Automatic Extrinsic Calibration of Stereo Camera and 3D LiDAR

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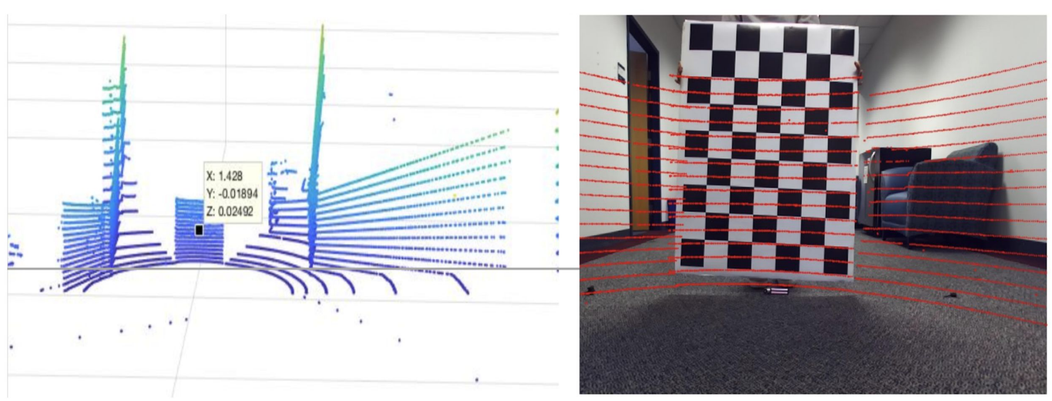
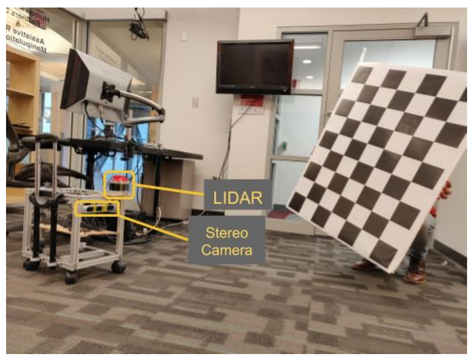
Introduction

- Calibrate two modalities of visual sensing using a single pose of calibration target without any user intervention in point cloud



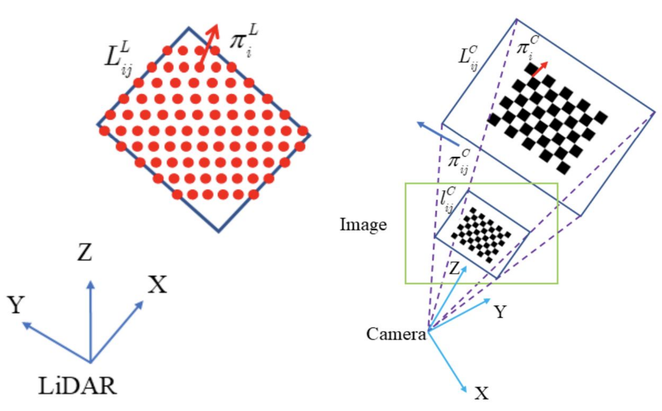
Motivation

- Stereo camera and 3D LIDAR are often jointly used for robot perception
- Automatic checkerboard segmentation from LiDAR is challenging
- Existing approaches require user intervention to give rough position of checkerboard plane in the point cloud



3D Line and Plane Correspondences

- **CAMERA frame**
  - 3D Plane: Planar parameters are computed by the homography between checkerboard and its image (dimension of square is known)
  - 3D Boundary: Intersection of the back-projected plane of 2D boundary and the checkerboard plane
- **LIDAR frame**
  - 3D Planes: RANSAC
  - 3D Boundaries:
    - Left and right end points of scan lines
    - Split at the point of maximum direction change



Geometric Formulation

- Notation
  - $[R_L\ t_L]$: Rotation and translation from LiDAR frame to left camera
  - $[R_R\ t_R]$: Rotation and translation from LiDAR frame to right camera
  - [R t]: Rotation and translation from left to right eye of stereo camera

$$R = R_L R_R^T$$

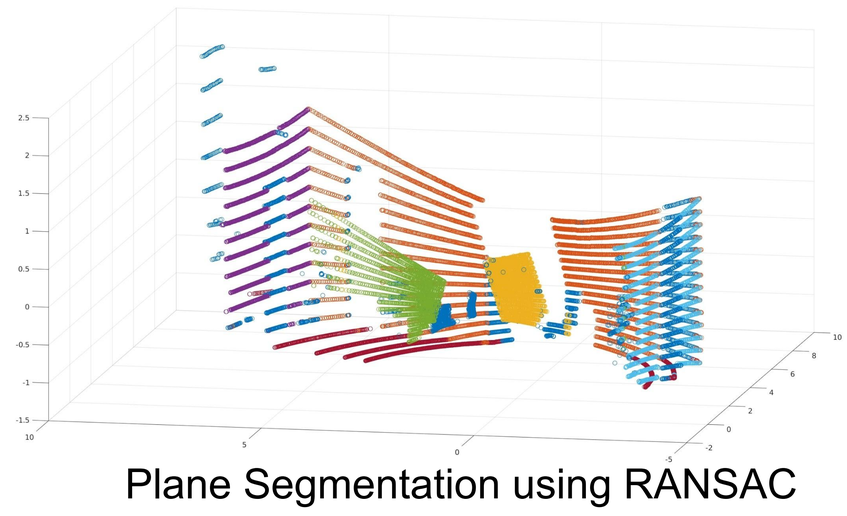
$$t = t_L - t_R$$

Method

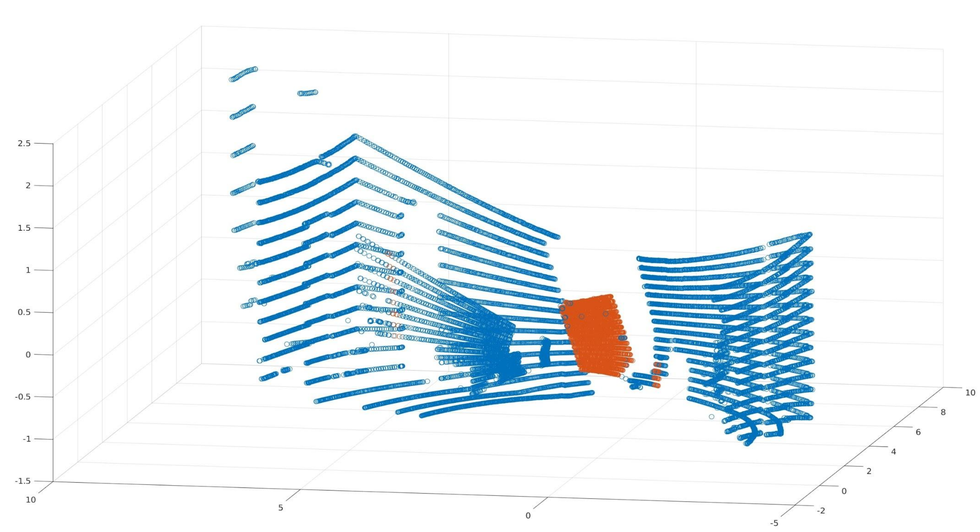
- Procedure requires a known transform between the RGB stereo pair
- We calibrate extrinsics for the two RGB-LiDAR pairs independently
- Checking the consistency of the transforms of both RGB-cameras gives us a notion of accuracy
- The central realization is that using 3D plane corresponding to the checkerboard will produce the best consistency
- This lends itself to an incremental checkerboard plane selection

Experiments & Results

- Collected RGB and LiDAR data sets for 3 poses of the calibration targets
- The algorithm works with a single calibration target pose but multiple poses give a more accurate result
- Incremental procedure: scales linearly with the number of calibration poses and is hence efficient to use when trying to get the best number



Plane Segmentation using RANSAC



Automatic extraction of checkerboard using left right consistency

Contributions

- Proposed automatic detection of checkerboard plane in the point cloud without any user intervention
- Potentially allows self-calibration by a mobile robot and a fixed calibration target

Lipu Zhou, Zimo Li and Michael Kaess, “Automatic Extrinsic Calibration of a Camera and a 3D LiDAR using Line and Plane Correspondences”, IROS 2018