Orientation Tracking

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I. Introduction

Orientation Tgracking

II. Pre-processing

The raw IMU data we get is 10-bit ADC values, which technically ranges from 0 to 1023. Since it's difficult to use those values directly in our filter, we have to convert them so that they have real-world physical units and meanings. Our goal here is to convert the readings from the micro-controller to acceleration with a unit of m/s^2 and angular velocity with a unit of rad/s. The equations used for converting raw values to real values are shown in Eq.1 and Eq.2.

$$\vec{a} = (\vec{a}_{raw} - \vec{a}_{bias}) * s_a \quad (1)$$

$$\vec{\omega} = (\vec{\omega}_{raw} - \vec{\omega}_{bias}) * s_\omega \quad (2)$$

where $\vec{a}_{bias}$ is [511.5, 511.5, 511.5] and $\vec{\omega}_{bias}$ is determined empirically by averaging the first 100 readings of one of the IMU data and is [373.63 , 375.20 , 369.66]. s_a and s_ω are the scale factors and their values are 0.0106 and 0.0171.

III. Methods

For the main unscented kalman filter algorithm, I basically followed the steps outlined in Kraft's paper [1]. For calculating quaternion mean, I used the method proposed by Cheon [2] instead of gradient descent. Another difference is that Kraft uses only $2n$ Sigma points uniform weights, while Cheon uses $2n + 1$ Sigma points with weights determined by parameters such as α, β and κ. Here I will describe the algorithm in detail. The following content is either from Kraft or from Cheon.

I. Process Model

Process model in kalman filter takes the from of

$$x_{k+1} = A(x_k, w_k) \quad (3)$$

where x is the state vector and w is the process noise.

II. Measurement Model

III. Initialization

IV. Prediction

V. Correction

IV. Discussion

References

[1] Edgar Kraft, *A quaternion-based unscented kalman filter for orientation tracking*. Information Fusion, 2003. Proceedings of the Sixth International Conference on Information Fusion, Vol. 1 (2003), pp. 47-54.

[2] Y.-J. Cheon and J.-H. Kim, *Unscented filtering in a unit quaternion space for spacecraft attitude estimation*. IEEE International Symposium on Industrial Electronics (ISIE 2007) (2007), pp. 66-71.

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