Optimal Attitude Estimation Using Measurement Covariance Based on U.K.F

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CONTROLA

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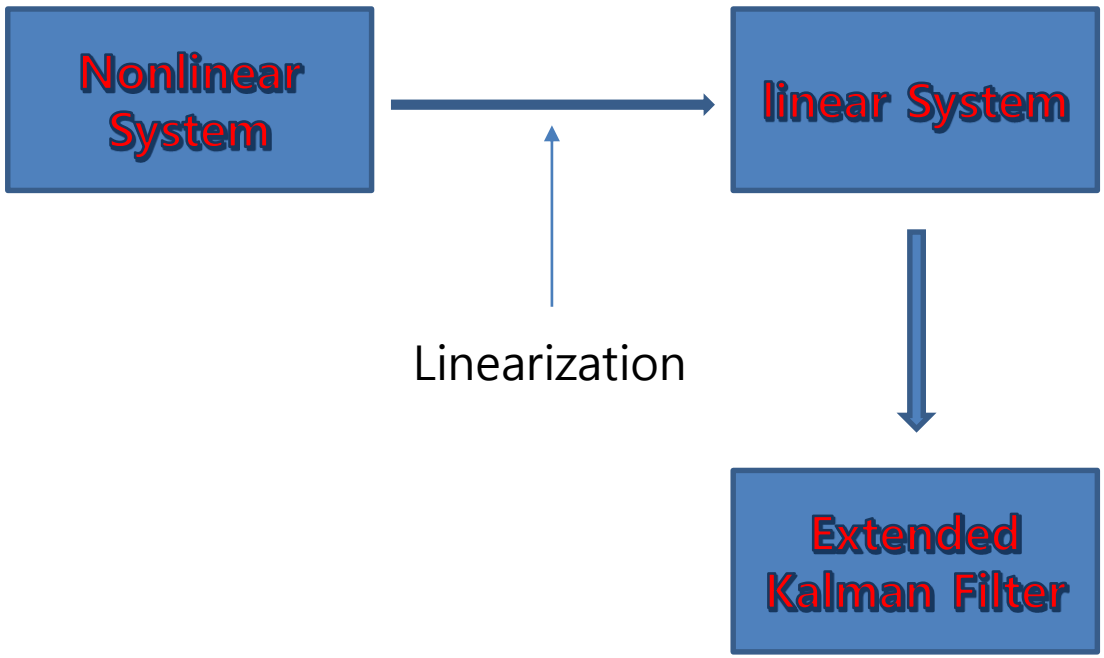
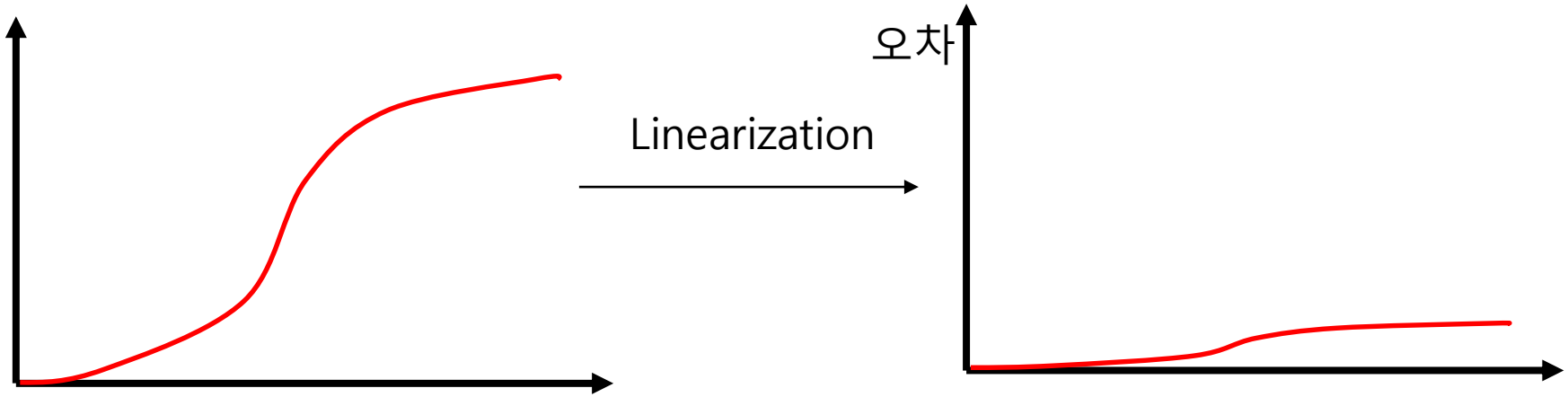


I Introduction

Research purpose

Nonlinear System



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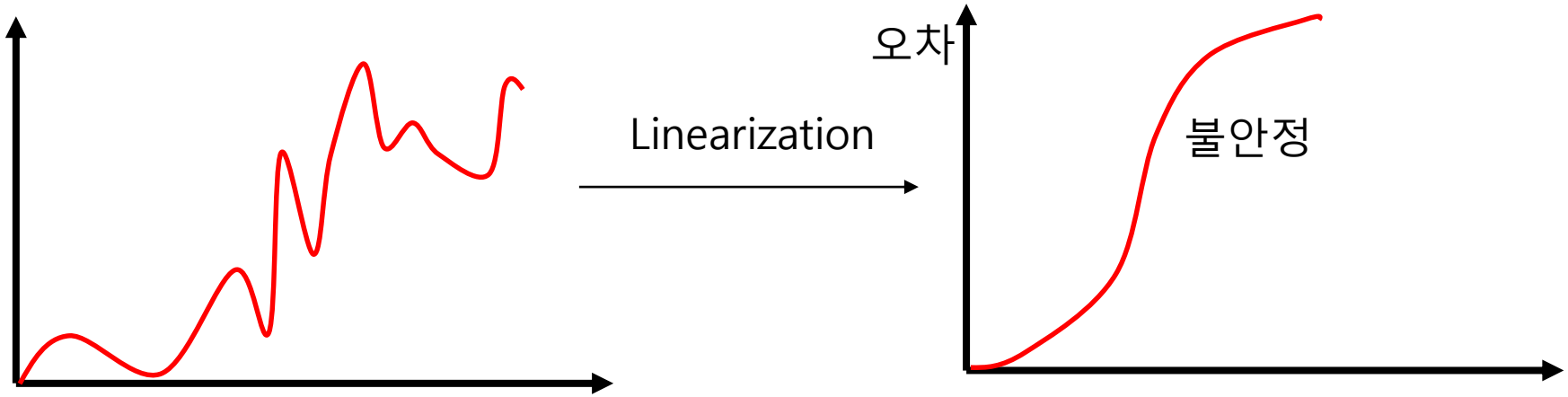


I Introduction

Research purpose

Unscented Kalman Filter → ~~Linearization~~

Ⅱ Algorithm

Unscented Kalman Filter

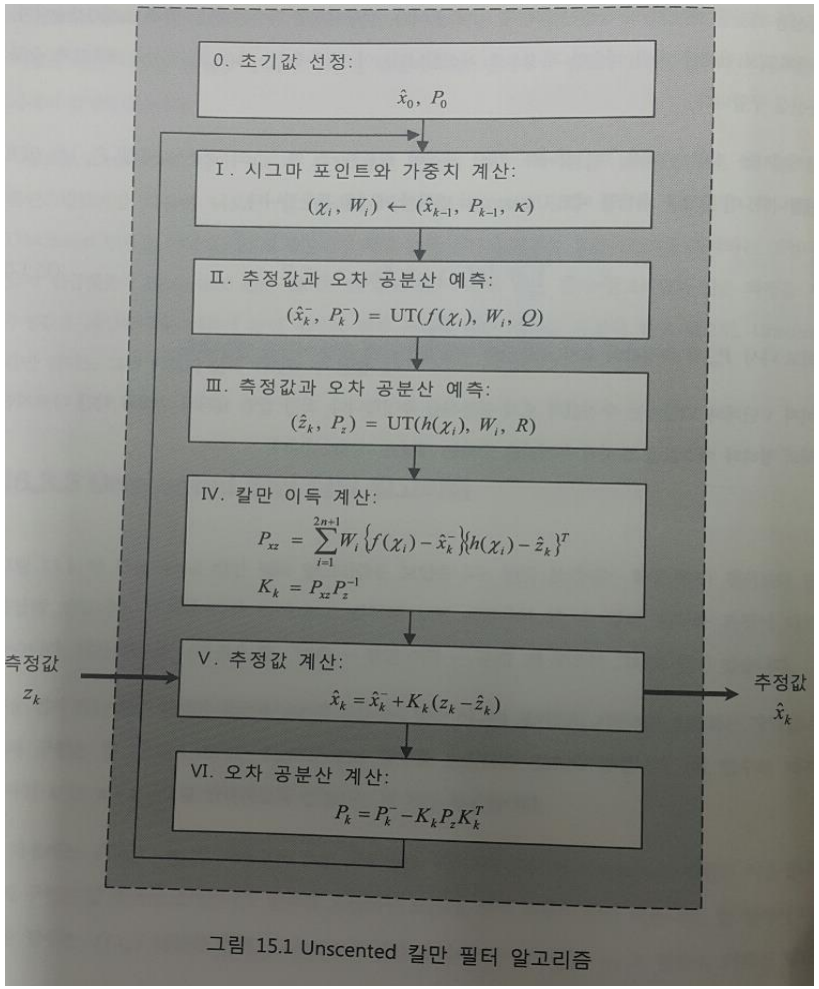


그림 15.1 Unscented 칼만 필터 알고리즘

Ⅱ Algorithm

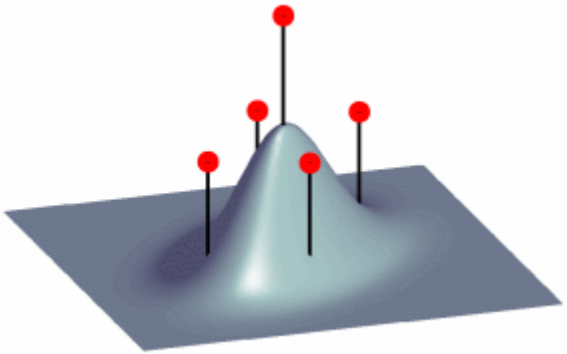
Unscented Kalman Filter

$$\mathbf{x}_{k+1} = \mathbf{f}(\mathbf{x}_k, k) + G_k \mathbf{w}_k$$

$$\tilde{\mathbf{y}}_k = \mathbf{h}(\mathbf{x}_k, k) + \mathbf{v}_k$$

1. 시그마 포인트와 가중치 계산

$$\boldsymbol{\sigma}_k \leftarrow 2n \text{ columns from } \pm\sqrt{(n+\lambda)[P_k^+ + \bar{Q}_k]}$$



$$\boldsymbol{\chi}_k(0) = \hat{\mathbf{x}}_k^+$$

$$\boldsymbol{\chi}_k(i) = \boldsymbol{\sigma}_k(i) + \hat{\mathbf{x}}_k^+$$

$$\boldsymbol{\chi}_{k+1}(i) = \mathbf{f}[\boldsymbol{\chi}_k(i), k]$$

Ⅱ Algorithm

Unscented Kalman Filter

2. 추정값과 오차 공분산 예측

$$\hat{\mathrm{x}}_{k+1}^{-} = \frac{1}{n+\lambda}\left\{\lambda\,\chi_{k+1}(0) + \frac{1}{2}\sum_{i=1}^{2n}\chi_{k+1}(i)\right\}$$

$$P_{k+1}^{-} = \frac{1}{n+\lambda}\left\{\lambda\,[\chi_{k+1}(0) - \hat{\mathrm{x}}_{k+1}^{-}]\,[\chi_{k+1}(0) - \hat{\mathrm{x}}_{k+1}^{-}]^{T} + \frac{1}{2}\sum_{i=1}^{2n}[\chi_{k+1}(i) - \hat{\mathrm{x}}_{k+1}^{-}]\,[\chi_{k+1}(i) - \hat{\mathrm{x}}_{k+1}^{-}]^{T}\right\} + \bar{Q}_{k}$$

Ⅱ Algorithm

Unscented Kalman Filter

3. 측정값과 오차 공분산 예측

$$\gamma_{k+1}(i) = \mathbf{h}[\boldsymbol{\chi}_{k+1}(i), k]$$

$$\hat{\mathbf{y}}_{k+1}^{-} = \frac{1}{n+\lambda}\left\{\lambda\gamma_{k+1}(0) + \frac{1}{2}\sum_{i=1}^{2n}\gamma_{k+1}(i)\right\}$$

$$P_{k+1}^{yy} = \frac{1}{n+\lambda}\left\{\lambda\left[\gamma_{k+1}(0) - \hat{\mathbf{y}}_{k+1}^{-}\right]\left[\gamma_{k+1}(0) - \hat{\mathbf{y}}_{k+1}^{-}\right]^T + \frac{1}{2}\sum_{i=1}^{2n}\left[\gamma_{k+1}(i) - \hat{\mathbf{y}}_{k+1}^{-}\right]\left[\gamma_{k+1}(i) - \hat{\mathbf{y}}_{k+1}^{-}\right]^T\right\}$$

$$P_{k+1}^{vv} = P_{k+1}^{yy} + R_{k+1}$$

Ⅱ Algorithm

Unscented Kalman Filter

3. 측정값과 오차 공분산 예측

$$P_{k+1}^{xy} = \frac{1}{n+\lambda}\left\{\lambda\left[\chi_{k+1}(0) - \hat{\mathbf{x}}_{k+1}^{-}\right]\left[\gamma_{k+1}(0) - \hat{\mathbf{y}}_{k+1}^{-}\right]^T + \frac{1}{2}\sum_{i=1}^{2n}\left[\chi_{k+1}(i) - \hat{\mathbf{x}}_{k+1}^{-}\right]\left[\gamma_{k+1}(i) - \hat{\mathbf{y}}_{k+1}^{-}\right]^T\right\}$$

Ⅱ Algorithm

Unscented Kalman Filter

4. 칼만 이득 계산

$$K_k = P_k^{xy}(P_k^{vv})^{-1}$$

5. 추정값 계산

$$\boldsymbol{v}_k \equiv \tilde{\mathbf{y}}_k - \hat{\mathbf{y}}_k^- = \tilde{\mathbf{y}}_k - \mathbf{h}(\hat{\mathbf{x}}_k^-, k)$$

$$\hat{\mathbf{x}}_k^+ = \hat{\mathbf{x}}_k^- + K_k \boldsymbol{v}_k$$

6. 오차 공분산 계산

$$P_k^+ = P_k^- - K_k P_k^{vv} K_k^T$$

Ⅲ Simulation & Result

Simulation A

State : Attitude error & bias
State Update : Gyro
Measurement : Accelerometer & Magnetometer
Filter : Unscented Kalman Filter

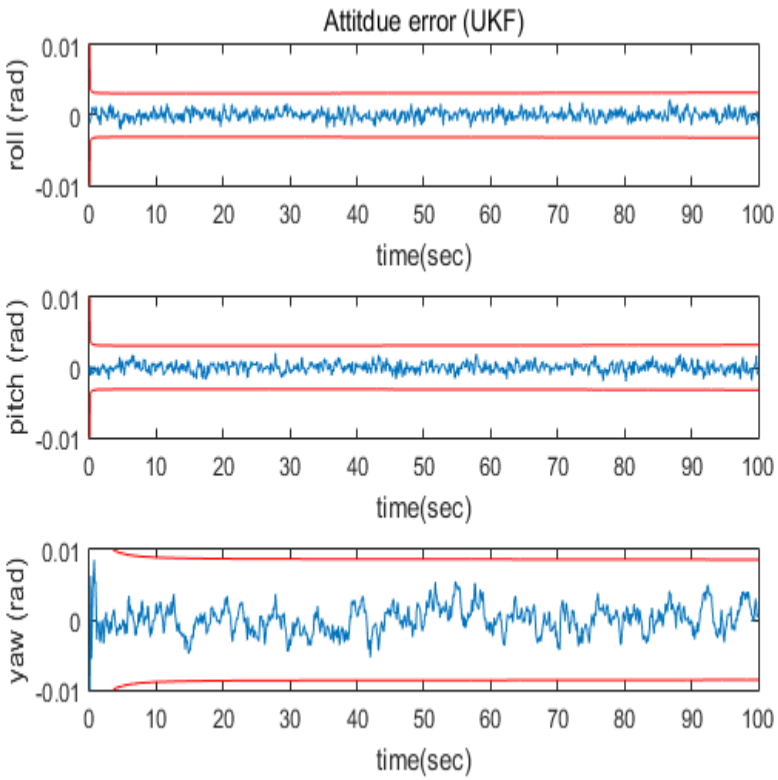
Simulation B

State : Attitude error & bias
State Update : Gyro
Measurement : Accelerometer & Magnetometer
Filter : Extended Kalman Filter

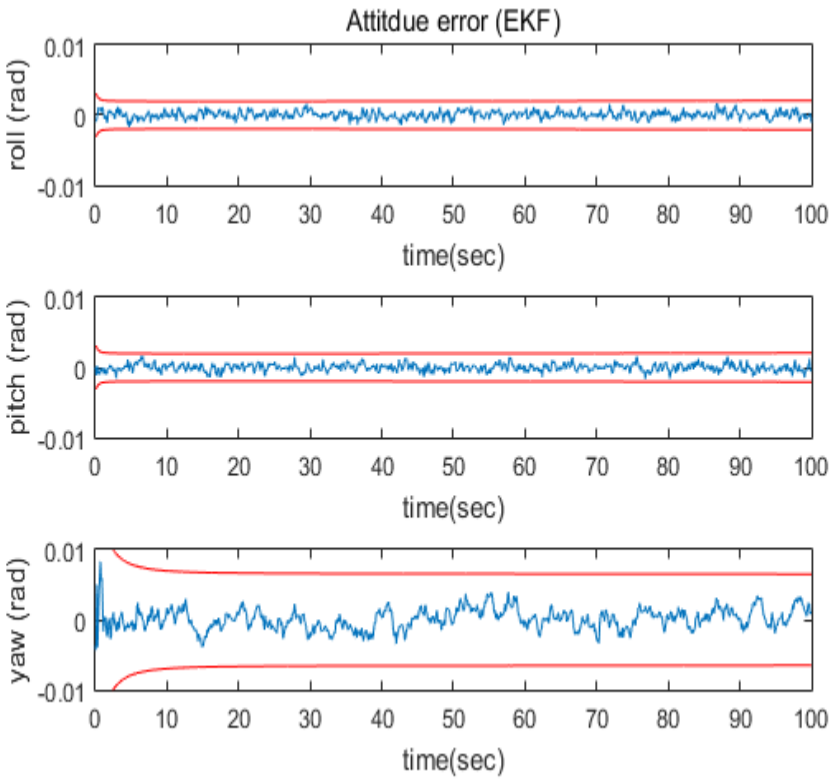
Ⅲ Simulation & Result

Attitude Error

Simulation A



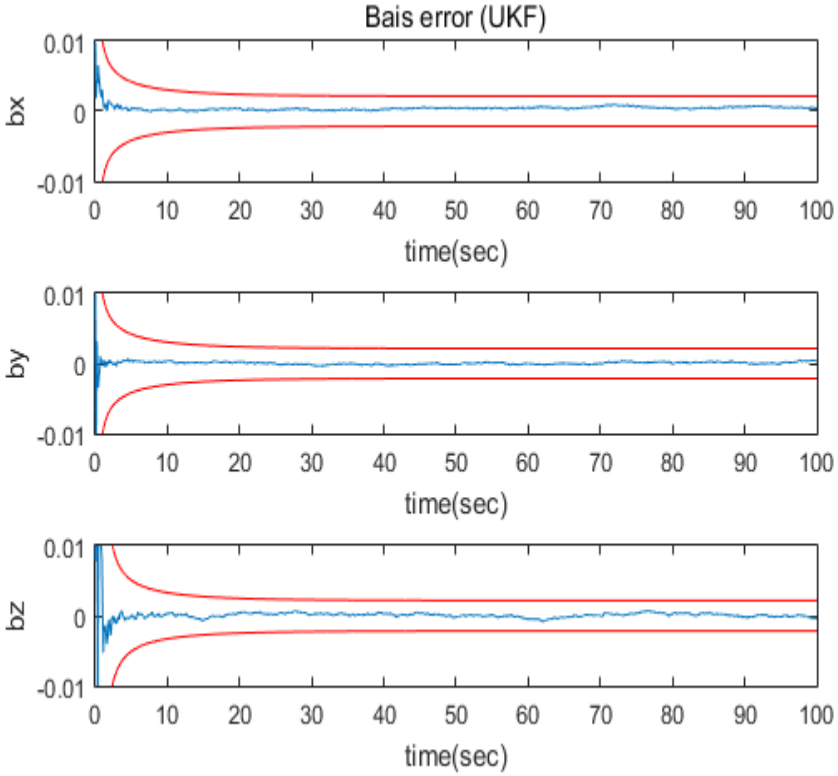
Simulation B



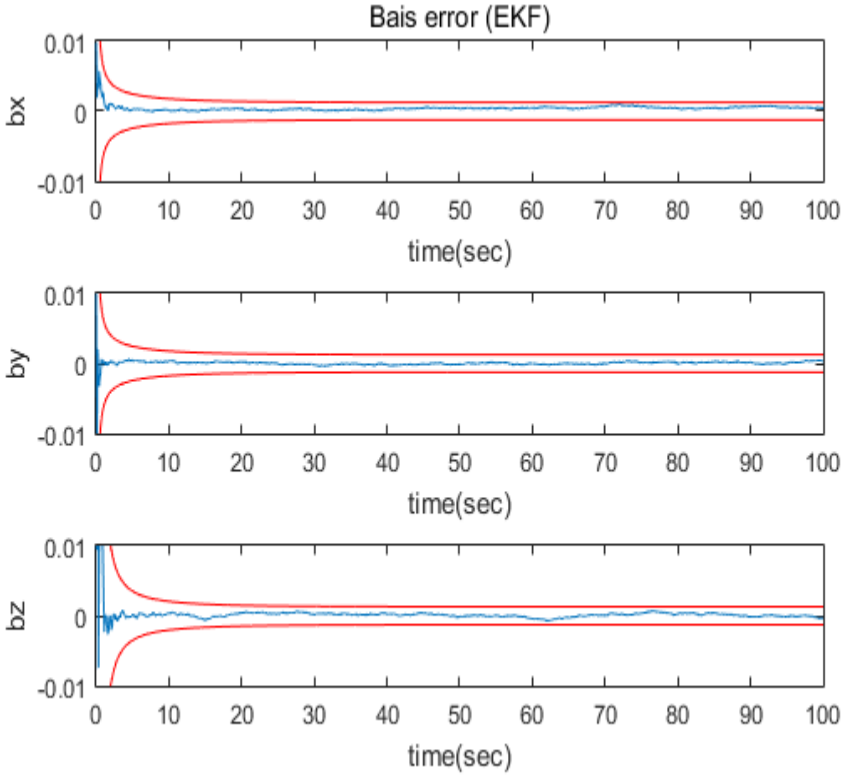
Ⅲ Simulation & Result

Bias Error

Simulation A



Simulation B



Ⅲ Simulation & Result

Result

1. 자세와 바이어스를 UKF와 EKF를 통해 비교했다.

2. 비선형성이 크지 않아 그렇게 두 필터의 오차가 비슷하게 나타났다.

3. 진동상황을 추가하면 UKF가 더 좋은 성능을 보일것이라 예상된다.

IV Future Plan

Next Seminar

1. Unscented Kalman Filter

2. Particle Filter


Q & A