Robust Visual Odometry Using Line Segment Features

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1. Introduction

The standard approach to visual odometry(VO) uses point correspondences between consecutive frames. However, this approach fails under a few circumstances. Texture less environments such as long hallways tend to be challenging for feature detectors. In inconsistent lighting conditions, feature matching tends to break down due to difference in illumination of the feature patches. However, it has been observed that these conditions are rich in geometric cues such as lines. In this project, we intend to recover relative pose between RGB-D frames for such scenes utilizing 3D lines estimated in the environment. We would also be modelling noise in the depth map as a gaussian distibution per point and consider it in our estimation process. We look to compare the system's performance with ORB-SLAM2 on the TUM fr1 dataset.

2. Related Work

Yang and Scherer's work[4] solves the exact same problem which makes use of both points and lines together as features to solve for pose. In our project, we implement a subset of its pipeline. More specifically their 3D line regularization algorithm is inspired from Lu et al.[2] which we intend to implement from scratch. PL-SLAM[1] uses photometric reprojection error for both lines and points to solve for the camera poses. Another closely related work in this space is Tarrio et. al.[3] which processes edges in a dense batched fashion compared to previous approaches.

3. Proposed Approach

We take the approach proposed in [2]. The problem which is formulated as a motion estimation problem given two RGB-D frames can be solved in two high level steps.

1. **Feature Detection And Uncertainty Analysis**
   In this step, lines in 2D are sampled and projected back into the 3D space. The sampling process is performed to avoid errors resulting from ambiguities in depth of points and linear projections of non-linear objects in the world. The position of each 3D point in space is associated with some uncertainty related to the pixel measurement of the corresponding points in 2D and their respective depths. A 2-point representation of lines in 3D is obtained after applying RANSAC followed by maximum likelihood estimate optimization.
2. **Motion Estimation**
   After obtaining the lines in 3D for a pair of consecutive RGB-D frames, we have to find corresponding lines between the two frames. First, the lines are matched in 2D using a line segment descriptor. Lack of geometric constraints can lead to false matches in 2D. Hence, this is followed by RANSAC to obtain an initial estimate of the relative motion between the two frames. The initial estimate is then refined by optimizing a non-linear objective using inliers from the RANSAC consensus set.

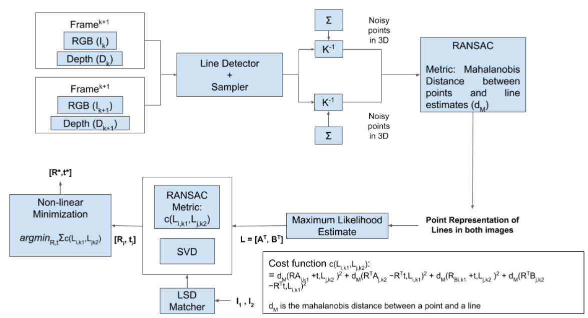

Figure 1. System Block Diagram

References

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