3D mapping of geospatial features using terrestrial laser scanner – A case study using scanned data of MNNIT Allahabad

Presented By:

Manohar Yadav
Assistant Professor, GIS Cell,
Motilal Nehru National Institute of Technology Allahabad

Common geospatial features present in MNNIT Campus

- Trees
- Buildings
- Road network
- Pole like structures

Buildings mapping and modeling

- 3D mapping
  - Three dimensional geometrical and radiometric information collection of features

- 3D modeling
  - 3D models represent a 3D object using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc.
  - After collection of data (points and other information), 3D models can be created by hand or algorithmically (Procedural modeling)

3D building models

- Demands increases in several society fields such as
  - Urban planning
  - Environment safety
  - Transportation
  - Navigation and virtual tourism
  - Construction

Methods

- Manual creation of building models
- Automatic building reconstruction
  I. 3D building structure recovery using 2D images
  II. Laser scanning

Manual creation of building models

- Slow process
- Necessary to measure the length of all the wall edges to make a wall face
- Time consuming when target building containing too many edges and /or there are many buildings to be modeled.
- Inaccurate procedure, because visual measurement of geometric properties (distance/size/area) may depend on human operator

3D building structure recovery using 2D images

- Partial solutions and limited success in constrained environments.
- Digital imagery is only data source used for the reconstruction for a long time and it is still hard to recover 3D building structures from 2D images.
- **Depth determination:** If two images are available, then the position of a 3D point can be found as the intersection of the two projection rays. This process is referred to as triangulation.
- Accurate camera calibration parameters, i.e., consists of intrinsic and extrinsic parameters are required.

Laser scanning

- Valuable data source for automatic building reconstruction
- Compare to digital imagery laser scanning give explicit 3D information which enables the rapid and accurate capture of the geometry of complex buildings
- Terrestrial laser scanning is able to provide very dense point clouds of building facades which gives enough raw data from which high detailed 3D building models can be obtained automatically

View of colour coded point cloud data of administrative block of MNNIT Allahabad

Building reconstruction steps

- Feature extraction
  - Segmentation
  - Feature recognition
- Geometry modeling
  - Geometry fitting
    - Wall
    - Roof & extrusion
    - Pillar
    - Door & window
  - Geometry estimation (in case of missing laser points)
  - Final model

Feature extraction

- Segmentation
  - Planar surface growing algorithm
  - Selection of seed surface
  - A seed surface consists of a group of nearby points that fit well to a plane.
  - Algorithm select arbitrary unclassified points and test minimum no. of points included in seed surface.
  - Seed surfaces grow to their nearby points
  - Growth based on thresholding criteria on normal distance from added point to the plane.
  - Generate many surfaces from raw building laser points

Feature extraction

- Feature recognition
  - Human understanding of building features based on its size, position, direction and topology

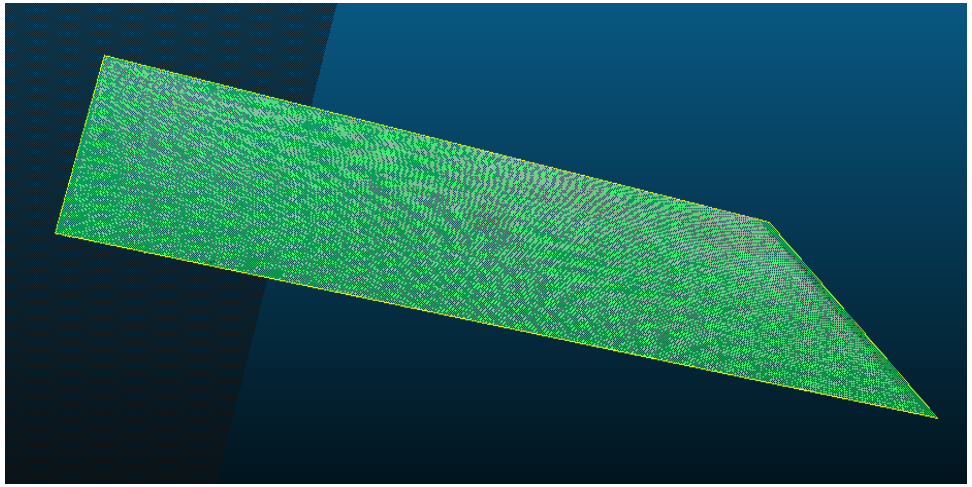
---

  - Machine understand and recognize building features based on its predefined size, position, direction and topology
  - Based on the these geometrical features constraints different features are recognized.
  - Ground is also included as features, because of its role in recognition of other features.

Machine Training

- Ground
  - Size: Segment with large area (based on building corner points)
  - Position: Lowest (based on *z* value)
- Wall
  - Segment with larger area.
  - Direction: Vertical (With respect to ground plane)
  - Topology: May intersect ground

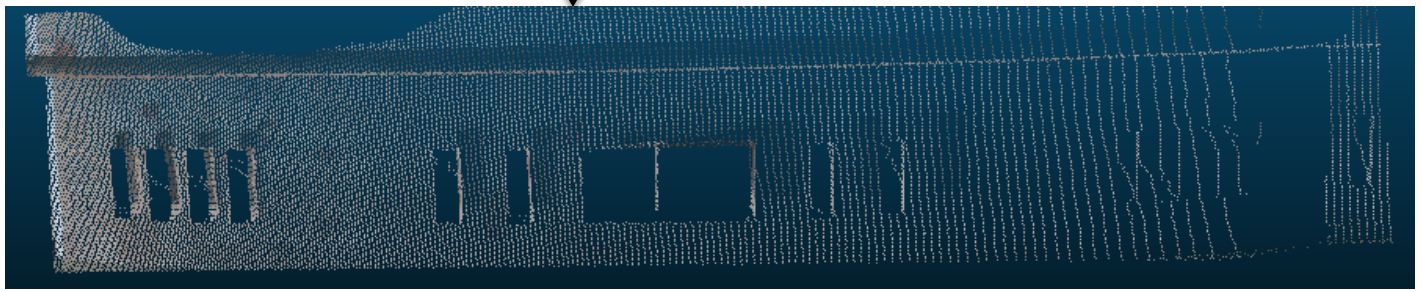
Extracted plane and recognized as Wall

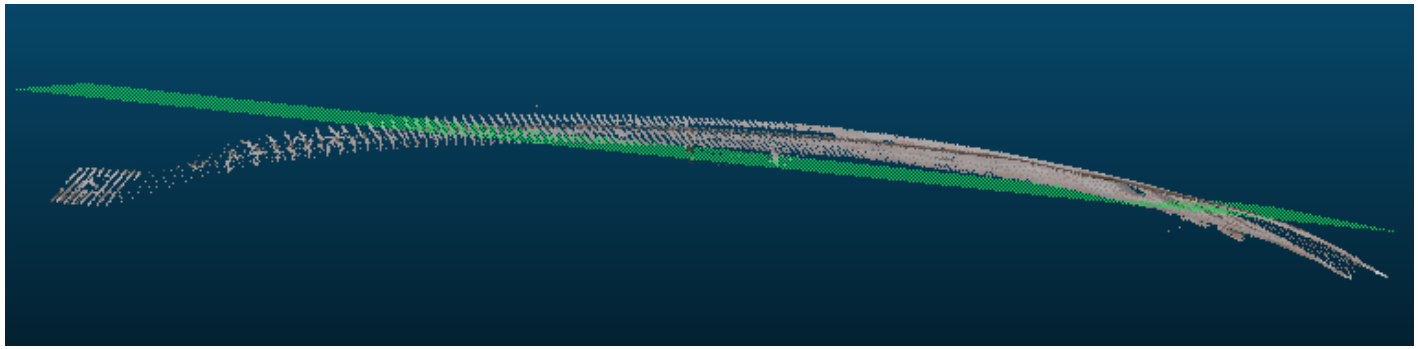


Machine Training

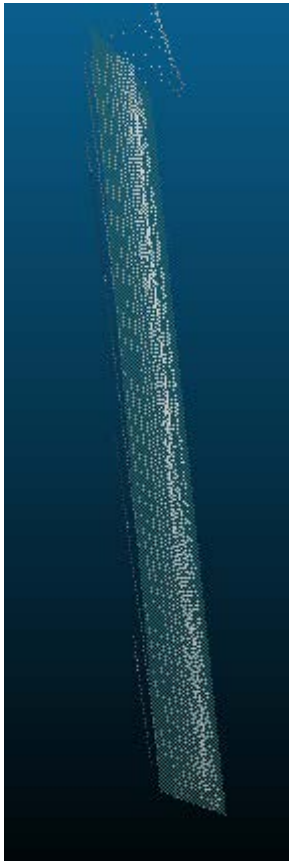
- Roof
  - Size: Segment with large area.
  - Position: Above wall
  - Direction: not vertical
  - Topology: Intersects a wall
- Door
  - Size: Area within certain range
  - Position: On the wall
  - Direction: Vertical
  - Topology: Interests the ground
- Window
  - Identifying holes in the wall

Wall and openings in the wall



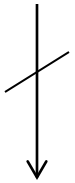


Pillars



Geometry modeling

- Fitting plus grouping of extracted feature segments.

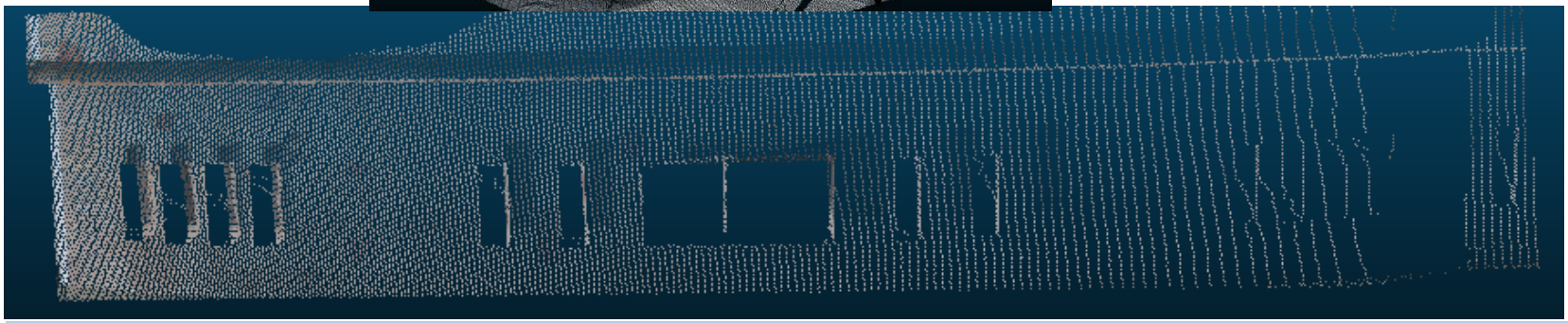


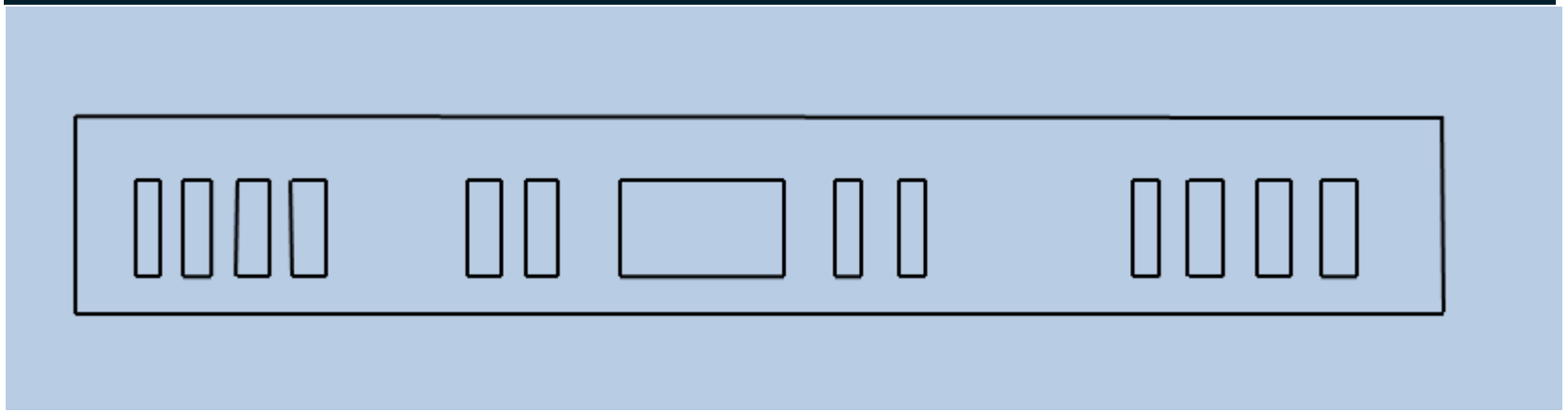
- Feature segment do not have complete geometry information i.e., due to occlusions
- Terrestrial laser scanning is generally ground based, so laser points for roof top and building segments, which are not in FOV of scanner are missing.
- The missing parts can be estimated based on existing laser points and knowledge about buildings.

Steps for geometry modeling

- Geometry fitting
- Geometry estimation
- Grouping/combining

Result of modeling of a building segment





Conclusions

- Raw laser points of building are segmented and recognised using the machine training.
- Individual segments geometries are estimated in case of occlusions based on existing boundary and knowledge about buildings
- Upper front part of building modeling is performed

References

- Pu, S., 2008. Generating building outlines from terrestrial laser scanning. In: International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 37 (Part B5). pp. 451456.
- Pu, S., Vosselman, G., 2007. Extracting windows from terrestrial laser scanning. In: International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 36 (Part 3/W52). pp. 320325.
- Vosselman, G., Gorte, B., Sithole, G., Rabbani, T., 2004. Recognizing structure in laser scanner point clouds. In: International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 46 (Part 8/W2). pp. 3338.

Thank You