Project Proposal - Group 1

"3D Reconstruction via Direct (Semi-)Dense Visual Odometry using Stereo/Monocular Camera"

1 Abstract

We propose to implement a (semi-)dense 3d reconstruction using a pair of stereo cameras or a monocular camera. We will only consider small static scenes. The reason why we use stereo/monocular camera is that they can be used in more practical situations, e.g. stereo cameras can be used in a robot or a self-driving car, monocular camera can be used in a cell phone. While RGBD cameras have limited usage, e.g. they can only be used in a certain range and the depth sensor(IR) is very sensitive to sun light. The reason why we choose direct image alignment is that it minimizes photometric err on every pixel of the image thus making use of the whole image information. Direct method has been proven to be more robust and accurate than feature based odometry. Moreover it can still run in real-time on a single CPU core if implemented appropriately. The whole project can be divided into 3 parts: a) Estimate the depth map of the scene using either stereo cameras or a monocular camera. For stereo cameras, we will implement depth estimation using block matching. For monocular camera, we will implement depth estimation proposed in [1]. We'll first implement with stereo cameras and then with monocular camera if time permits. b) Estimate camera motion between consecutive frames via direct (semi-)dense image alignment. We will implement it using the method proposed in [1, 2, 3]. We will implement our own Levenberg-Marquard optimizer with iteratively re-weighted residuals. c) Reconstruct the whole scene given the pre-computed depth map and camera poses in previous steps. We will either implement it on our own or borrow it from existing open source codes like OpenMVG or OpenMVS depending on the workload of previous steps. Note that step (a) and (b) can be done in parallel, step (c) will be done after merging the work of (a) and (b).

The detailed steps of the project is listed in the 2nd page.

2 Requirements

- Stereo Cameras(with global shutter, with standard view or wide field of view)
- Monocular Camera(with global shutter, with standard view or wide field of view)

3 Team

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4 Work Plan

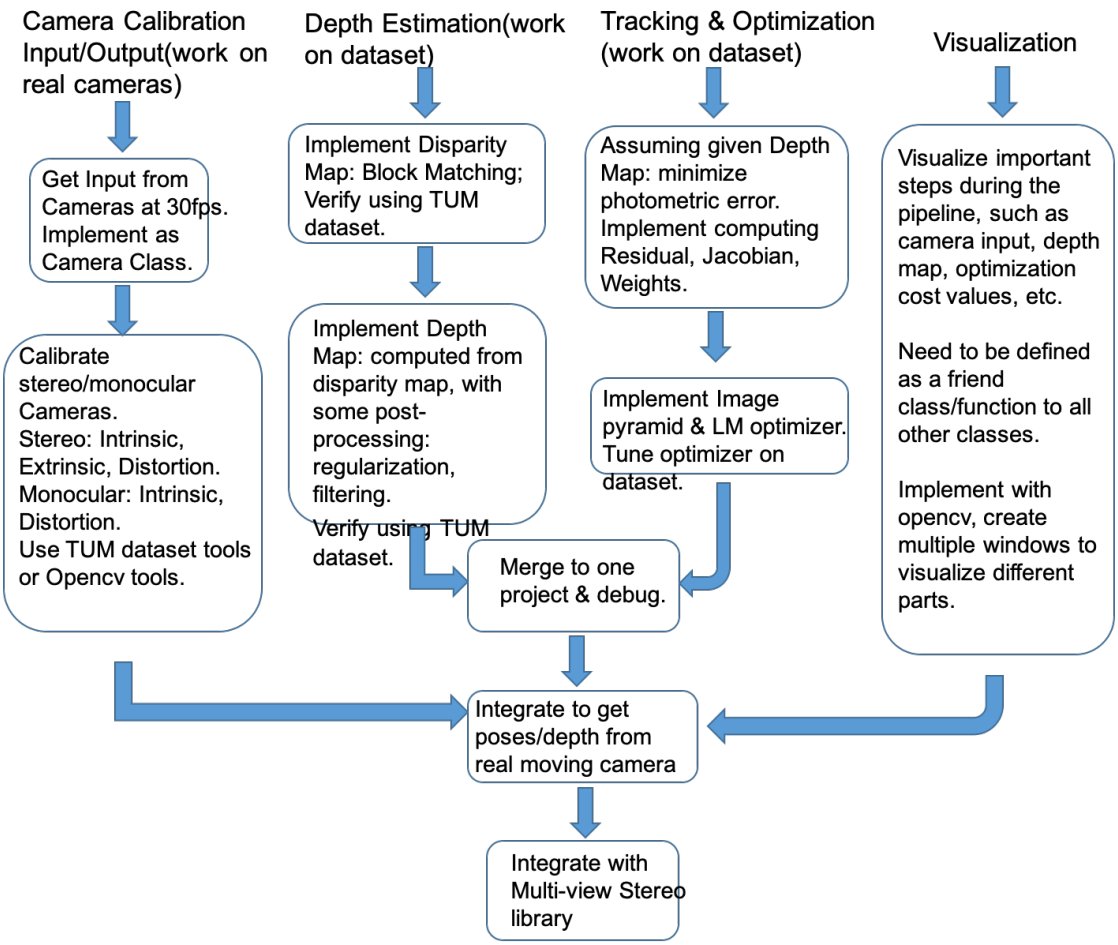

Figure 1: Method overview.

We will use OpenCV, Eigen, OpenMVG/OpenMVS(only for final multi-view registration). In addition, we'll follow Google C++ Style and define everything as Classes. Each class will only expose necessary function to other classes so that we can integrate works from different parts in the end.

References

[1] Jakob Engel, Jurgen Sturm, and Daniel Cremers. Semi-dense visual odometry for a monocular camera. In *The IEEE International Conference on Computer Vision (ICCV)*, December 2013.

[2] C. Kerl, J. Sturm, and D. Cremers. Robust odometry estimation for rgb-d cameras. In *2013 IEEE International Conference on Robotics and Automation*, pages 3748–3754, May 2013.

[3] Christian Kerl, Jurgen Sturm, and Daniel Cremers. Dense visual slam for rgb-d cameras.