# ESE 650 Project 2: Camera Orientation Tracking

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## Algorithm Description:

1. **IMU Sensor Calibration**
   a) Take the average of the IMU's first 2 seconds output data. For X and Y axis, regard this as the sensor bias. For Z axis, take one g from the average, the result is the Z axis bias.
   b) From the IC datasheet and PCB design, get the sensor's sensitivity, thus compute the scale factor.
2. **Unscented Kalman Filter**
   An unscented Kalman filter with quarternion representation is implemented to track the camera orientation. The UKF is a extension of the classic Kalman filter to nonlinear process and measurement models. The basic idea of UKF is to approximate the Gaussian probability distribution by a set of sigma points. I followed the Kraft paper step by step to realize the algorithm in Matlab.
   a) Initialize all the parameters needed, including the initial state, state covariance, process noise covariance, and measurement noise covariance.
   b) Generate sigma points from the initial state and state covariance using Cholesky Decompositon.
   c) Project the obtained sigma points ahead in time using the process model, resulting in a different set of state vectors.
   d) Calculate the mean and covariance of the state vectors. Note the method of compute quaternion mean and covariance is special. Princeple components is used here to get the quaternion mean.
   e) Transform the state vectors through measurement model to expected the measurements.
   f) Calculate the expected measurements' mean and covariance.
   g) Calculate the cross correlation matrix of the current state set and the expected measurement set.
   h) Calculate the Kanlman gain from the results of last step.
   i) Compare the real measurement and the expected measurement to get the innovation.
   j) Update the state vector and state covariance from the innovation, the Kalman gain, the predicted measurement covariance and the measurement noise covariance.
   k) Continue to process the next state vector in the time sequence as the same procedure above.

## 3. Visualization

The UKF orientation tracking result are shown below. The threes axis in the images are roll, pith and yaw (in rad). The yellow lines are the ground truth (from vicon) and the red lines are the tracking results.

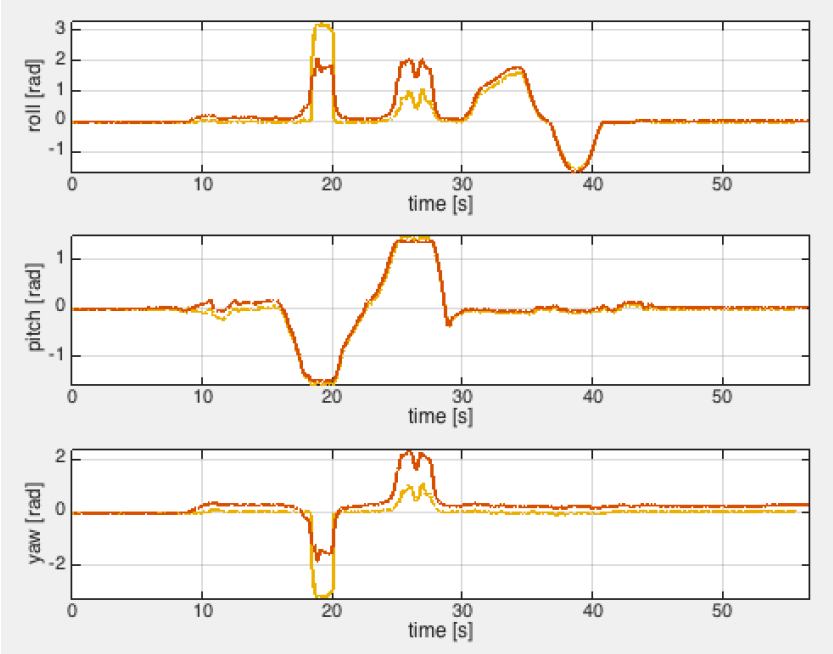


Fig. 1 Dataset 1 tracking result

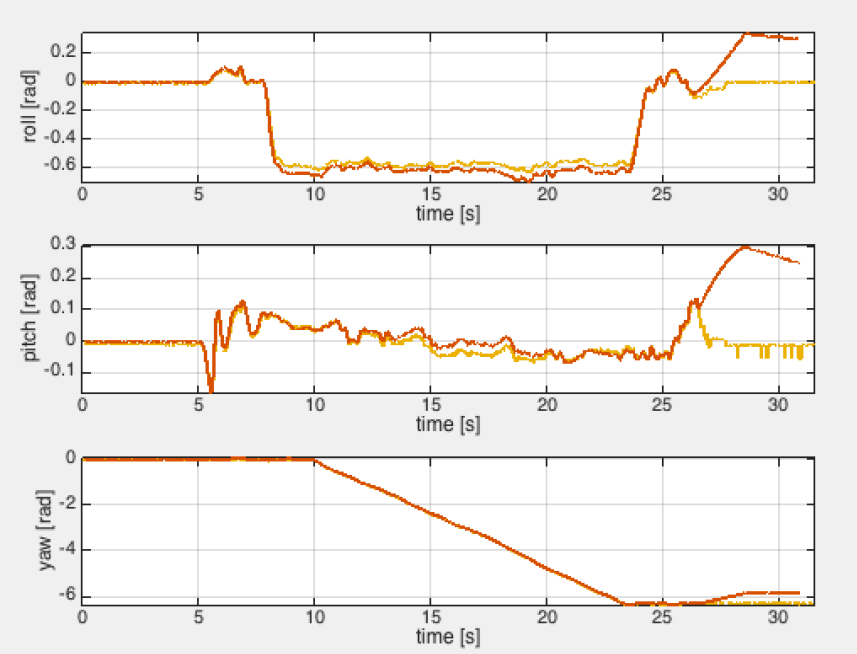


Fig. 2 Dataset 10 tracking result

A panoramic image (as shown in Fig. 3 ) is also constructed based on the tracking result of Dataset10. The middle part of the image is misaligned. This may be caused by the gyroscope drifting when the camera stopped moving.

Another possible reason is the Z axis movement of the camera when it was put on the floor. The rest part of the panorama looks fine.

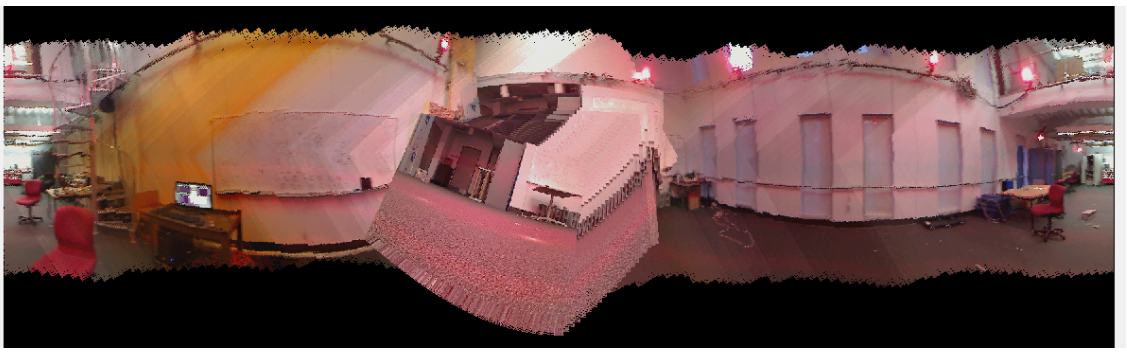

Fig. 3 Panorama constructed from dataset 10

## Running Instruction:

1. Make sure the 'code' folder is in the Matlab's 'current folder'.
2. Make sure the test imu, vicon, cam files are in the corresponding folders and the three folders should also be in the Matlab's 'current folder'
3. Run the 'main.m' file section by section.
4. Please note when running the 'load data' section, the dataset number, the vicon and the cam data existence flags should be manually set.