Building Extraction - LIDAR

R&D Program for NASA/ICREST Studies

Project Report 09/16/01

Program Objectives:

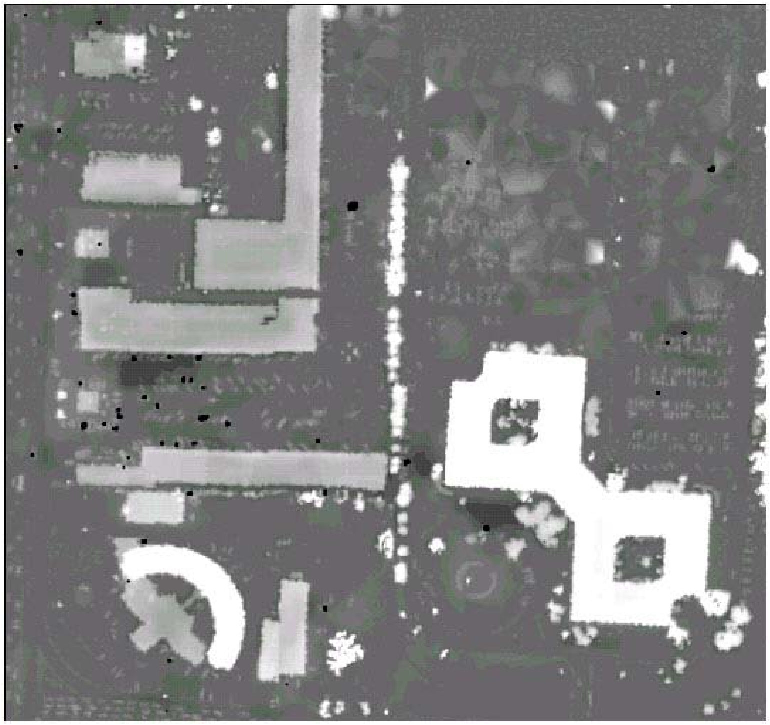
Building Extraction:

1. Create a robust methodology within existing software components of image processing and geographic information systems for the extraction of building footprints from LIDAR data.
2. Examine the feasibility of creating 3D views of these building footprints within the vegetative context of the image scene.
3. Examine the feasibility of determining basic roof-types from the LIDAR data and use these within the 3d viewing of the extracted building sets.
4. Conduct an accuracy assessment of the methods created and examined against ground truth information.

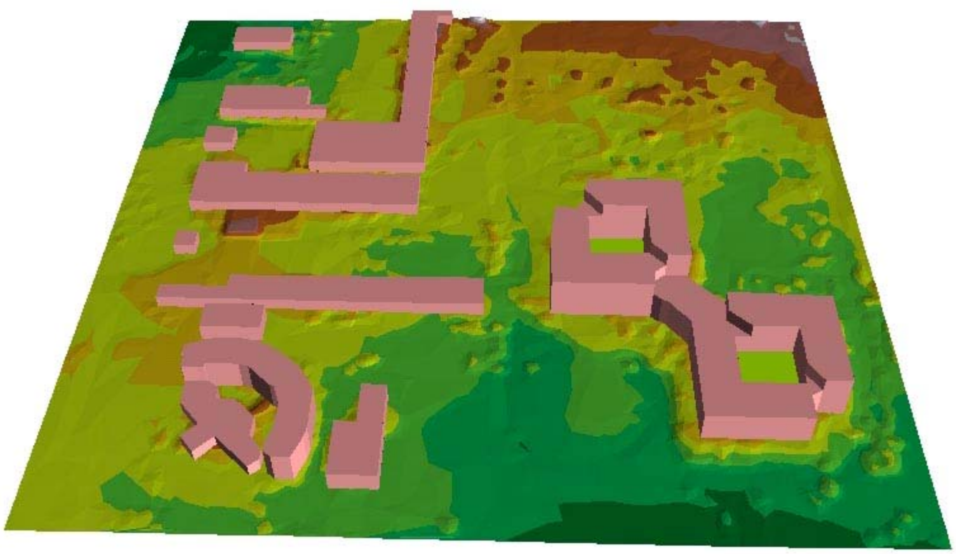
Progress Summary:

Building information is extremely important for many applications such as urban planning, telecommunication, or environment monitoring etc. Automated techniques and tools for data acquisition from remotely sensed imagery are urgently needed. This research presents an automatic approach for building extraction and reconstruction from airborne Light Detection and Ranging (LIDAR) data. First a digital surface model (DSM) is generated from LIDAR data and then the objects higher than the ground are automatically detected from DSM. Based on general knowledge about buildings, geometric characteristics such as size, height and shape information are used to separate buildings from other objects. The extracted building outlines are simplified using an orthogonal algorithm to obtain better cartographic quality. Watershed analysis is conducted to extract the ridgelines of building roofs. The ridgelines as well as slope information are used to classify building types. The buildings are reconstructed using three parametric building models (flat, gabled, hipped). Finally, the results of extraction are compared with manually digitized reference data to conduct an accuracy assessment. The experimental results are very promising.

This research created an automatic approach for building extraction and reconstruction solely based on LIDAR data. First DSM is generated from original LIDAR point data, then we threshold the normalized DSM (the difference between DSM and bare elevation) to get an initial segmentation. Buildings and trees are separated based on surface roughness measured by differential geometric quantities. After raster-to-vector conversion, the building outlines are simplified using an orthogonal algorithm. We utilize slope information and watershed analysis to determine the building roof types. Finally the buildings are reconstructed using three parametric models. The experimental results are presented and assessed by comparing with reference data.



Normalized DSM of a downtown area



3D view of extracted buildings draped on DEM

Accuracy Assessment

We compare the automatically extracted buildings with reference data manually digitized from aerial photograph with 0.25m resolution. The reference data contain building outlines and roof type information. We can get the completeness and correctness measure by comparing number of extracted buildings with reference data. Horizontal RMS error can be obtained by calculating the distance between corresponding building corners. Overlaying extracted building with reference data will lead to the overlay error as well as area & perimeter difference measure. Due to lack of height information of reference data, we cannot assess the vertical geometric accuracy. We compare extracted roof types with reference data to obtain classification accuracy. The seven quality measures (completeness, correctness, classification accuracy, RMS error, area difference, perimeter difference, and overlay error) are used to access accuracy for the two tested data sets. The calculated quality measures for the two test data sets are listed in table 1.

Table 1 Accuracy assessment of building extraction

	1. Residential scene	2. Downtown scene
Total Building Number	79	12
Completeness	93.7%	100%
Correctness	97.4%	86.7%
Classification Accuracy	90.9%	91.7%
RMS	1.01	1.09
Area Difference	15%	
Perimeter Difference	11%	
Overlay	22.9%	11.5%

The residential scene has 79 buildings. 93.7% buildings are extracted by our approach. The un-extracted are few small houses removed by a size threshold. Only two large vegetation areas were extracted wrong as building. The roof type classification is quite good with 90.9% correctness. All the 12 buildings in downtown scene are extracted, but two large vegetation areas are extracted also. Only one building is misclassified.

A second method of automated building extraction was also assessed. This process uses morphology to extract buildings from the normalized DEM in the image software package ENVI. On a small test area, the in-house building extraction program was compared to the ENVI morphology method to determine the most accurate extraction method. Based on the test area, and two different parameter sets for each, the correctness of the in-house building extraction program averaged 95.5% while the ENVI morphology method averaged only 82.5%. This value was found by comparing the extracted buildings to a “truth” set of building footprints extracted using heads-up digitizing in ArcInfo from a 0.25-meter resolution aerial photography base, georectified using GPS ground control points. From the 75 total reference buildings in the “truth” set, the in-house program totaled only 3.5 false buildings on average whereas the ENVI morphology method averaged 17 false buildings. Only the ENVI morphology method missed any of the reference buildings where 5 buildings were missed on average, while the in-house program did extract all reference buildings from the data set.

<u>Ongoing Activities:</u>

Current efforts are now focused on finishing the generation of building footprints for the City of Springfield and Greene County, Missouri. A LIDAR processing and building extraction protocol are being refined for use in further implementation. Tasked to be completed by November 2001.

A publication is underway for peer reviewed journal publication.

Building Extraction & 3D Generation/Validation/Error Modeling Team

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