Implemented UKF and stitching the image

Chunyi Lyu PID: A53217186

I. Introduction

Along with the development of auto vehicles, Unscented Kalman Filter applied for navigation and control. In scientific fields, we use certain model to describe the dynamic of systems. But in the real world, there is always noise which make the control not so accurate. So we make use of sensor to gain new information so that we can keep track of robots. Unscented Kalman Filter deal with the situation that when we encounter the nonlinear system.

II. Problem formulation

Given the ground truth and sensors output, we try to build UKF model to predict the next step, and compare with the ground truth to see the results.

- Implement basic quaternion functions
- Implement the quaternion average function
- Calibrate the bias. Since the sensor doesn't move so much at the beginning, we can use it to calibrate the bias.
- Implement simple integration. Just build the baseline.
- Implement the predict step to get the initial guess of robot next move.
- Implement the update step which extract from our observation to calibrate our model.
- Generate a panorama using the vicon orientation to see the output.

III. Technical approach

A. Quaternion function

$$H = C + Cj$$

generate complex number$C = R + Ri$,$q = [q_s, q_v]$ so that we can map R onto unit-norm quaternion.

B. UKF

1) Predict: We set initial value and get sigmas:

$$E_t^i = columns(sqrt(2n(P_(t+1) + Q)))$$

Then we get next state:

$$q_{t+1|t}^i = q_{t|t} * exp([0, 1/2E^i]) * exp([0, 1/2 * w_t * t])$$

which $*$ stands for multiply by quaternion. Then we get q mean by quaternion. After that, we should get e by following:

$$e^i = q_{t+1|t}^i (q_{t+1}^{mean})^{-1}$$

2) update: We get Z by gravity:

$$(0, Z_{t+1}^i) = q_{t=1|t}^{-i} [0, g]^T q_{t+1|t}^i$$

$$Z_{t+1}^{mean} = mean(Z_{t+1})$$

So we will get the covariance matrixP_{ZZ} and adding noise to get P_{VV} Then will get the covariance of sigma and thenP_{xz} So the Kalman gain will be

$$K_{t+1} = P_{XZ} * P_{VV}^{-1}$$

so that we can update P by:

$$P_{t+1|t} = P_{t+1|t} - K_{t+1} P_{VV} K_{t+1}^T$$

C. Result and discussion

1) simple integral: On training set: In this picture, we can see that the integral perform well, bu t the integral curve is little bit lower than ground truth. On test set: Graph 10:

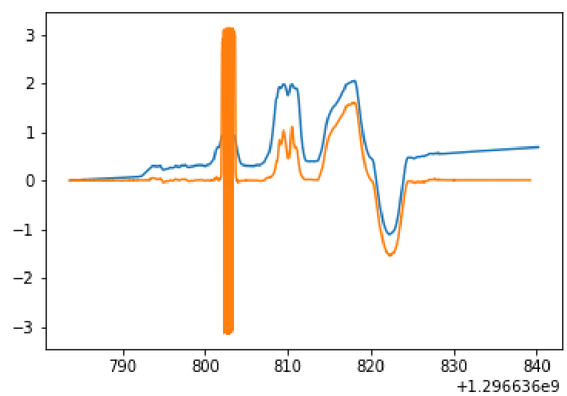

Fig. 1. roll integral

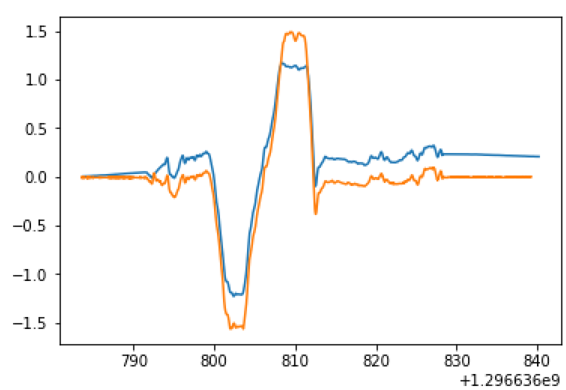

Fig. 2. pitch integral

Graph 11: Graph 12: Graph13:

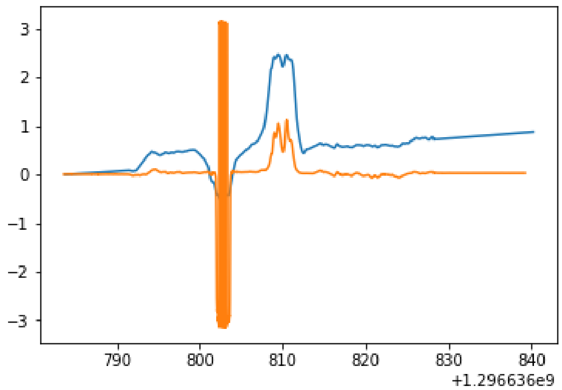

Fig. 3. yaw integral

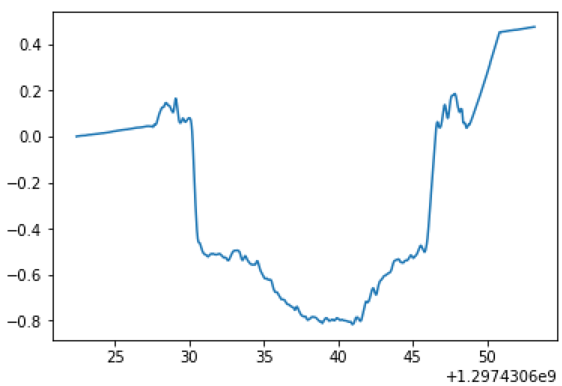

Fig. 4. picture 10,roll

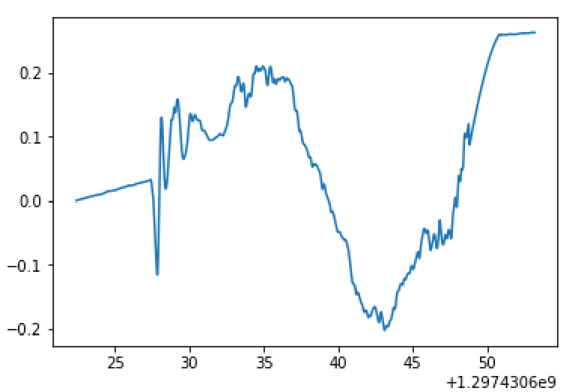

Fig. 5. picture 10,pitch

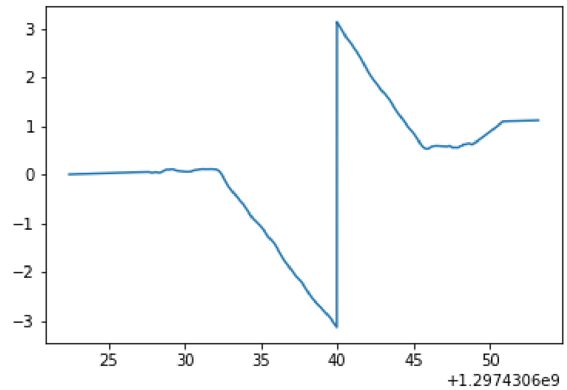

Fig. 6. picture 10,yaw

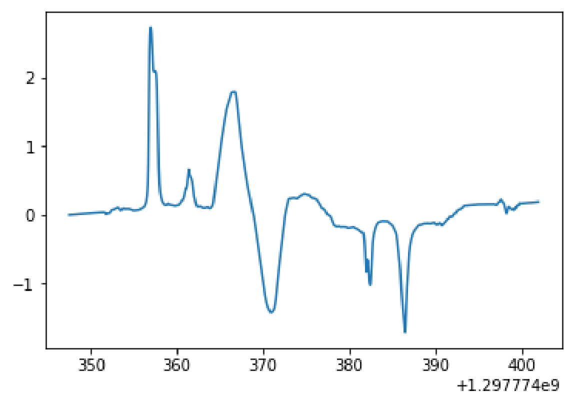

Fig. 7. picture 11,roll

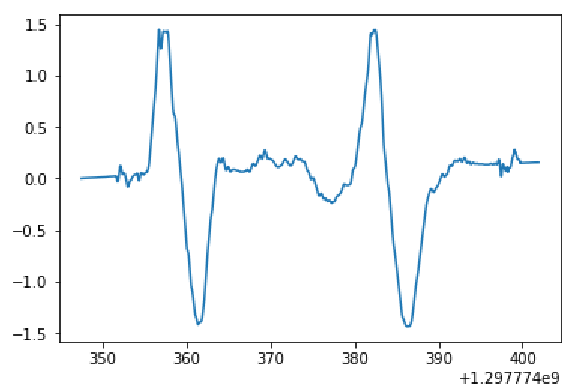

Fig. 8. picture 11,pitch

2) predict: On training set: In the predict step, we can see the predict line doesn't coordinate as good as simple integral, this is because we add noise to it. For test data:

3) update: For train set: We can see it improve a little bit because we calibrate the predict after we observe the output. For test set: As we can see above, in the test dataset, the simple integral, predict, update output looks similar, which means although in test data set, the oscillation is very strong, our prediction still somehow stay right.

4) For stitching picture: For this picture, we first change the sphere coordinate to Cartesian coordinate, then change it to body frame use vicon data. After doing that, we change it back to sphere coordinate and unwrap it.

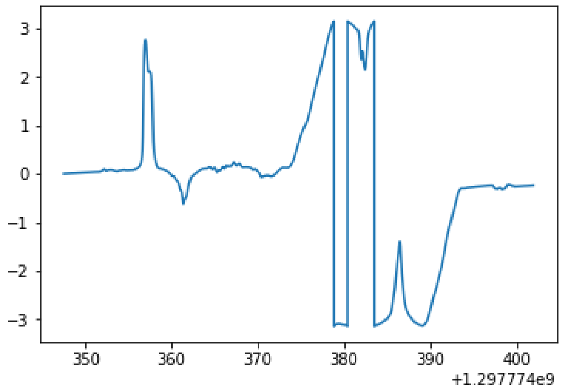

Fig. 9. picture 11,yaw

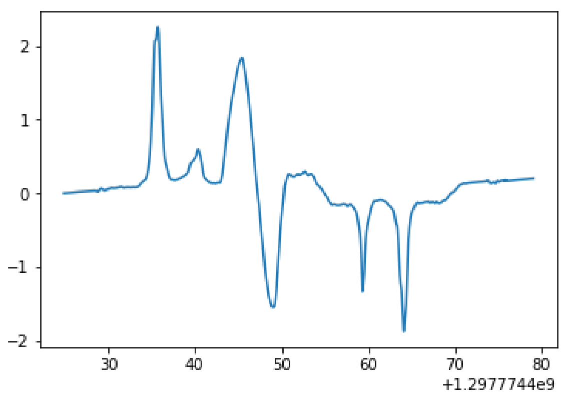

Fig. 10. picture 12,roll

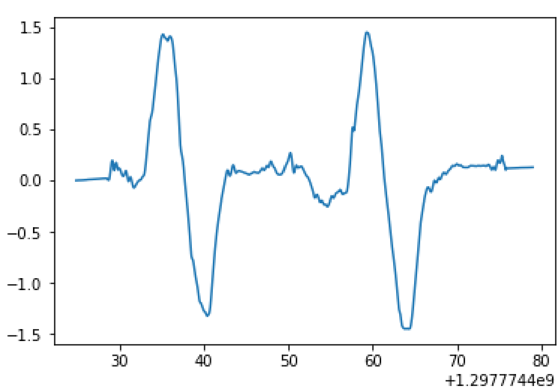

Fig. 11. picture 12,pitch

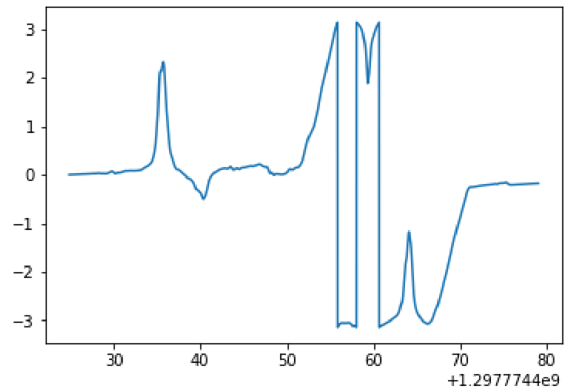

Fig. 12. picture 12,yaw

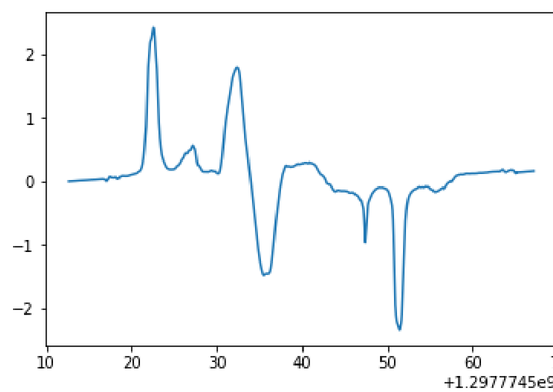

Fig. 13. picture 13,roll

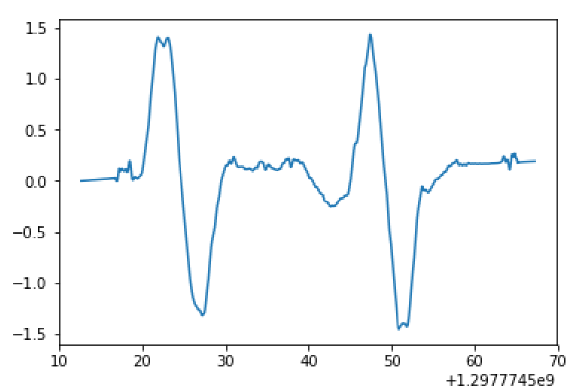

Fig. 14. picture 13,pitch

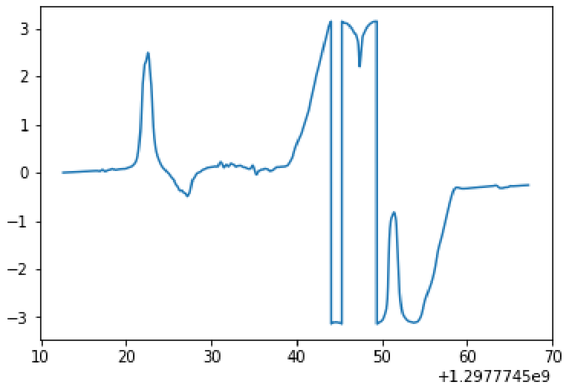

Fig. 15. picture 13,yaw

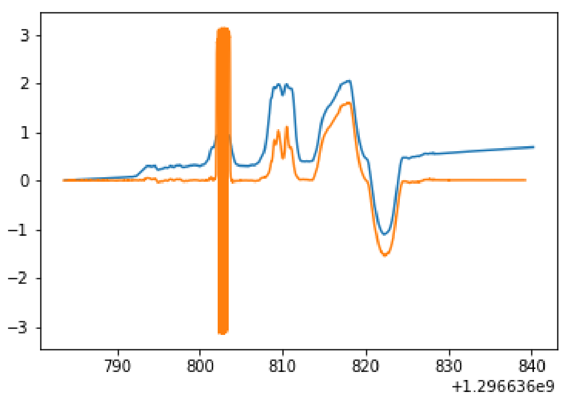

Fig. 16. picture 1,roll

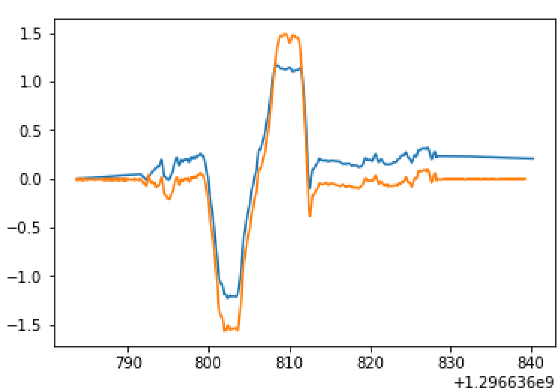

Fig. 17. picture 1,pitch

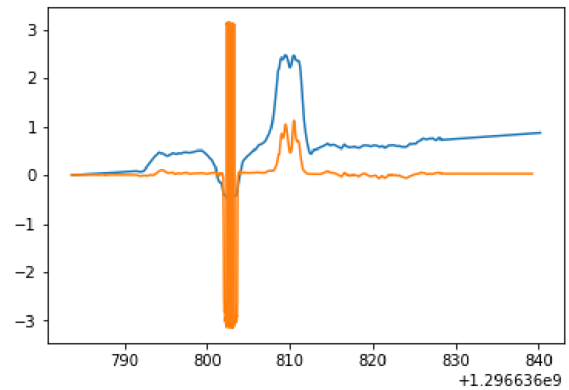

Fig. 18. picture 1,yaw

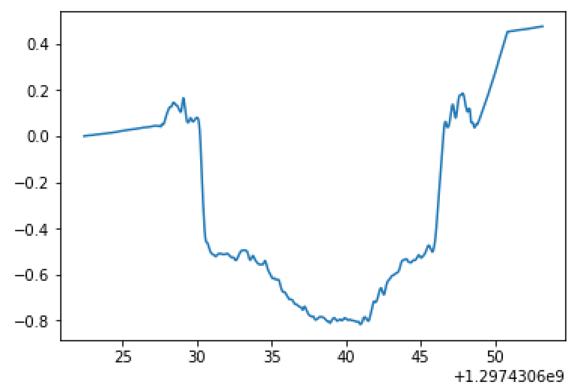

Fig. 19. picture 10,roll

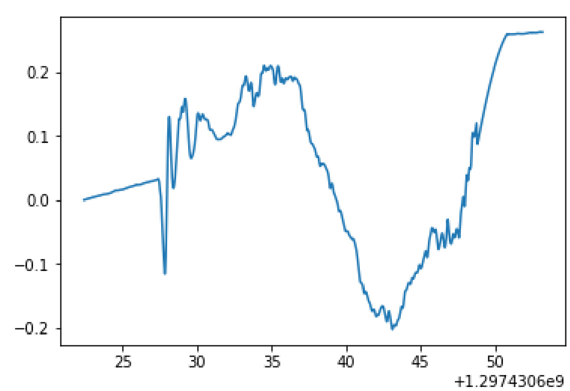

Fig. 20. picture 10,pitch

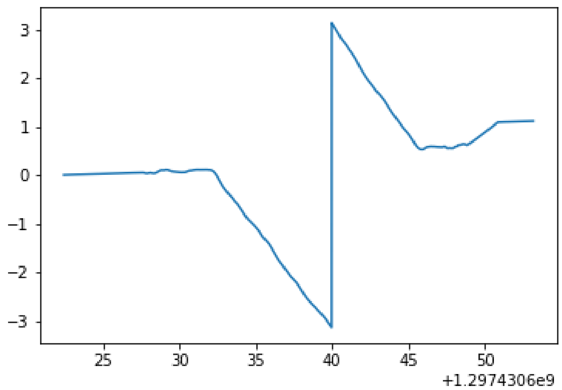

Fig. 21. picture 10,yaw

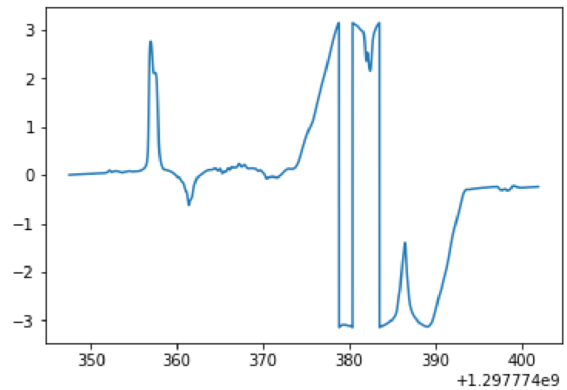

Fig. 24. picture 11,yaw

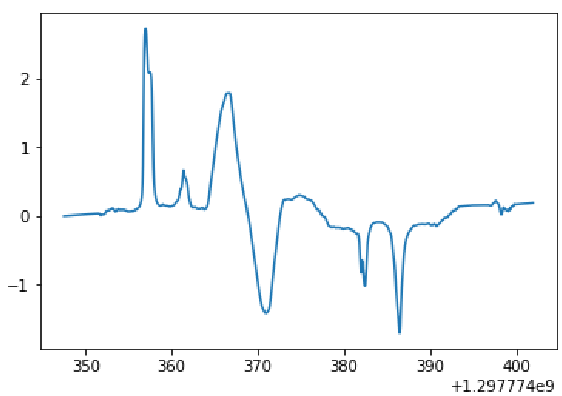

Fig. 22. picture 11,roll

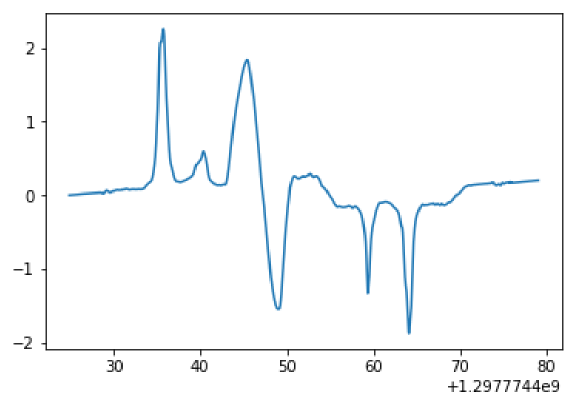

Fig. 25. picture 12,roll

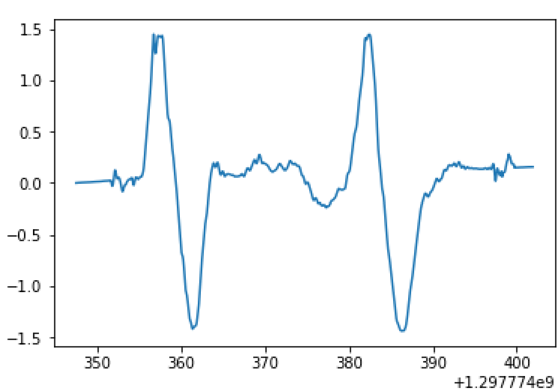

Fig. 23. picture 11,pitch

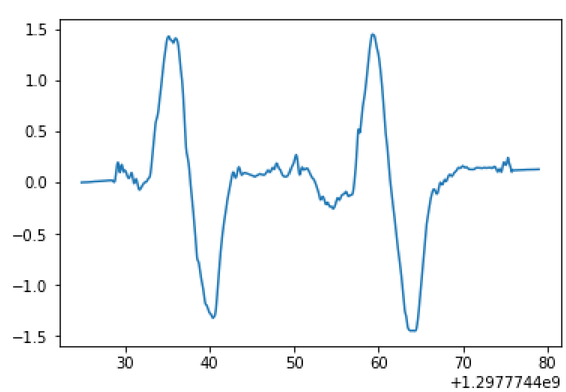

Fig. 26. picture 12,pitch

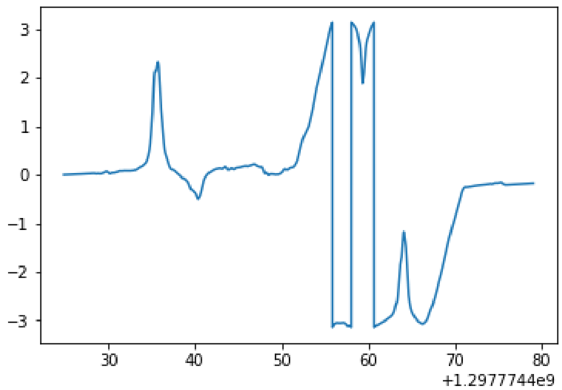

Fig. 27. picture 12,yaw

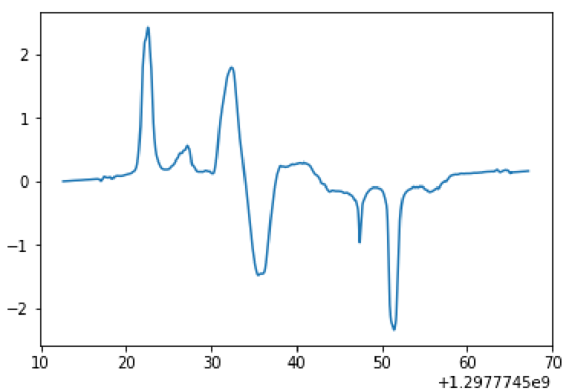

Fig. 28. picture 13,roll

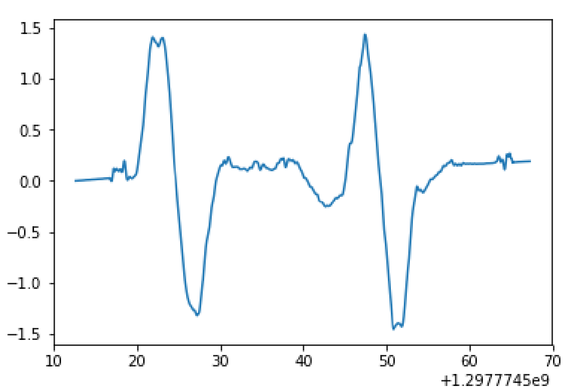

Fig. 29. picture 13,pitch

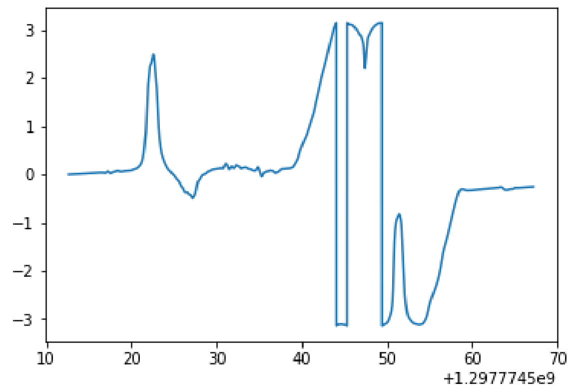

Fig. 30. picture 13,yaw

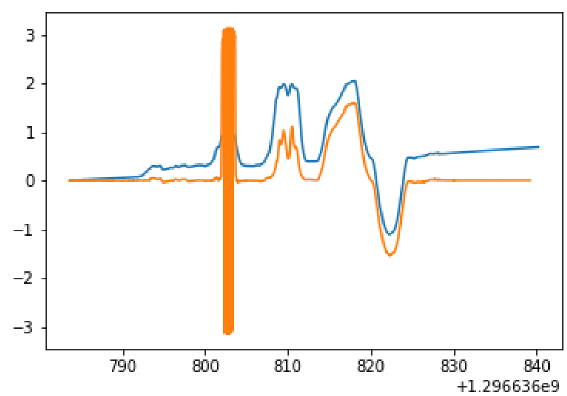

Fig. 31. picture 1,roll

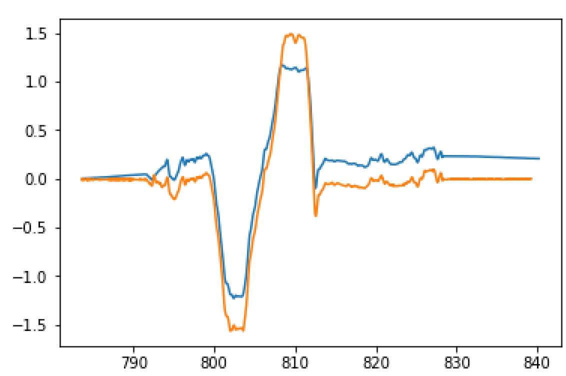

Fig. 32. picture 1,pitch

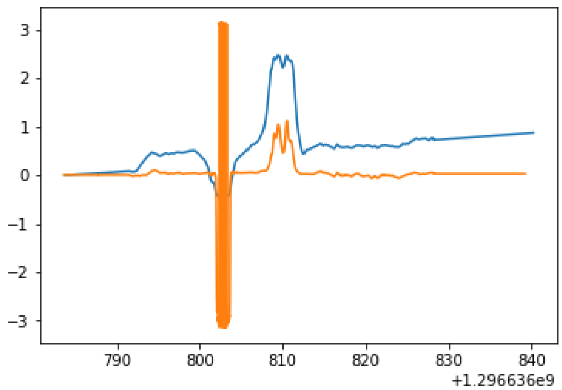

Fig. 33. picture 1,yaw

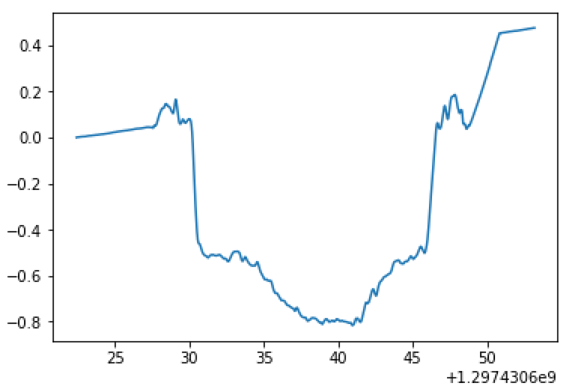

Fig. 34. picture 10,roll

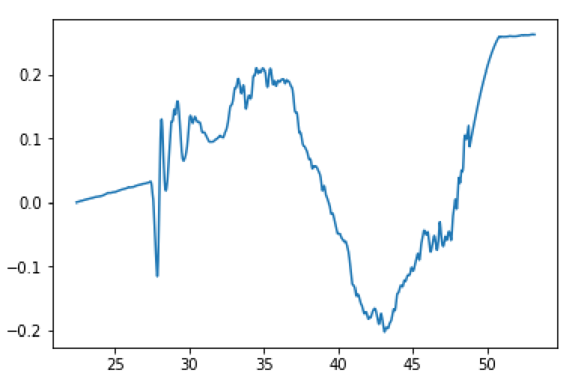

Fig. 35. picture 10,pitch

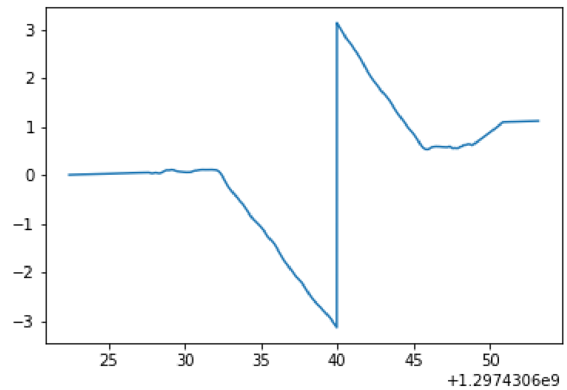

Fig. 36. picture 10,yaw

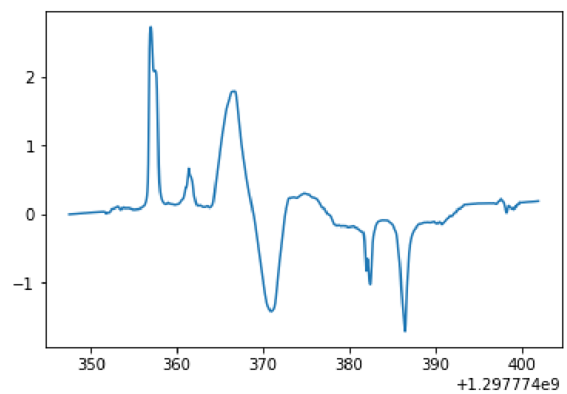

Fig. 37. picture 11,roll

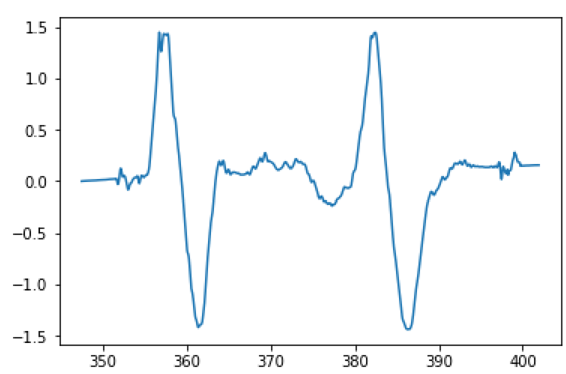

Fig. 38. picture 11,pitch

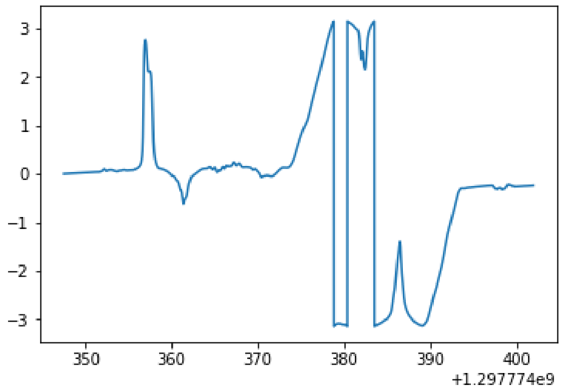

Fig. 39. picture 11,yaw

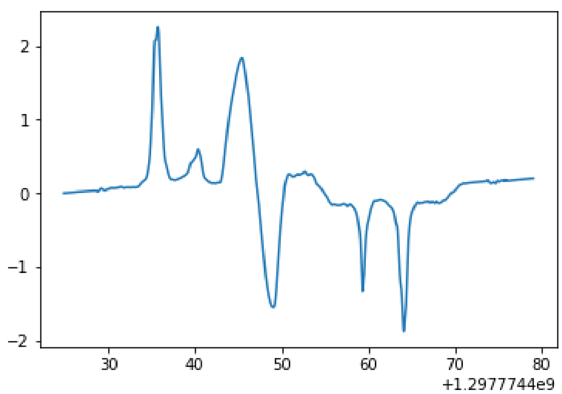

Fig. 40. picture 12,roll

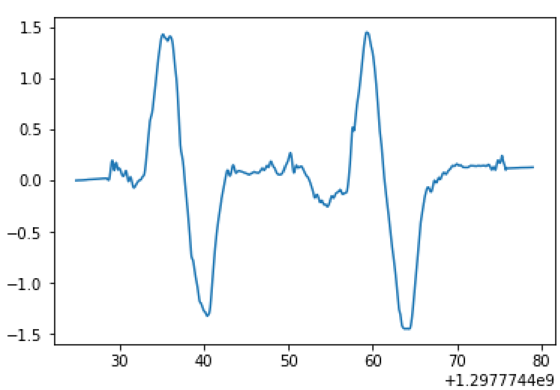

Fig. 41. picture 12,pitch

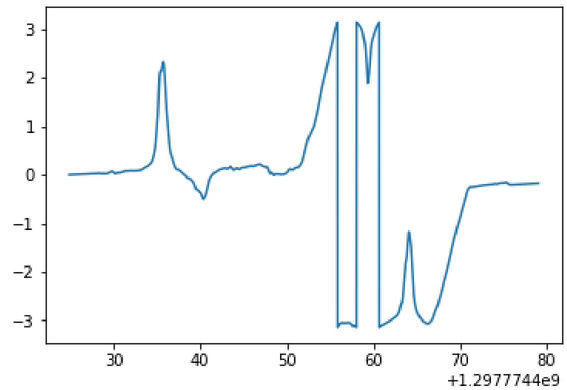

Fig. 42. picture 12,yaw

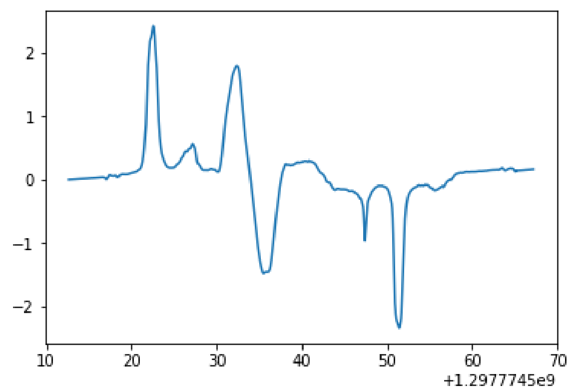

Fig. 43. picture 13,roll

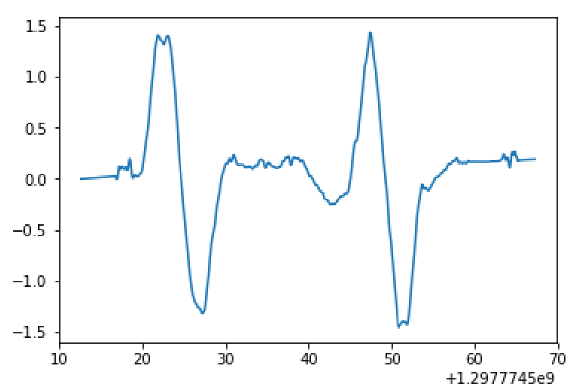

Fig. 44. picture 13,pitch

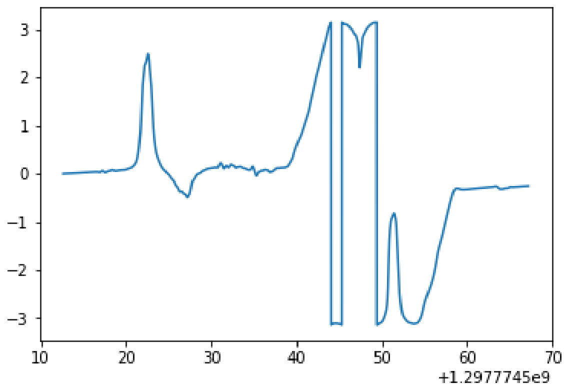

Fig. 45. picture 13,yaw

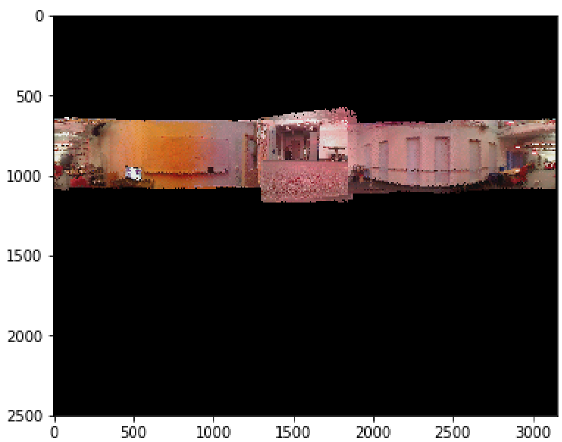

Fig. 46. picture8 stitching

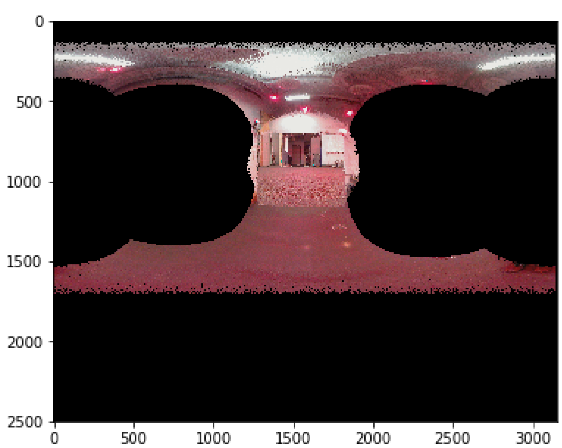

Fig. 47. picture1 stitching

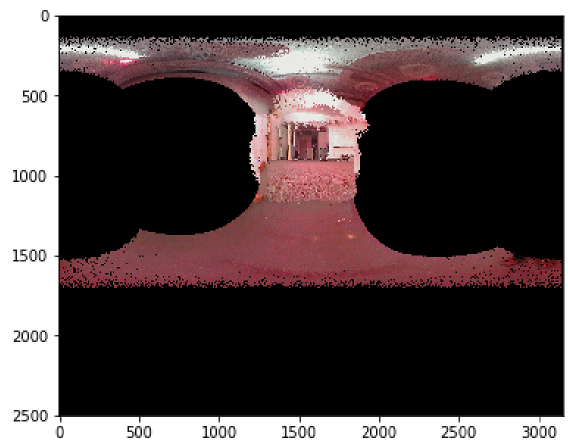

Fig. 48. picture 2 stitching