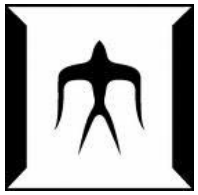
Passivity based
Human-Robot team cooperative control

Simulation and System Identification



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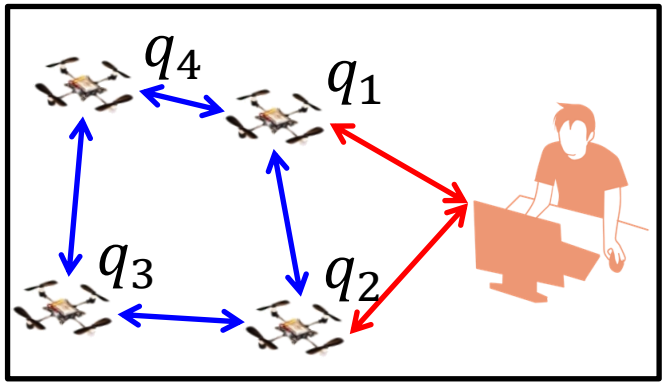
Natsuya Miyazawa

Outline

- Simulation
- How to Identify H(s)
- Matlab - System Identification Toolbox
- System Identification and verification of passivity

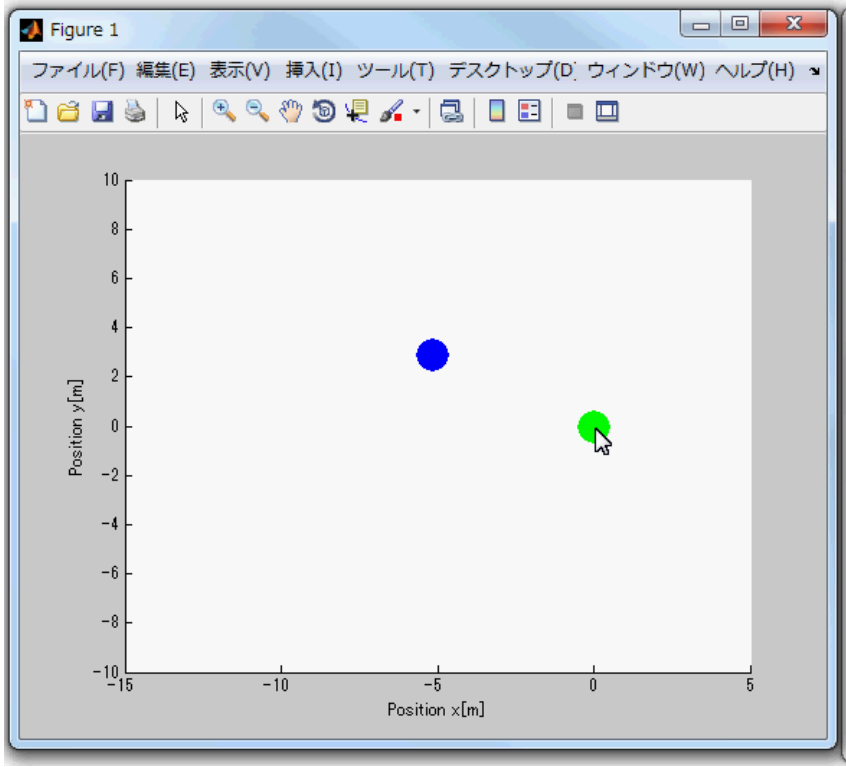
Simulation

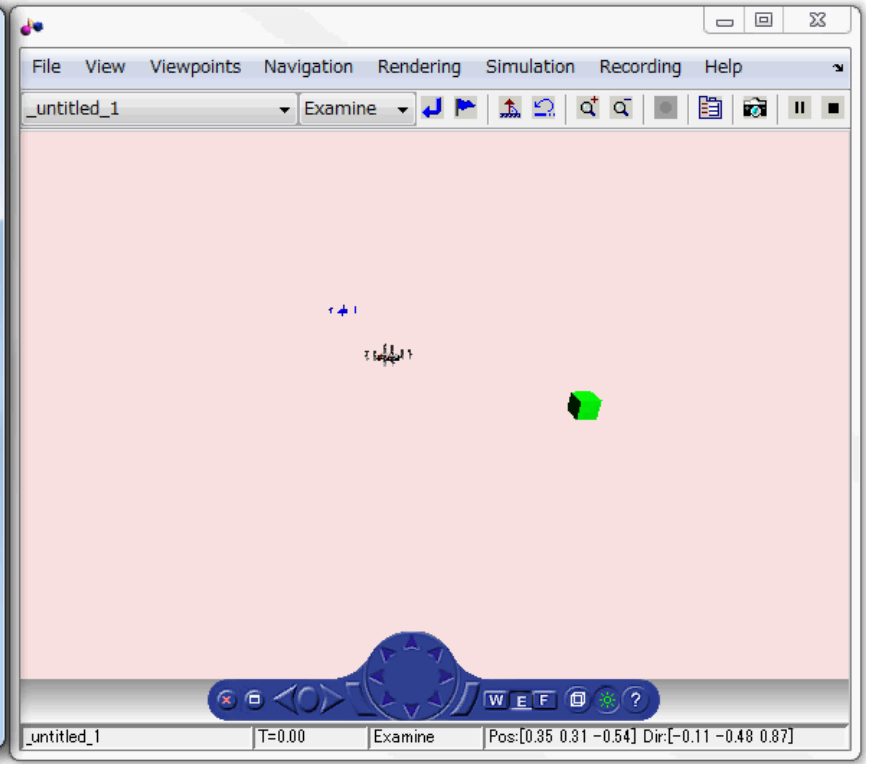


$D(s)$:Time Delay

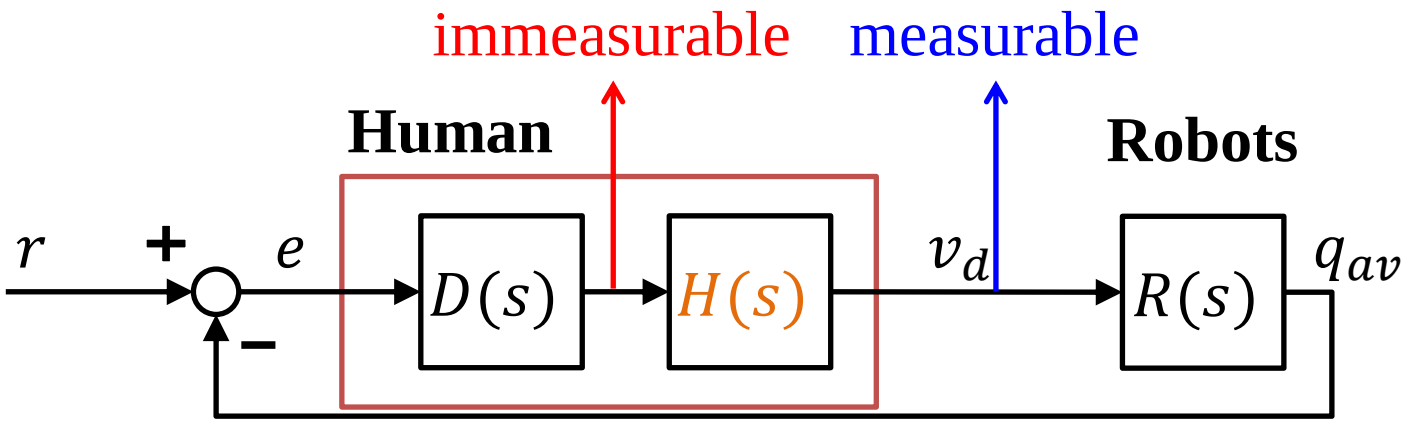
$$q_{av} = \frac{q_1 + q_2}{2}$$

$$R(s) = \frac{s^2 + s + 2}{s^3 + 2s^2 + 4s}$$ ← use ‘linmod’





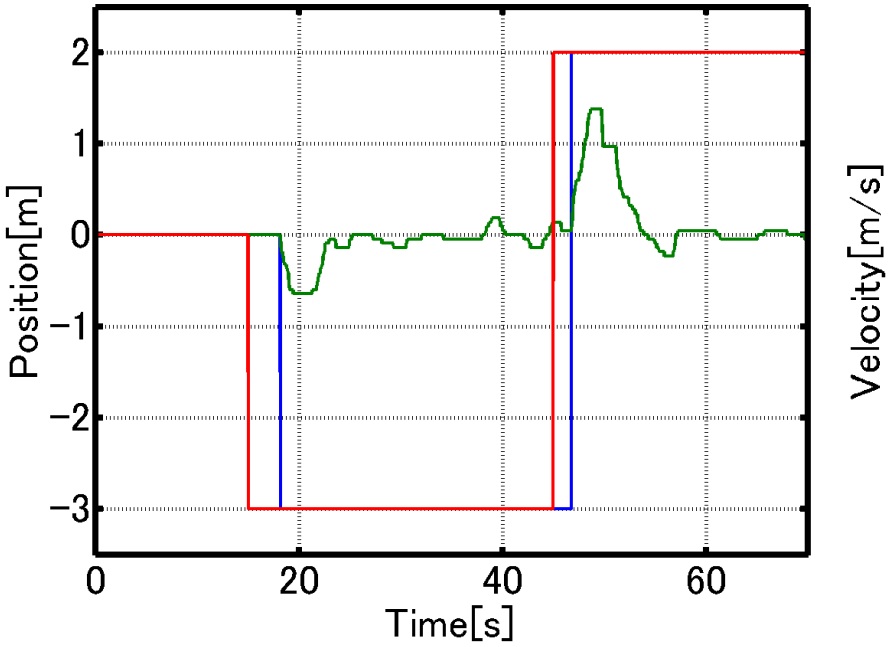
How to Identify H(s)



SISO system $\Rightarrow DH = HD$

Red:r

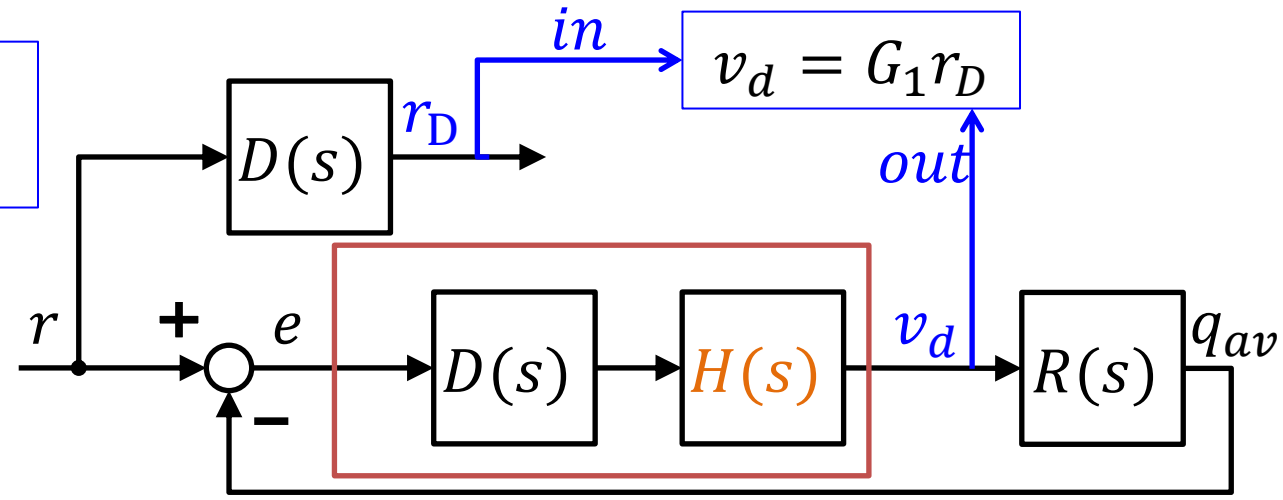
Blue:r_D



Green:v_d

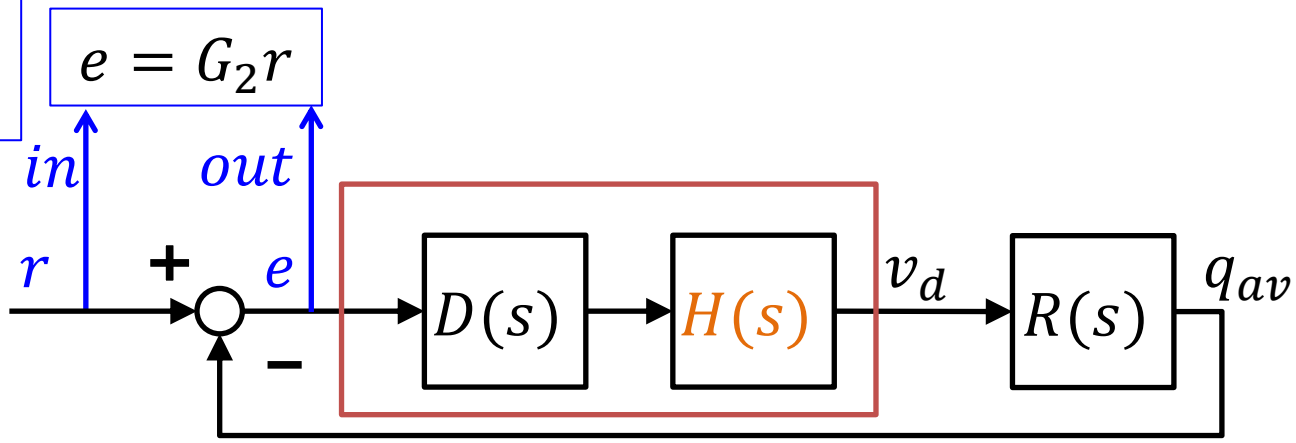
How to Identify H(s)

$$G_1(s) = \frac{H}{1 + RHD}$$



$$G_2(s) = \frac{1}{1 + RHD}$$

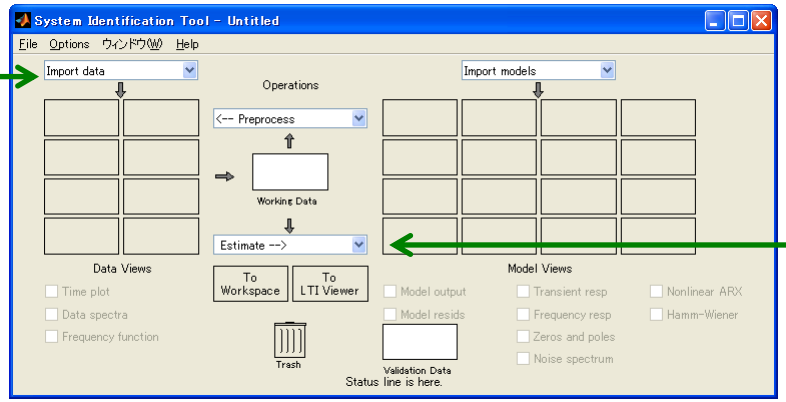
$$H = \frac{G_1}{G_2}$$



Matlab - System Identification Toolbox

GUI : type ‘ident’

Select
Time domain data



Select
Transfer Function Models

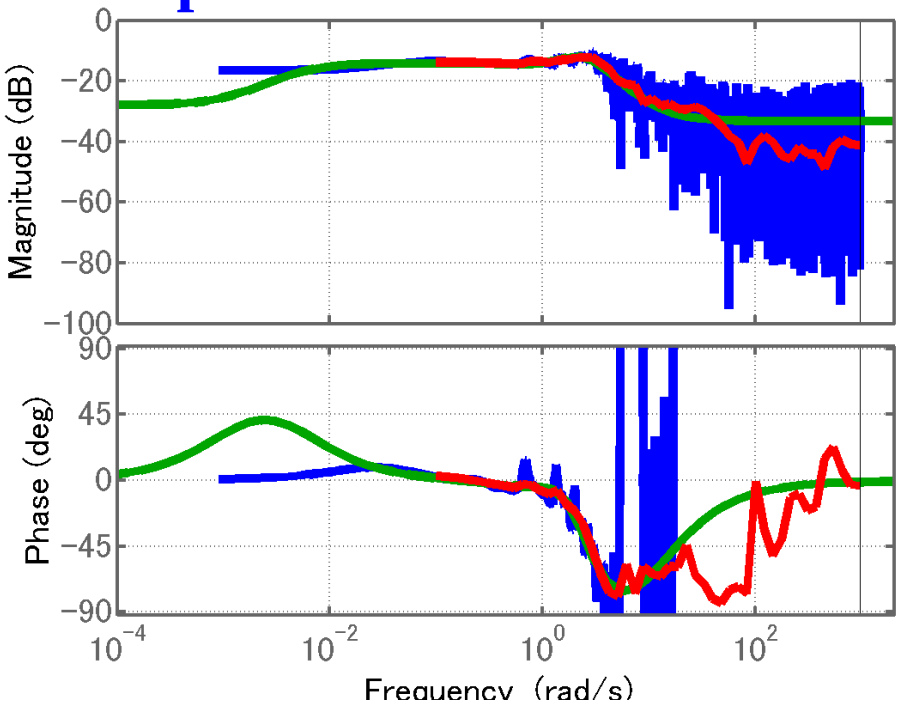
Using ‘tfest’ internally

Functions to Identify Frequency-Response [1]

- ‘tfest’: Transfer function estimation
- ‘etfe’ : Estimates an empirical transfer function using Fourier analysis. Frequencies [1:N]/N*pi/Ts
- ‘spafdr’: Estimates a frequency response with a variable frequency resolution using spectral analysis. Frequencies {wmin,wmax,NP} (NP : number of logarithmically spaced points)

System Identification and verification of passivity

Bode plot



Green: 'tfest'

Blue: 'etfe' $N = 2^{20}$

Red: 'spafdr' $\{0.1, pi/Ts, 50\}$

Passivity [2]

A minimal state space representation of transfer function $H(s)$ is passive if

- poles of $H(s)$ have nonpositive real parts;
- the phase shift of $H(s)$ doesn't exceed $\pm 90°$.

Transfer function 'tfest'

$$H(S) = \frac{0.022(s + 0.0011)(s^2 + 2.1s + 1.7)(s^2 + 21s + 12)}{(s + 3.0)(s + 1.2)(s + 0.0054)(s^2 + 2.7s + 5.7)}$$

Passive in this case

Future Work

- Experiment – collision avoidance
- deal with time delay

References

[1] http://www.mathworks.co.jp/jp/help/ident/ug/identifying-frequency-response-models.html

[2] Cooperative Control Design