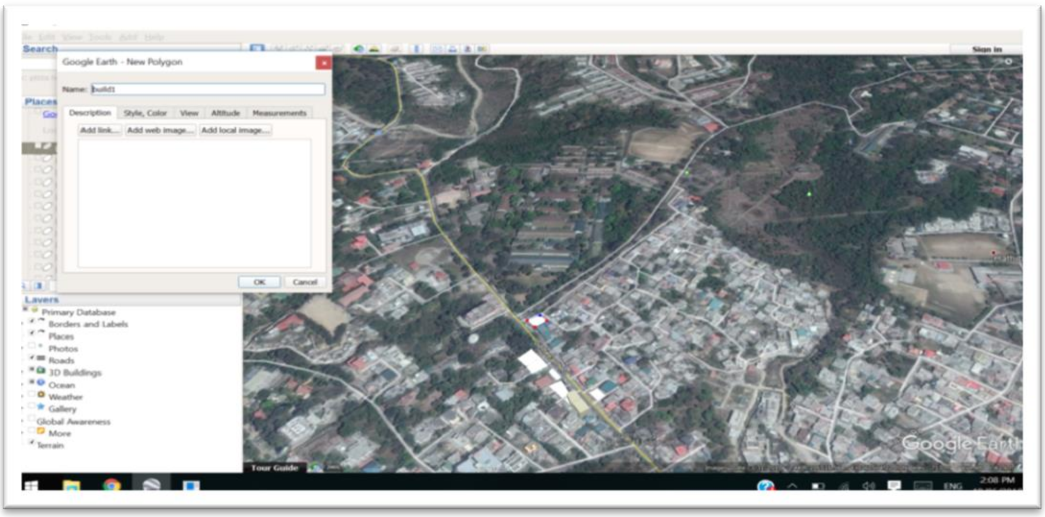

Fig.6 Generation of KML files

KML files of the all the buildings can be made using Google Earth which is required for 3D generation at next stage. Rusu & *et al.* 2009, present a framework for 3D geometric shape segmentation for close-range scenes used in mobile manipulation and grasping, out of sensed point cloud data (Fig.6).

6. Height Extraction

After point cloud is generated, georeferenced point cloud is activated and data is geo-referenced with the already created automated georef file in the project folder. It is done to match the point cloud data with the real-world coordinates. Click on height extraction button and browse for the point cloud file present in the project folder and open point cloud. Open cloud compare application and click ok and yes to all buttons and it gives the cloud points and adjusts accordingly. Pick two points for each floor for extracting height and save as x,y,z points in new height folder under the main project folder and save point (Fig.7). Repeat the same step for each building (Meenakshi, 2016).

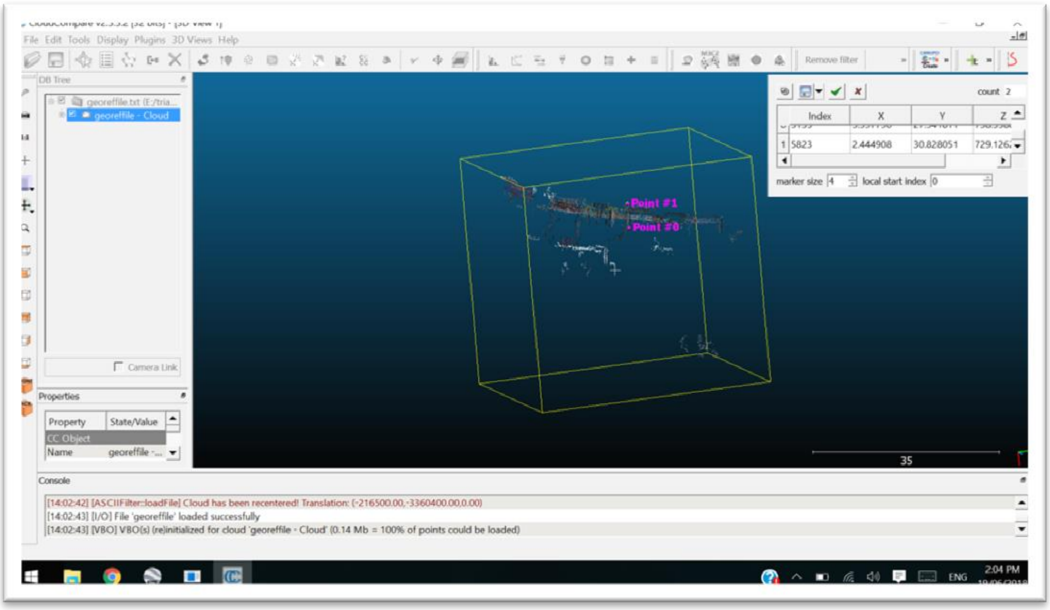

Fig.7 Height Extraction

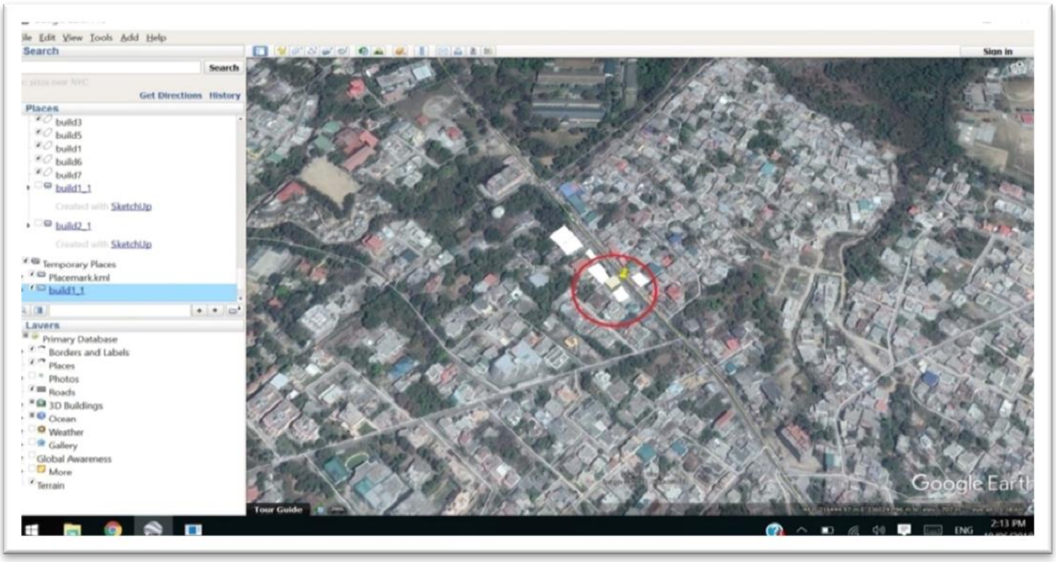

Fig.8 Red Circle indicate location of Buld_1

7. 3D model Generation

It compiles the grid, elevation and attribute's information related to the building segment and creates a 3Dmodel with fine textures that is visualized on a web portal such as Google Earth. Load the KML file and footprint of building one and repeat this process for rest of the buildings and click the construct button (Fig.8 & 9).

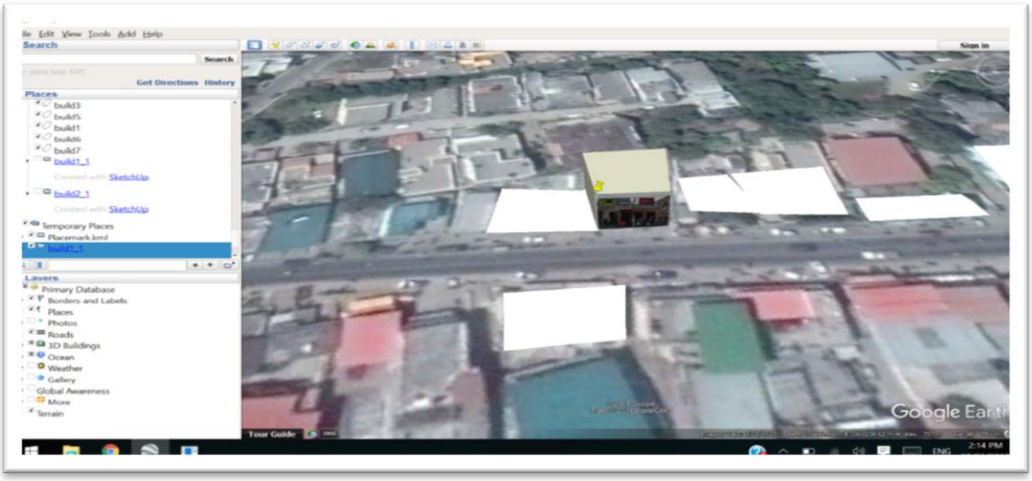

Fig.9 Final Output displaying the 3D Model

8. Database Query

As per our database query, load the attribute that gives the name and area etc. (Fig.10).

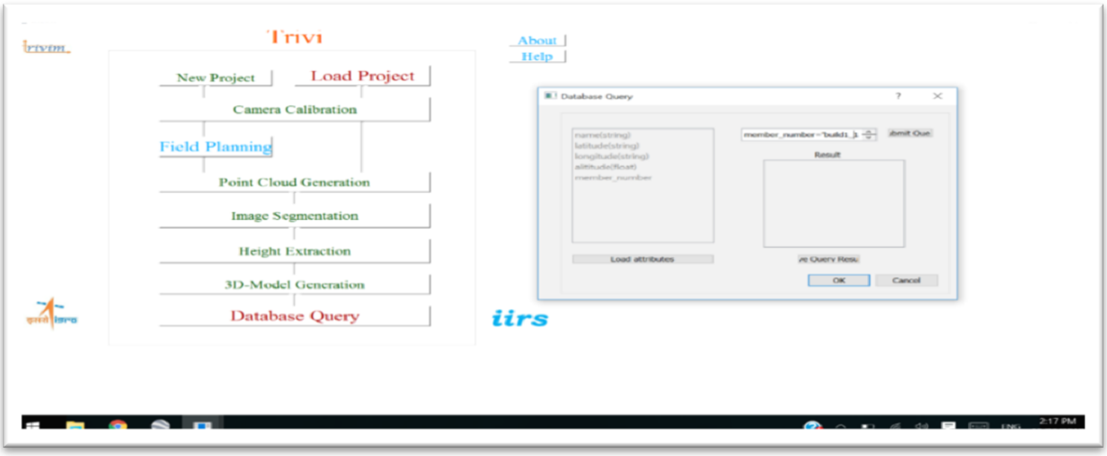

Fig.10 Database Query

Assessment of Urban Morphology

1. Regarding Urban Morphology

The surveyed area is 176 meters long Garhi Cantt Street of which morphology is clearly coming forward through 3D visualization. The summery of morphometric analysis is written in the following table. Here the analysis is regarding the floor numbers and their usage (Table.1).

Table 1 Urban Morphology of Cantt Street, Dehradun

N= 123 Sample Photo

Sr. No.	Particulars	Number of Buildings
1	Total Surveyed Buildings	22
2	Buildings with Ground Floor	06
3	Buildings with Multiple Floors	15
4	Buildings with Tin Roof	09
5	Buildings with Commercial Usage	19
6	Buildings with Residential Usage	03

Source: *Field Survey, 2018*

2. Regarding TRIVIM Software

Trivim is open source & user-friendly software. One should be easily downloaded from IIRS official website. It is very useful for creating 3D models of various applications of government departments such as municipal, taxation, surveying, architecture etc.

The camera parameters of NikonD5300 which is used in this project is as follows (Table. 2).

Table 2 Camera Calibration Parameters

Sr. No.	Parameters	Value
1	Camera Name	Nikon D5300
2	Sensor width	23.6
3	Focal Length (mm)	18.00
4	Distortion Coefficients	-0.03999479

3. Regarding Database Attributes

This is one of the best parts of this software that it can be attached with some attributes which will be seen through query window. It possesses a complete data set which comprising Lat/Long. Position of that particular building, height and rest of the information is provided by the user at the time of image segmentation (Table.3). That is why it becomes very useful especially urban local body governance for planning and execution.

Table 3 Database Query

Street Length=176 meters

Sr. No.	Building Name	Latitude	Longitude	Altitude	Usage Type
1	Build1_1	-216345.6538	-3360168.9156	711.29309	Grocery
2	Build2_1	-216345.7094	-3360168.8508	712.50787	Sweet Shop
3	Build2_2	-216345.7094	-3360168.8508	717.50787	Residential
4	Build3_1	-216346.1444	-3360168.5994	713.29254	Multiple Shops
5	Buildm_n	-	-	-	-

Source: *Field Survey, 2018*

Build3_1

Field Survey at Garhi Cantonment Road, near Survey of India, Dehradun

Conclusion

For the purpose of the present study surveyed street area is 176 meters long Garhi Cantt Street, near IIRS, Dehradun of which morphology is clearly coming forward through 3D visualization. Herein also analyse the floor numbers and their usage in surveyed street. Trivim is one of the open sources & user-friendly software which is used to create 3D street views without using any commercial software. This is one of the best parts of this software that it can be attached with some attributes which will be seen through query window. It possesses a complete data set which comprising Lat/Long. Position of that particular building, height and rest of the information is provided by the user at the time of image segmentation. That is why it becomes very useful especially urban local body governance for planning and execution. There are some limitations like the process of TRIVIM is slow and sometimes erroneous also. So, a higher and advanced version is prime requirement to make it popular and efficient. Larger area coverage is very much time taking and effortful. A high end geo-tagged camera is pre-requisition for the use of TRIVIM software which is may costly. So, we recommend that mobile based app must be developed by the IIRS.

Acknowledgement

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Conflicts of interest

There are no conflicts of interest.

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