

EE565: MOBILE ROBOTICS

LAB # 8: VISUAL ODOMETRY BY SFM ALGORITHM

DESCRIPTION & MOTIVATION

One of the most widely used robot application that uses vision perception techniques is 3D mapping. In this lab, students will estimate 3D structure of a static object using a single camera by taking its multi-view images and running optical flow and standard SfM algorithm. They'll also estimate odometry of the vision sensor (visual odometry) to see camera motion.

LAB TASK & ASSIGNMENT

STRUCTURE FROM MOTION & VISUAL ODOMETRY

1. Use AR Drone's front camera (image_transport package) to take video stream. Capture 2 images of the same static scene from different views whose structure you want to find (store the images).
2. Run Pyramid Lukas-Kanade optical flow (goodFeaturesToTrack & calcOpticalFlowPyrLK methods) on these two images to store feature point-correspondences that will be used for essential matrix estimation.
3. Calibrate AR Drone camera using camera_calibration to get the camera matrix and distortion coefficients vector (you may use the matrices obtained in Lab 7).
4. Undistort feature points and estimate Essential Matrix from these points and the camera intrinsics using
 - a. 8 point algorithm
 - b. RANSACYou may need to find the fundamental matrix before you can do this.
5. Decompose the Essential Matrix (SVD) to get Rotation and Translation between the camera frames of both images.
6. Do triangulation to get the projection matrix and consequently get the 3D points.
7. Store these points in a PointCloud structure and visualize it in RViz.
8. Estimate the camera motion from your estimated 3D points (use solvePnP function). This gives you the camera odometry obtained visually (hence the term visual odometry).
9. Now, take another image of the same scene (third frame) and find optical flow between 2nd and 3rd frames and also repeat above process of finding the essential matrix.
10. When estimating camera motion, input the solvePnP function with 2D image points from all three frames.

You may take help in understanding the overall working of SfM algorithm from the following link, which is an SfM implementation that uses just 2 images and farneback optical flow:

<http://subokita.com/2014/03/26/structure-from-motion-using-farnebacks-optical-flow-part-2/>

Bonus:

- Implement running SfM algorithm i.e. instead of processing pre-stored images, make it work with live stream.
- Work with more than three images to find an estimate of the 3D structure and the odometry from these images. Visualize the 3D structure in RViz.