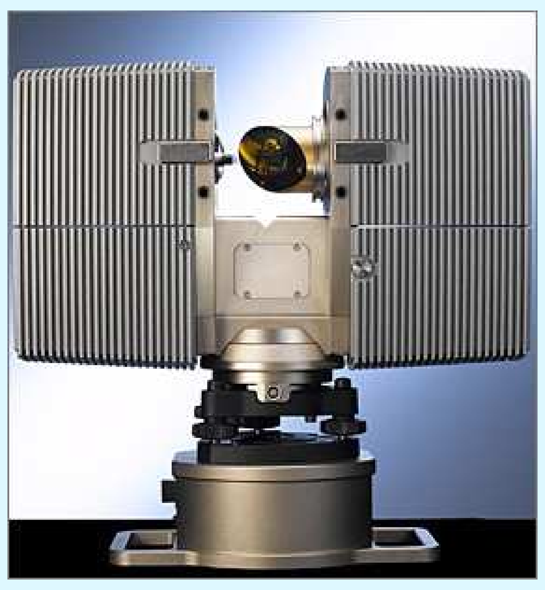
Reducing the error in terrestrial laser scanning by optimizing the measurement set-up

This presentation introduces the notion of point cloud quality. An experimental room is scanned from two different stand-points. It is shown that by moving the laser scanner stand-point by approximatively two meter, the point cloud quality can be improved by 25%.

Terrestrial Laser Scanning



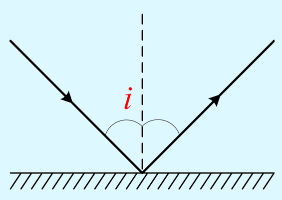
FARO LS880 HE80

Cessna airplane and its point cloud colored with intensity

The terrestrial laser scanning technology is increasingly being used for representing and analyzing 3D objects in a wide range of applications, like visualization and modeling, but also monitoring of man made structures. Such surveying applications require not only a quickly obtainable high resolution point cloud but also observations with a known and well described quality. A laser scan provides a spherical representation of the surroundings with the scanner as the origin of a local coordinate system. The range is described as the distance measurement between the object surface and the scanner. Four main parameters influence the quality of the range measurement, specified as follow:

- Scanner mechanism.
- Properties of the scanned surface.
- Conditions of the experiment environment.
- Scanning geometry.

Scanning Geometry



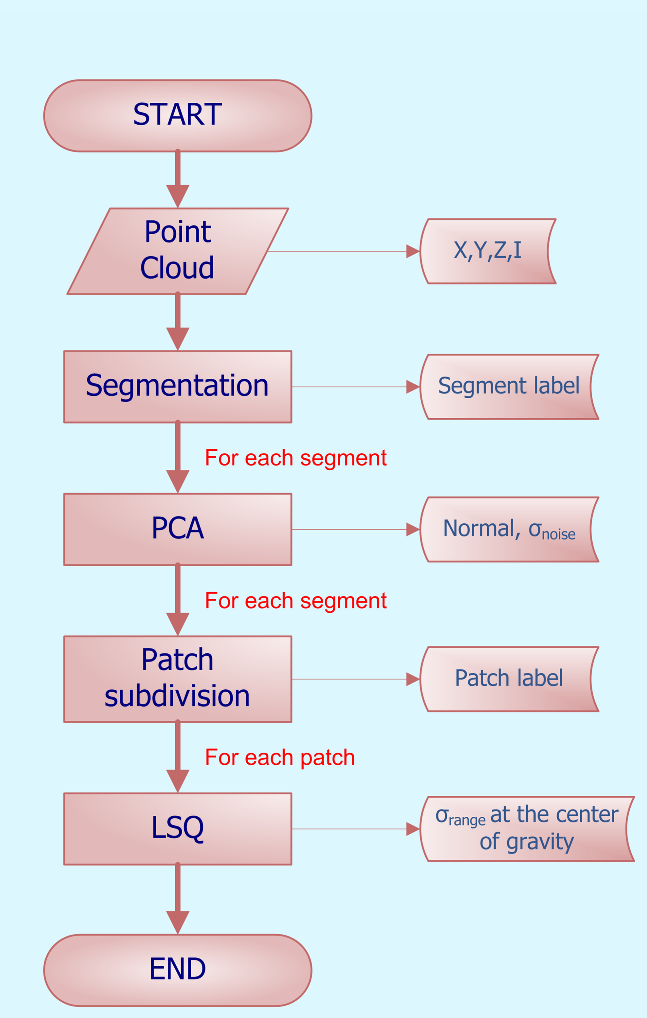
Incidence Angle.

To obtain a 3D point cloud, the scene is scanned from different positions around the considered object. The ideal set-up for scanning a surface of an object is to position the laser scanner in such a way that the laser beam is near perpendicular to the surface. When scanning a complex scene, not all object surfaces can be scanned in this ideal way. The different incidence angles and ranges of the laser beam on the surface result in 3D points of varying quality. Here we define the incidence angle as the angle between that surface normal that is pointing in the surface, and the incoming laser beam direction. The following two correlated components variate with respect to the scanning geometry:

- Range quality.
- Point cloud density.

The stand-point of the scanner that gives the best accuracy, in terms of mean Least Square Error, is in general not known. Using the optimal standpoint of the laser scanner on a scene will improve the average quality of individual point measurements.

Method

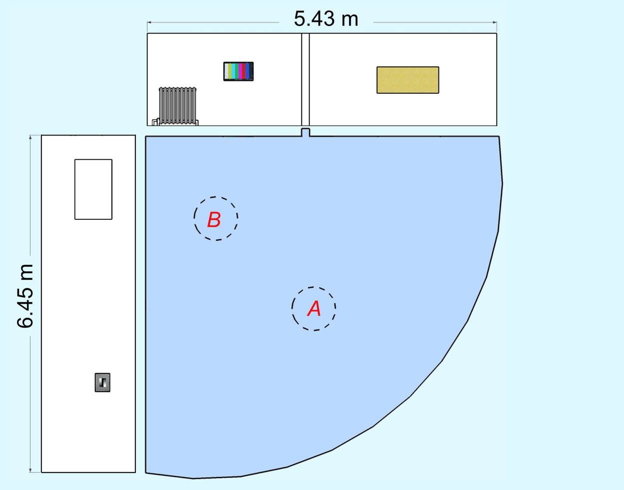


The quality of the point cloud is described using error propagation. The point cloud is first segmented based on a planar feature extraction algorithm. Each segment is then subdivided into small patches of 20×20 cm.
Principal Component Analysis is used to estimate planar parameters for each patch. The deviation from the points to the planar patch allows to estimate a local noise level σ_{noise}.

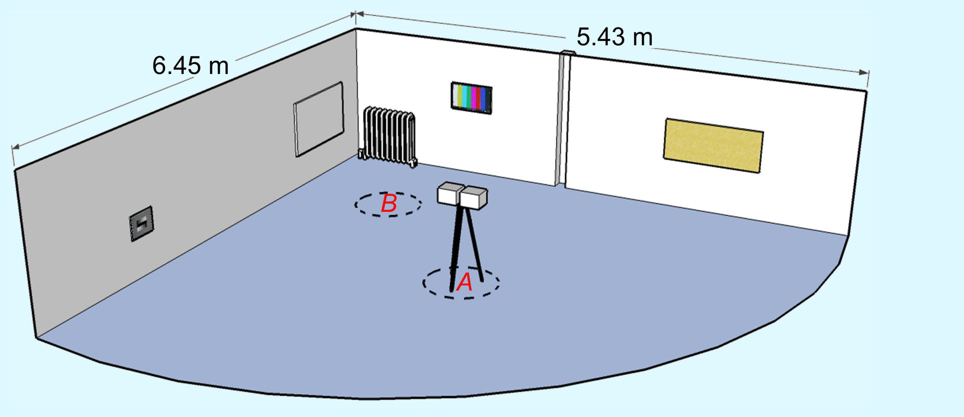
The quality of a local patch is evaluated by one number: the standard deviation σ_{range} of the distance of the scanner to the center of the patch. The local point density is incorporated in the local point cloud quality by considering the redundancy in determining local patch parameters.
The quality of a segment is computed by averaging the local patch qualities of the patches belonging to the segment. The total error is then defined as the average of all individual patch qualities.

Experiment set-up

The room scanned for this experiment contains two white and smooth planar walls and a planar floor covered with light colored linoleum. Two test plates that were used in previous studies are added on the two planar walls, together with a white coated plywood and a medium-density fibre board. The laser scanner scans the room from two different stand-points.

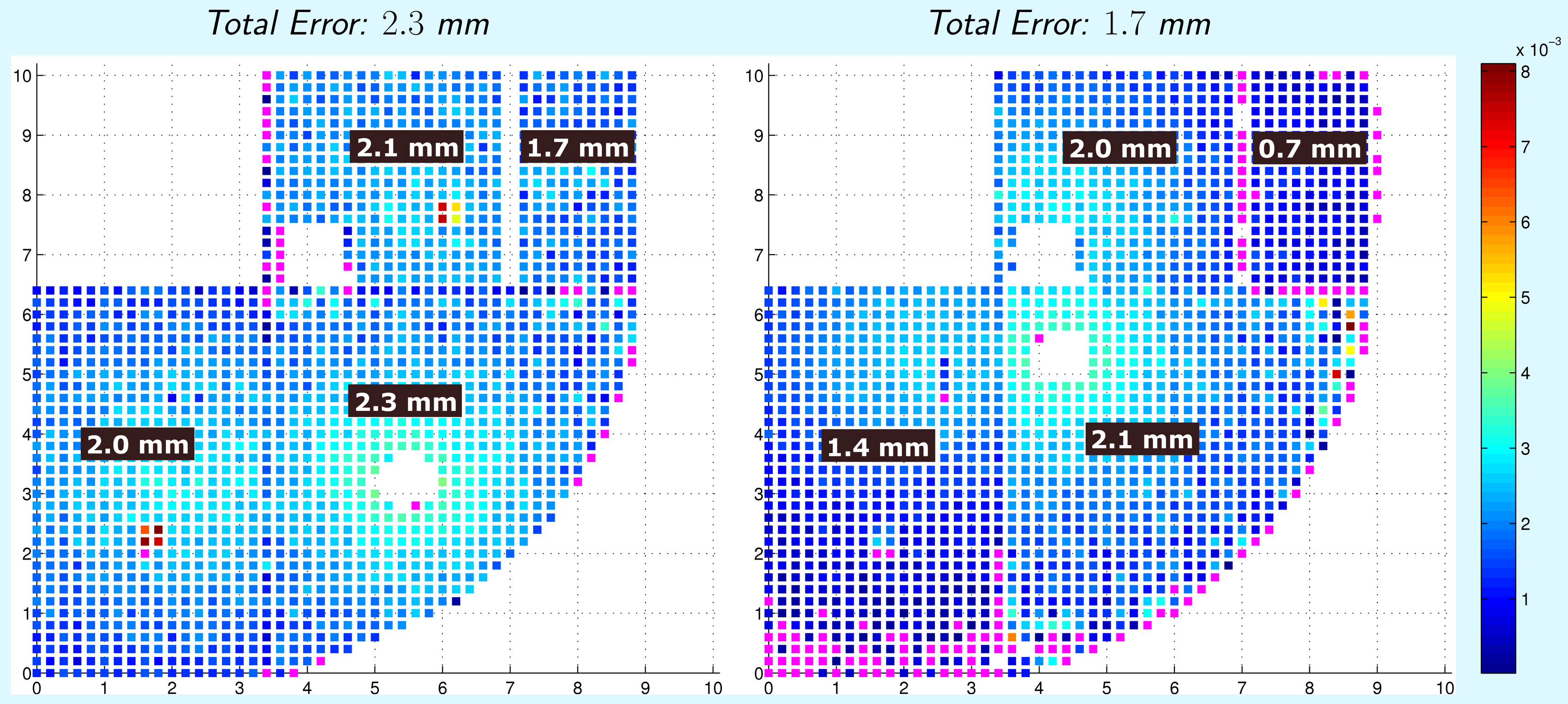


Stand-point A is approximately situated in the middle of the room. Stand-point B is situated in the corner formed by the two planar walls. It is investigated which of the two stand-points result in a point cloud of best quality.



3D view model of the experiment setup and the net model, A and B are two stand points of the laser scanner.

Results

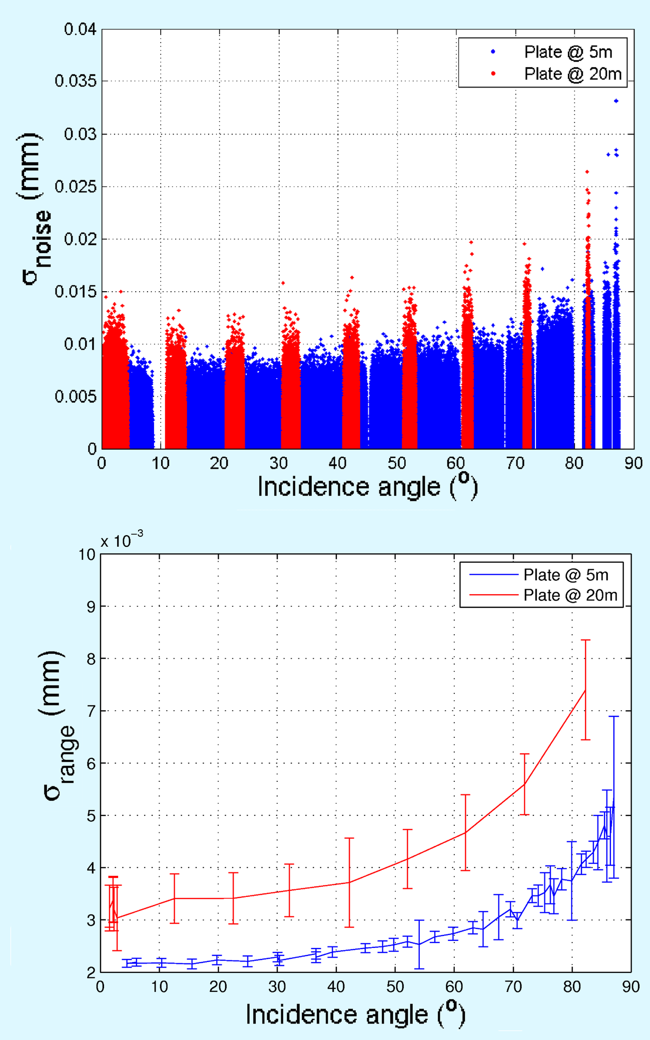


Individual patch quality, σ_{range}, per patch. For the four largest segments, the mean individual patch quality is plotted.

On average, the position in the corner (stand-point B) results in patches of better quality. The average patch variance for all patches together equals 2.3 mm for stand-point A and 1.7 mm for stand-point B.
In the proceedings paper, the quality differences between the two point clouds are further investigated.

Conclusions and future work

By introducing a notion of point cloud quality, that incorporates both the point density and the individual point quality, it is shown that by moving a scanner by a few meters, the point cloud quality can be improved by 25 %.
In a next work, the optimal scanner position will be identified beforehand by using error models from the major error components.
The scene will at first be scanned at a low resolution from an arbitrary stand-point, using reference objects with known error behavior placed in the scene.
The error model of the reference objects is determined using a noise level model σ_{noise} per point and a range quality model σ_{range} per patch, which depends on e.g. scanning geometry.
The analyze of the quality of the reference objects in the scanned scene will enable to place the laser scanner at a position that gives optimal point cloud quality, w.r.t the modeled error.



Noise level σ_{noise} and range quality σ_{range} of a reference plate scanned from different scan angles at two range placements.

Sylvie Soudarissanane, Roderik Lindenbergh and Ben Gorte
Delft Institute of Earth Observation and Space Systems (DEOS)
S.S.Soudarissanane@tudelft.nl

TU Delft

Faculty of Aerospace Engineering

Delft University of Technology