Fast and Robust Registration and Calibration of Depth-Only Sensors

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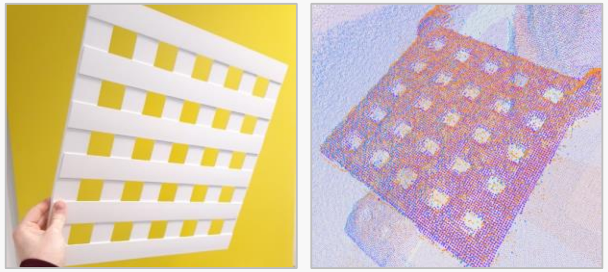
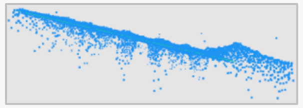
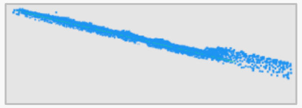


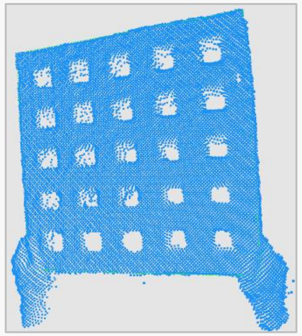
Figure 1: Shots of our 3D lattice target (left); our lattice represented by point clouds from multiple cameras after registration (right).



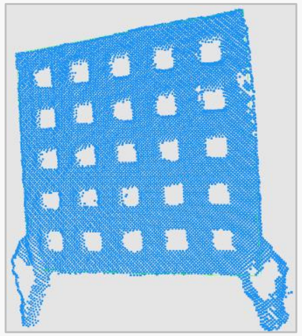
(a) PC (side view)



(b) Inliers (side view)



(c) PC (top view)



(d) Inliers (top view)

Figure 2: Original point cloud section (a) and (c) and the RANSAC inliers (b) and (d).

Motivation:

Register multiple range cameras into a common coordinate system by:

- a **depth image only** (no color or infrared image is needed compared to common methods),
- using a 3D lattice target for **more precise registration** results than automatic feature detection.

Algorithm Overview:

1. Find lattice candidates by identifying and clustering gap segements along the scanlines.
2. Filter the lattice candidates by plausibility check of, among others, the eigenvectors and eigenvalues.
3. Continue only with points of the original point cloud that are close to the lattice candidate.
4. Fit a plane into the points to estimate the normal by using RANSAC and split the points into inliers and outliers (Fig. 2).
5. Estimate lattice axes directions and filter occasional false detections of hole centers by our new, model-based heuristic (Fig. 3)

Finally, we register the depth cameras using the SVD-based transformation estimation of the Point Cloud Library.

Results:

- In a real world application (three Kinect V2 cameras were mounted on the ceiling of an operating room), the lattice was detected in 9,815 of 11,478 frames recorded by three different cameras.
- On average, 22.2 of the 25 hole centers were detected in each lattice.
- The average derivation was 4.1mm with a standard deviation of 3mm for each grid node compared to an ideal grid placed at the detected center hole along the axes.
- On average, the detection required 76.67ms per frame, with a standard deviation of 41.94ms.

Further Work:

- Currently we are conducting a more extensive evaluation with groud truth data points.

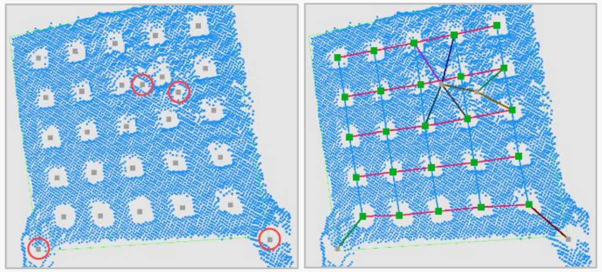


Figure 3: Estimation of axes based on noisy grid nodes (left, gray) using our heuristic. The color of the edges (right) represents the orientation cluster id. Using the two largest clusters (blue and pink), the x- and y-direction of the grid can be stably determined even with very noisy data and likely valid grid nodes (green) can be identified.

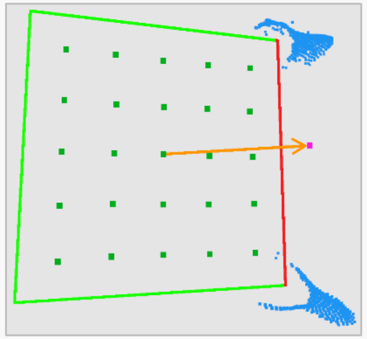


Figure 4: Estimate the one-sided unique direction of the lattice by points around the lattice (usually the hands).

The source code is publicly available as part of an Unreal Engine 4 plugin: https://gitlab.informatik.uni-bremen.de/cgvr_public/lattice_based_registration

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