Simulation of Stochastic Visual Motion Observer

July 23
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Purpose of this simulations

Stability analysis of Stochastic VMO

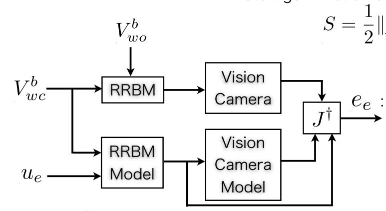
Modifications

1. V_{wo}^{b} : brownian motion
2. error feedback gain

$$u_e = -k_e \begin{bmatrix} 1 & 0 \\ 0 & \frac{4}{4-\phi(e^{\hat{\xi}\theta_{ee}})} \end{bmatrix} e_e$$

Storage Function of the estimate error system

$$S = \frac{1}{2}\|p_{ee}\|^2 + \phi(e^{\hat{\xi}\theta_{ee}})$$



Purpose (2)

How to decrease $\|e_e\|$ in the simulation

Theoretically

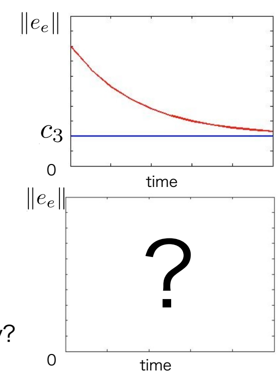
$$c_3 = \frac{\mathrm{tr}(\Sigma\Sigma^{\mathrm{T}})}{4k_e}$$

Σ : covariance matrix

$$\Sigma = \begin{bmatrix} 0.1 & 0 & 0 & 0.01 & 0 & 0 \\ 0 & 0.1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.01 & 0 & 0 & 0 \\ 0.01 & 0 & 0 & 0.01 & 0.01 & 0 \\ 0 & 0 & 0 & 0.01 & 0.01 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.01 \end{bmatrix}$$

Simulation

decrease theoretically?



Wiener process

Definition

i)stationary independent increments

ii) the increments follows the normal distribution

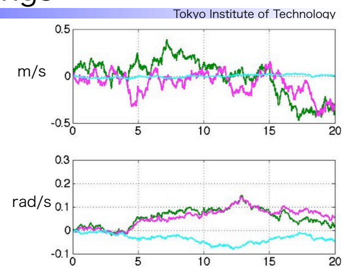
expected value $\mathrm{E}[w(t) - w(s)] = 0$

variance $\mathrm{E}[\{w(t) - w(s)\}^2] = \sigma^2|t - s|$

Simulation settings

$$V_{wo}^{b} = \begin{bmatrix} V_x \\ V_y \\ V_z \\ \hline W_x \\ W_y \\ W_z \end{bmatrix}$$

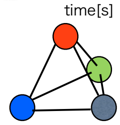
$$V_{wc}^{b} = 0$$



simulation time : 20[sec]

sampling time : 0.01[sec]

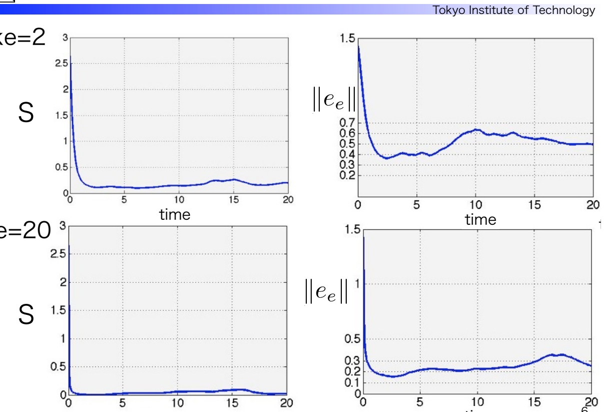
the number of each trials : 20



Example result

ke=2

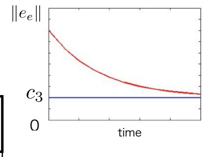
ke=20



Simulation results

Comparison about the means of S and $\|e_e\|$ in each ke

$$u_e = -k_e \begin{bmatrix} 1 & 0 \\ 0 & \frac{4}{4-\phi(e^{\hat{\xi}\theta_{ee}})} \end{bmatrix} e_e$$



ke	0.2	2.0	20	50
S	67.1	1.51	0.17	0.62
$\|e_e\|$	2.69	0.65	0.27	0.38
C3	2.6×10^{-2}	2.6×10^{-3}	0	0

S and $\|e_e\|$ are the smallest

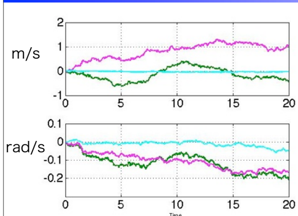
when ke is 20

Conclusion

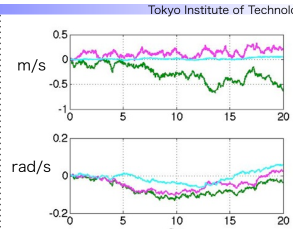
- Storage Function can be kept small as ke becomes small
- The limit of ke depends on sampling time
- Covariance matrix?

$$\Sigma = \begin{bmatrix} 0.1 & 0 & 0 & 0.01 & 0 & 0 \\ 0 & 0.1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.01 & 0 & 0 & 0 \\ 0.01 & 0 & 0 & 0.01 & 0.01 & 0 \\ 0 & 0 & 0 & 0.01 & 0.01 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.01 \end{bmatrix}$$

Failure example



Successive large input



Large input?

What cause VMO to fail?