Department of Infrastructure Engineering

GEOM90038 Advanced Imaging

Lab Assignment 3: Laser scanning

Due for submission at 10:00 pm on Friday of Week 9

Note: This assignment can be carried out in a group. You can choose your group member (no more than 2 members per group) and work together on the assignment. However, each student must submit an individual report outlining their method and results. Please ensure one member of the group has a computer to run the software.

The task

The aim of this assignment is to learn the laser scanning technology for capturing natural and built environments in the form of a 3D point cloud. The assignment involves data capture using two lidar sensors, registration of the corresponding point clouds, and evaluation by calculating the distance between the corresponding (closest) points of the two point clouds. To carry out these tasks you will use a software called CloudCompare, which is a free open-source software and can be downloaded from: http://www.danielgm.net/cc/release/

Data

During the lab session in the first week of the assignment we will scan a location on campus using two sensors: the FARO terrestrial laser scanner (TLS), and the Zeb sensor. The resulting point clouds will be shared via LMS.

The procedure

1. *Registration of the Zeb point cloud to the TLS point cloud*
    a. Open the two point clouds in CloudCompare. In the DB Tree window on the left you can click each point cloud to see its properties including the number of points.
    b. Manual alignment: use the Translate/rotate tool  to approximately align the Zeb point cloud with the TLS point cloud. Make sure you select the Zeb point cloud in the DB Tree window so you don't translate/rotate the TLS point cloud. Different viewing tools and also the segmentation tool might be helpful when aligning the point clouds visually.
    c. Coarse registration: once the point clouds are approximately aligned perform a coarse registration by selecting the two point clouds in the DB Tree window and then selecting: Tool > Registration> Align (point pairs picking). Choose the TLS point cloud as reference. Make sure you select a sufficient number of corresponding points to allow for the calculation of residual errors. Note the registration error (RMSE) and include it in your report.
    d. Fine registration: perform a fine registration by selecting the two point clouds in the DB Tree window and then selecting: Tool > Registration> Fine registration (ICP). This applies the Iterative Closest Point (ICP) algorithm which iteratively minimizes the distance between the closest points in the two point clouds. Inspect the two point clouds to ensure the fine registration is done properly. Note the registration error (RMSE) and include it in your report.

2. *Calculation of cloud-cloud distance*
    a. Once the Zeb point cloud is registered to the TLS point cloud you can calculate cloud-cloud distances by selecting the two point clouds from the DB Tree window and then selecting: Tool > Distances > Cloud-Cloud Dist. Again choose the TLS point cloud as reference.
    b. Experiment with different settings. Take into account that large distances may occur when a surface is present in one point cloud but not in the other (e.g. due to occlusion). Therefore, you need to set a maximum distance in the parameter setting window based on your estimate of the maximum distance between corresponding surfaces. The registration error can help you make a reasonable estimate.

3. *Evaluation and analysis*
    a. Once the distances are calculated visualise these by selecting the Zeb point cloud and selecting the last scalar field from the properties window. Check the Visible check box to see a color bar.
    b. Export the Zeb point cloud in a .txt file and create a histogram of the distances (the last columns in the text file). Try to separate the small distances, which are between corresponding surfaces, from large distances, which occur due to the lack of correspondence.
    c. Include the colour visualisation of the distances and the histograms in your report. The colour visualisation shows the spatial distribution of the distances between the two point clouds, and the histogram shows the probability distribution of the distances.
    d. Analyse the accuracy of the Zeb point cloud relative to the TLS (which is the more accurate sensor) based on the calculated distances. If you identify any deformations or gross errors in the Zeb point cloud, provide a visualization of the error. Provide also an analysis of the completeness of each point cloud. Include your analyses in the report.

Submission

Write an individual report outlining the process and your results. Include the following content:

a. Introduction: describe the aims and your general approach to the assignment.
b. Methods: explain the method you followed to perform each of the tasks of the project.
c. Results: report the results including the accuracy of registration and the cloud-cloud distances. Provide an analysis of the results including the completeness of each point clouds. Provide a comparison of the two sensors in terms of precision, completeness and richness of the data.
d. Conclusions: provide a summary of your findings and what you learned about laser scanning.
e. References: provide a list of references if your text includes any information from other sources.

Submit a digital version of your report via LMS and in pdf format only.

Marking rubric

Appropriate length and proper formatting	5%
Proper introduction	10%
Proper description of the workflow	15%

Accuracy of registration	20%
Correctness of cloud-cloud distances	20%
Proper analysis of the results	20%
Logical conclusions	10%