SHARP 3D RECONSTRUCTION OF BUILDING FAÇADES USING RANGE DATA

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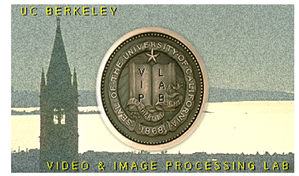
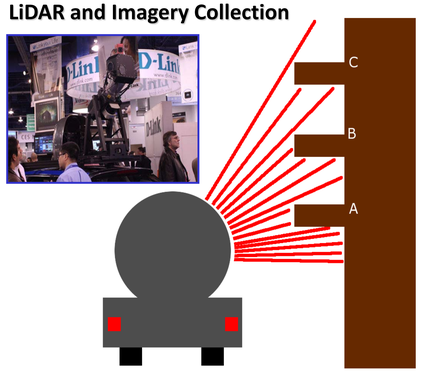
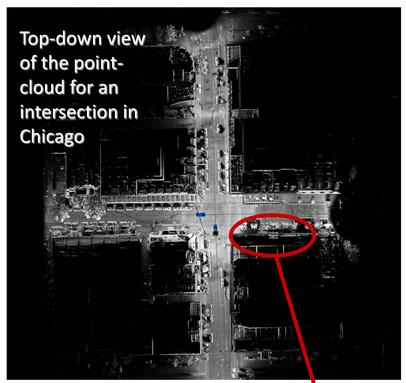


Problem Statement

LiDAR and Imagery Collection



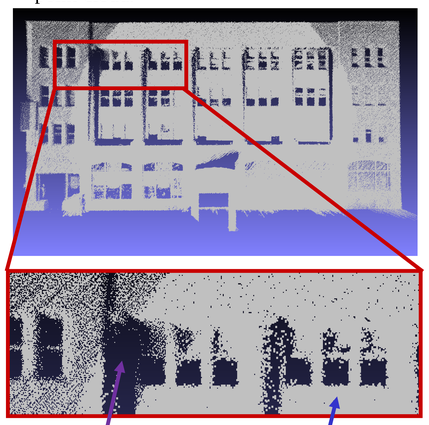
- Laser range scans and panoramic photography are captured from street level using an acquisition vehicle.
- The GPS and localization systems on the vehicle generate a world-coordinate point-cloud.
- Many areas in the point-cloud are occluded, requiring estimates of the underlying geometry.



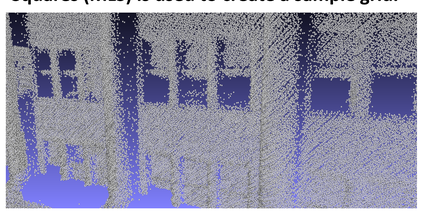
Point-cloud Sampling

Algorithm Overview

- Want to generate sharp 3D model of individual façades.
- Samples are noisy due to localization error of vehicle.
- Occlusions, windows, and acute scan angle cause high density of gaps in point-cloud.

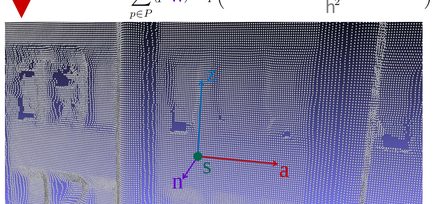


Combination of areas of noisy over-sampling with complete gaps in the point-cloud require the points to be interpolated. Moving Least-Squares (MLS) is used to create a sample grid.



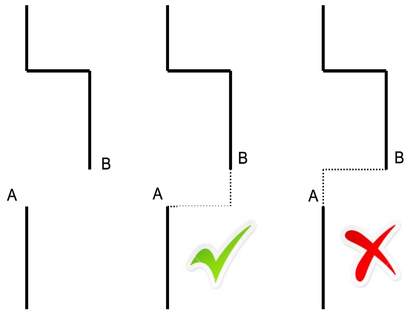
Resampling is completed by selecting uniformly spaced points, s, along the façade. Depth at s is the MLS average, with length h, of neighboring points, P:

$$\sum_{p \in P} (p^T \mathbf{n}) \, exp\left(- \frac{((p-\mathbf{s})^T \mathbf{a})^2 + ((p-\mathbf{s})^T \mathbf{z})^2}{\mathbf{h}^2} \right)$$



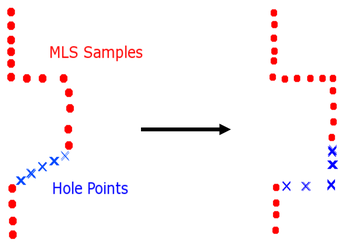
Hole Filling

Architecture Estimation Heuristic

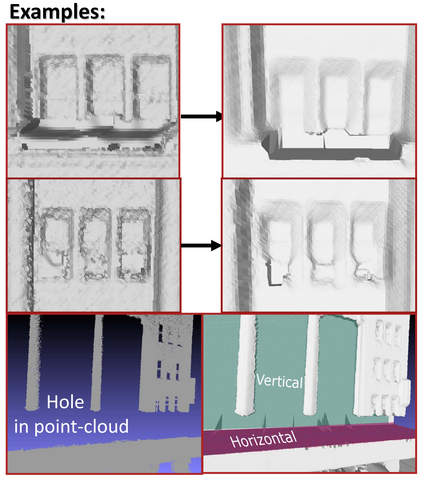


Gaps in the point-cloud are assumed to be caused by occlusions from the building architecture (e.g. window ledges, balconies).

Holes are filled with axis-aligned planes, at the maximum depth of each hole.

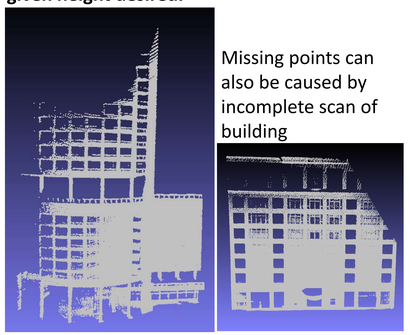


Examples:



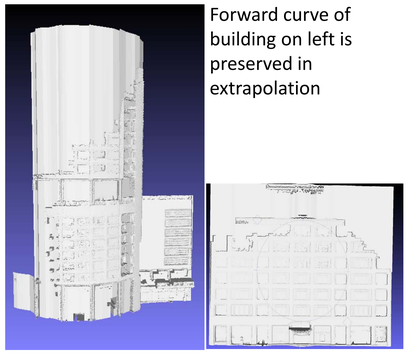
Building Extrapolation

Scans are collected solely from ground-level, which results in minimal or no return for upper stories of buildings. General shape of façade must be extrapolated from existing model, given height desired.



Missing points can also be caused by incomplete scan of building

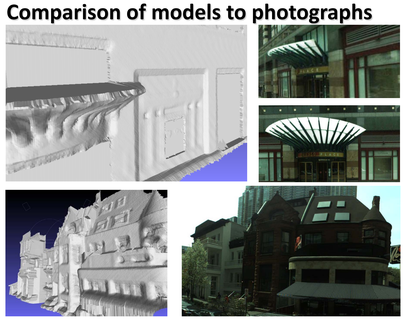
Mean depth of points below extrapolation area used to fit piece-wise linear approximation to missing façade.



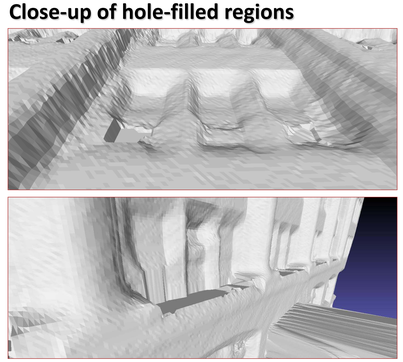
Forward curve of building on left is preserved in extrapolation

Results

Comparison of models to photographs

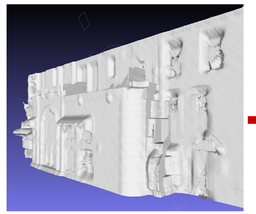


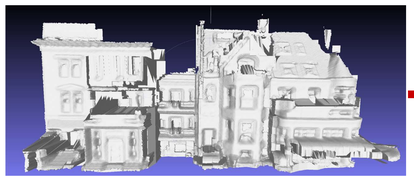
Close-up of hole-filled regions

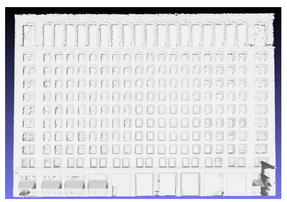


Output Models

Untextured triangulations

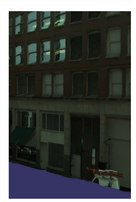






With Texturing

Models textured using imagery



Full Building Models

Acknowledgements

All scans and imagery were collected by and are owned by Navteq © 2011.