

EECS 16B CSM

Bryan Ngo

UC Berkeley

2020-10-25

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

Stability

Continuous

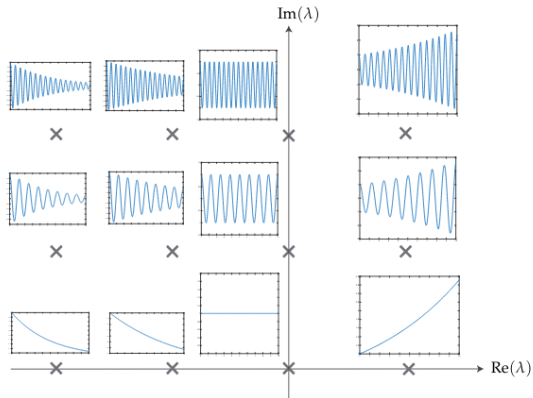
EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares



Discrete

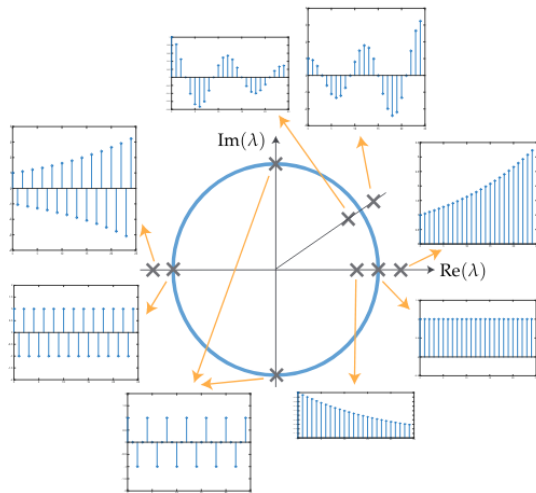
EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares



EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

Feedback

Open-Loop

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

$$\mathbf{x}[t + 1] = \mathbf{A}\mathbf{x}[t] + \mathbf{B}\mathbf{u}[t] \quad (1)$$

- define a certain range of use
- simpler
- no restraints apart from stability

Closed-Loop

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

$$\mathbf{u}[t] = \begin{bmatrix} k_1 & k_2 & \cdots & k_n \end{bmatrix} \begin{bmatrix} x_1[t] \\ x_2[t] \\ \vdots \\ x_n[t] \end{bmatrix} \quad (2)$$

$$\mathbf{x}[t+1] = \mathbf{A}\mathbf{x}[t] + \mathbf{B}\mathbf{K}\mathbf{x}[t] = (\mathbf{A} + \mathbf{B}\mathbf{K})\mathbf{x}[t] \quad (3)$$

- adaptable to a wide range of use
- more complex
- self-correcting
- requires more constraints

Controller Canonical Form

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

$$\mathbf{x}[t+1] = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 1 \\ a_1 & a_2 & a_3 & \cdots & a_n \end{bmatrix} \mathbf{x}[t] + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \vdots \\ 1 \end{bmatrix} \mathbf{u}[t] \quad (4)$$

$$\det(\mathbf{A} + \mathbf{BK} - \lambda \mathbf{I}) = \lambda^n - \sum_{i=1}^n (a_i + k_i) \lambda^i \quad (5)$$

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

Least Squares

Quick Review

EECS 16B
CSM

Bryan Ngo

Stability

Feedback

Least Squares

$$\mathbf{Ax} = \mathbf{b} \implies \hat{\mathbf{x}} \approx ([\mathbf{A}]^\top \mathbf{A})^{-1} [\mathbf{A}]^\top \mathbf{b} \quad (6)$$

- we want to minimize the error vector $\mathbf{e} = \mathbf{b} - \mathbf{Ax}$