ROB-6213: Project 3

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Part 1

Visual Pose Estimation

This part is in 'pred_step' and 'upd_step':

Step1. Process Model

Define parameters:

$$\alpha = 0.25, \beta = 2, k = 3, g = [-0.23, -0.19, -9.829]$$
$$\lambda = \alpha^2(n+k) - n$$

Build the process model as the same as part1:

$$R(q) = \begin{bmatrix} cos\theta cos\varphi & sin\psi sin\theta cos\varphi - cos\psi sin\varphi & cos\psi sin\theta cos\varphi + sin\psi sin\theta \\ cos\theta sin\varphi & sin\psi sin\theta sin\varphi + cos\psi cos\varphi & cos\psi sin\theta sin\varphi - sin\psi cos\theta \\ -sin\varphi & sin\psi cos\theta & cos\psi cos\theta \end{bmatrix}$$

$$G(q) = \begin{bmatrix} cos\varphi cos\theta & -sin\theta & 0 \\ cos\varphi sin\theta & cos\theta & 0 \\ -sin\varphi & 0 & 1 \end{bmatrix}$$

$$\dot{x} = \begin{bmatrix} x_3 \\ G(x_2)^{-1}(\omega_m - x_4 - n_g) \\ R(q)(a_m - x_5 - n_a) \\ n_{bg} \\ n_{ba} \end{bmatrix} = f$$

Step2. Compute Sigma Points

We use methods below to get sigma points:

Cholesky decomposition

$$S = \sqrt{\lambda + n} * chol(\textstyle\sum_{t-1}), \quad W = [S, -S]$$
$$X_{aug} = \mu_{aug} + W$$

Step3. Propagate Sigma Points and Compute mean & covariance

$$X_t = f(X_{aug}, \mu_{aug})$$

$$\bar{\boldsymbol{\mu}}_t = \sum_{i=0}^{2n'} W_i^{(m)} \chi_t^{(i)} \qquad \bar{\boldsymbol{\Sigma}}_t = \sum_{i=0}^{2n'} W_i^{(c)\prime} \left(\chi_t^{(i)} - \bar{\boldsymbol{\mu}}_t\right)\left(\chi_t^{(i)} - \bar{\boldsymbol{\mu}}_t\right)^T$$

Step4. Update Step

1. Assumptions and Linearization

The process is also not complex.

Because our Observation Model is simple. We can directly get that

$$C_t \text{ is a } 6 \times 15 \text{ identity matrix } W_t \text{ is a } 6 \times 6 \text{ identity matrix.}$$

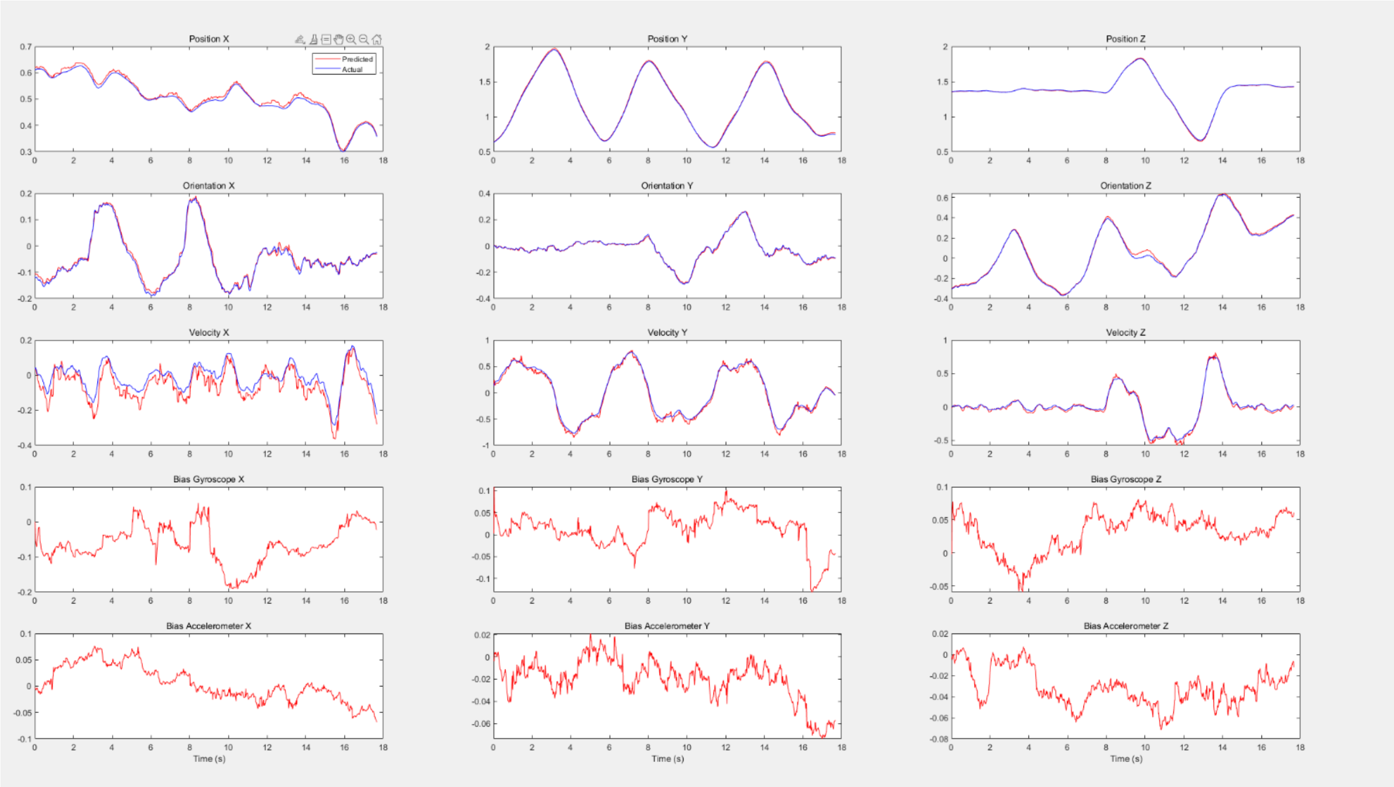
2. Update Step

$$K_t = \bar{\textstyle\sum}_t C_t^T (C_t \bar{\textstyle\sum}_t C_t^T + W_t R_t W_t^T)$$
$$\mu_t = \bar{\mu}_t + K_t C_t \bar{\textstyle\sum}_t$$
$$\textstyle\sum_t = \bar{\textstyle\sum}_t - K_t(z_t - g(\bar{\mu}_t, 0))$$

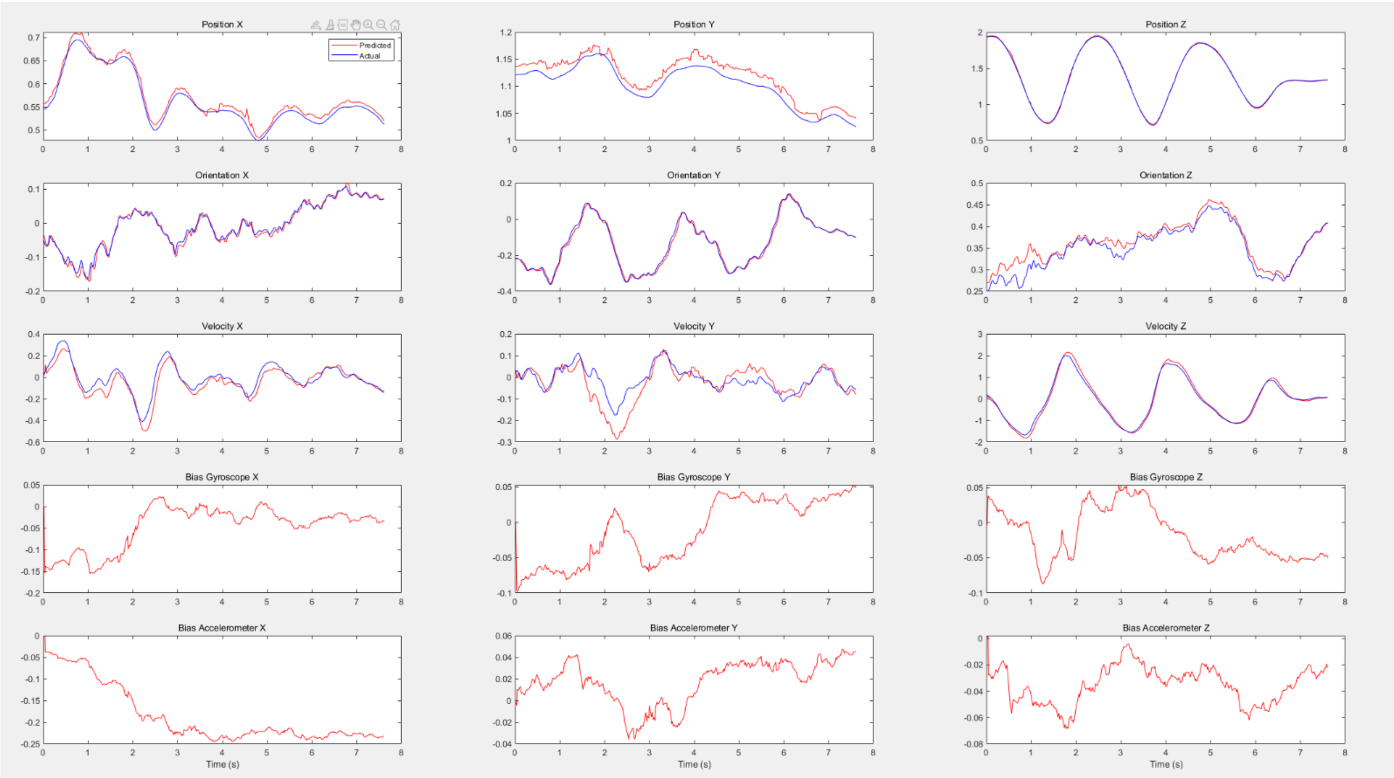
$\boldsymbol{K_t}$ **is the Kalman-gain.** The Kalman-gain is the weight given to the measurements and current-state estimate, and can be "tuned" to achieve a particular performance. With a high-gain, the filter places more weight on the most recent measurements, and thus conforms to them more responsively.

Plotting results:

Datasheet 1:



Datasheet 4:



Part 2

Prediction Step

This part is the same with part1.

Update Step

Step1. Measurement Model

Build the nonlinear model:

$$Z = g(x_t, v_t) = Adjoint * [x_3; w_b]$$

$$Adjoint = \begin{bmatrix} R_c^b & -R_c^b * \widehat{r_{bc}} \\ 0 & R_c^b \end{bmatrix}$$

Step2. Compute Sigma Points

We use methods below to get sigma points:

Cholesky decomposition

$$S = \sqrt{\lambda + n} * chol(\textstyle\sum_{t-1}), \quad W = [S, -S]$$

$$X_{aug} = \mu_{aug} + W$$

Step3. Propagate Sigma Points and Compute mean & covariance

$$Z_t = g(X_{aug}, \mu_{aug})$$

$$\boldsymbol{z}_{\mu,t} = \sum_{i=0}^{2n''} W_i^{(m)''} Z_t^{(i)}$$

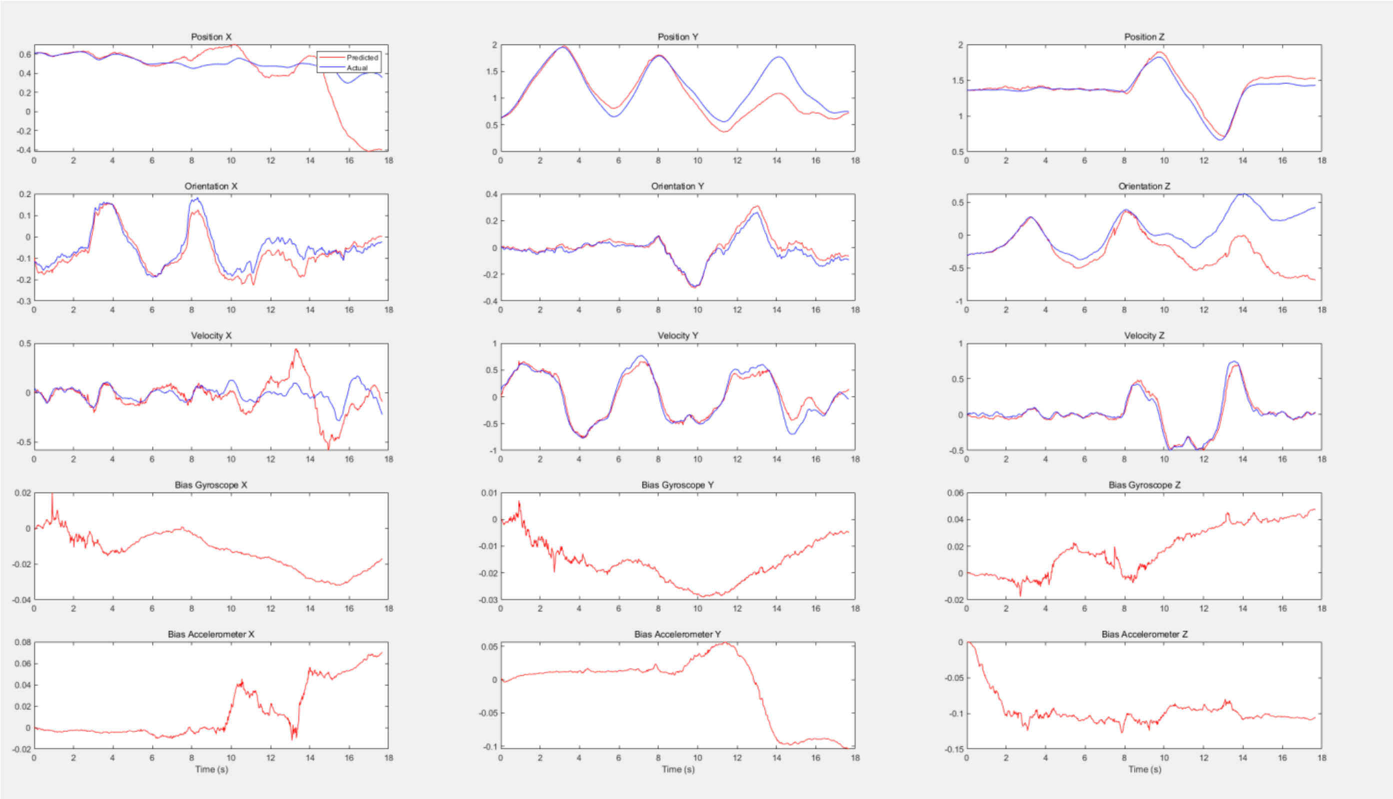
Update

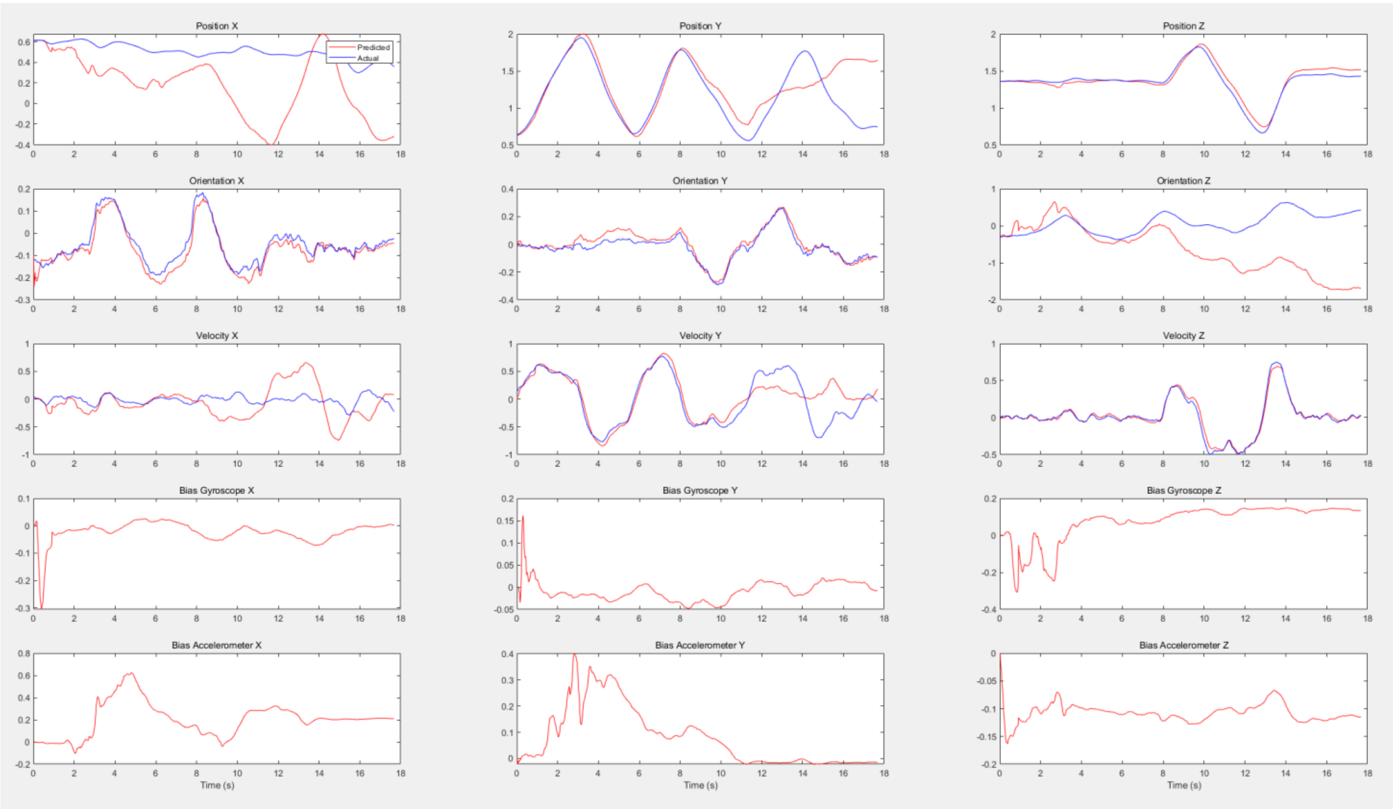
$$\boldsymbol{C}_t = \textstyle\sum_{i=0}^{2n''} W_i^{(c)''} \left(\chi_{aug,t}^{(i),x} - \bar{\boldsymbol{\mu}}_t\right)\left(Z_t^{(i)} - \boldsymbol{z}_{\mu,t}\right)^T \qquad \boldsymbol{S}_t = \textstyle\sum_{i=0}^{2n''} W_i^{(c)''} \left(Z_t^{(i)} - \boldsymbol{z}_{\mu,t}\right)\left(Z_t^{(i)} - \boldsymbol{z}_{\mu,t}\right)^T$$

- $\boldsymbol{\mu}_t = \bar{\boldsymbol{\mu}}_t + \boldsymbol{K}_t\,(\boldsymbol{z}_t - \boldsymbol{z}_{\mu,t})$
- $\boldsymbol{\Sigma}_t = \bar{\boldsymbol{\Sigma}}_t - \boldsymbol{K}_t\,\boldsymbol{S}_t \boldsymbol{K}_t^{\,T}$
- $\boldsymbol{K}_t = \boldsymbol{C}_t\,\boldsymbol{S}_t^{\,-1}$

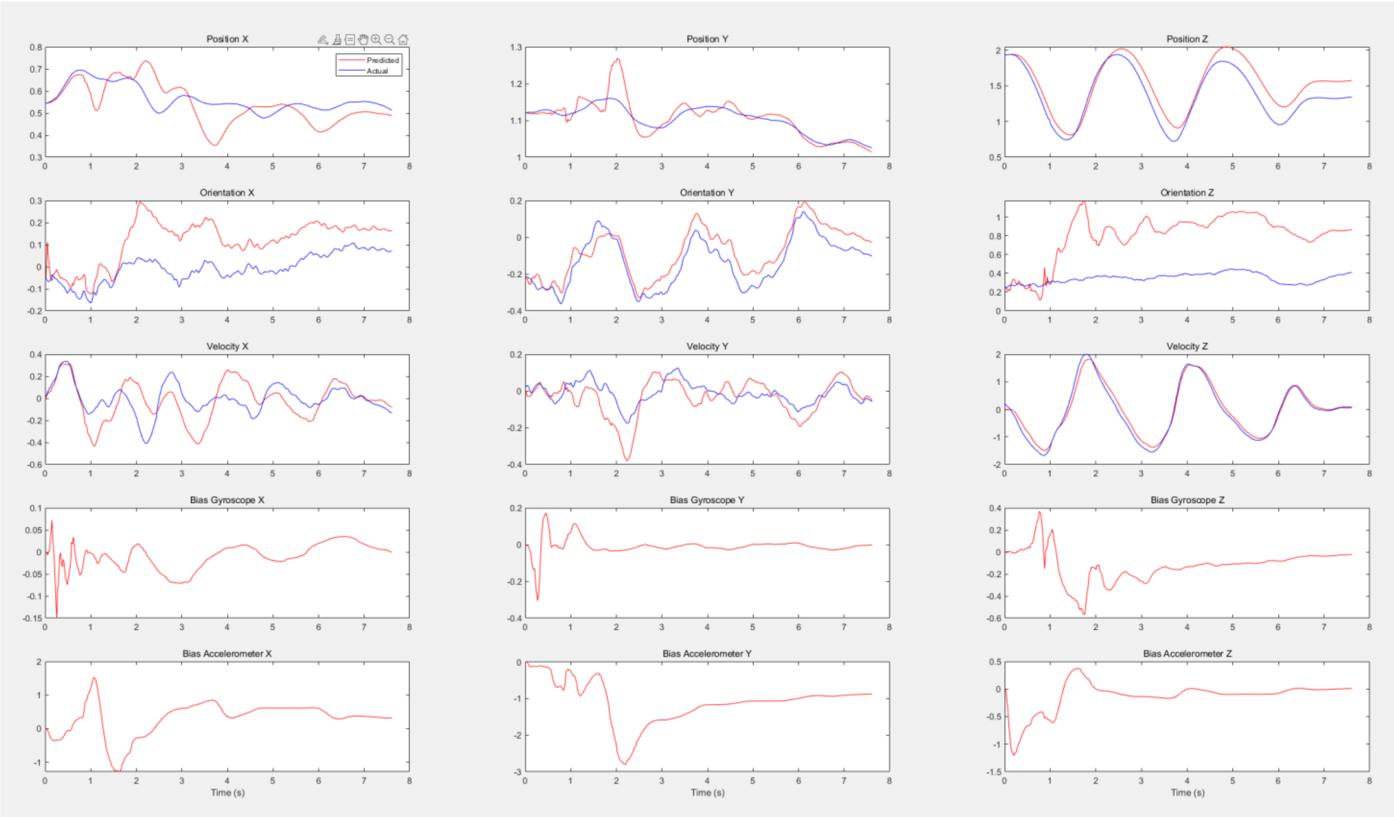
Plotting results:

Datasheet 1:





Datasheet 4:


Position X
Predicted
Actual
Position Y
Position Z
Orientation X
Orientation Y
Orientation Z
Velocity X
Velocity Y
Velocity Z
Bias Gyroscope X
Bias Gyroscope Y
Bias Gyroscope Z
Bias Accelerometer X
Bias Accelerometer Y
Bias Accelerometer Z
Time (s)
Time (s)
Time (s)

Conclusion

There are still some mistakes in part2-update step. I think it is due to some mistakes happened in the measurement model.