Project 4: Visual Inertial Odometry

Radha Saraf
Email: rrsaraf@wpi.edu

Sai Ramana Kiran Pinnama Raju
Email: spinnamaraju@wpi.edu
Using 1 late day

***Abstract*—The aim of this project is to implement visual inertial odometry based on Stereo Multi State Constrained Extended Kalman Filter**

I. Implementation overview

The following sections give an overview about each function that was implemented as part of this project.

A. Gravity and Bias Initialization

In this part, we had to first compute the initial orientation of the IMU with respect to the world frame. This was achieved by computing the orientation of the gravity vector measured in current body frame (NED frame) and measured how much it is rotated with respect to the inertial frame. We used rodrigues formulation to calculate the angle between two vectors.

B. Process Model

Process model was implemented according to the equations given in the papers [2] and [1]. We used 3rd order matrix exponential approximation is interpolating the process covariance and propagated the camera state covariance according to the given equations

C. Predicting new state

For predicting the new state of the camera, a 4th order runge kutta function approximation is used from given process model.

D. State augumentation

State augumentation is done whenever new images from camera are received. This is achieved by using the latest IMU state to the new camera state.

E. Adding Feature observation

This function adds new feature from the images or updates the feature if the feature already exists.

F. Measurement update

In this step, all the measurements gathered in new cycle is concatenated and used to compute the augmented residuals using the null space trick. With many other mathematical simplicfications the matrix H_x is computed which in turn is further simplified using the QR decomposition. An SVD decomposition could also be employed but is computationally expensive compared to QR decomposition. Moreover, using these decomposed matrices, Kalman gain is computed according to the equation 28 in [2]. This kalman gain, is further used to propagate the process covariance.

II. Results

1 outlines the error estimates that were observed during the overall trajectory comparison according to the [3]. The given errors are Absolute Trajectory Error (ATE) and are computed using SE3 formulation. 3 and 4 show the trajectory and it's comparison with respect to the ground truth captured using the vicon sensors.

	RMSE	Min	Max	Mean	STD
Rotation	129.348	46.428	149.463	127.0341	24.358
Translation	0.079	0.0077	0.1618	0.0747	0.0276
Scale	1.0629	0.00071	3.502	0.8153	0.6819

Fig. 1. Absolute Trajectory Error (ATE)

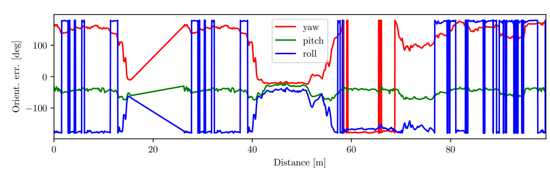

Fig. 2. Rotation Errors

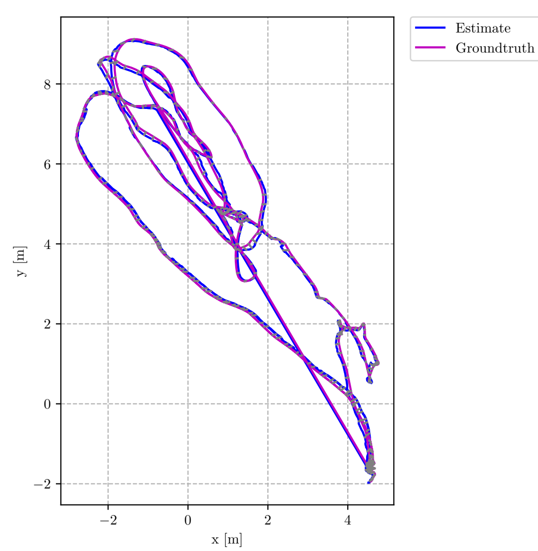

Fig. 3. Trajectory X-Y

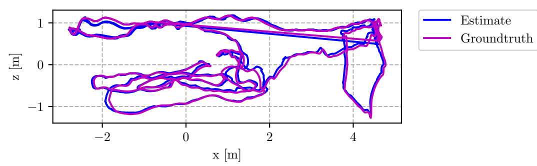

Fig. 4. Trajectory X-Z

REFERENCES

[1] Sun, Ke, et al. "Robust stereo visual inertial odometry for fast autonomous flight." IEEE Robotics and Automation Letters 3.2 (2018): 965-972.

[2] A. I. Mourikis and S. I. Roumeliotis, "A multi-state constraint kalman filter for vision-aided inertial navigation," Robotics and automation, 2007 IEEE international conference on, pp. 3565–3572, 2007

[3] Zichao Zhang, Davide Scaramuzza: A Tutorial on Quantitative Trajectory Evaluation for Visual(-Inertial) Odometry, IEEE/RSJ Int. Conf. Intell. Robot. Syst. (IROS), 2018.