Experiment 7

State feedback features in digital domain.

Background:

A rehash of digital state space feedback control design concepts will be useful for this problem.

Objective:

To design state feedback for a given digital state-space system, so as to realise performance specifications for different applications.

Tutorial:

In the MATLAB platform, go through the procedural steps as described for:

- *Create state-space model:* https://in.mathworks.com/help/control/ref/ss.html
- *Working with state space quadruple models.*
- *Eigenvalues and Eigenvectors:* https://in.mathworks.com/help/symbolic/eigenvalues-and-eigenvectors.html?searchHighlight=eigenvalues&s_tid=doc_srchtitle
- *Creating Discrete-Time Models:* https://in.mathworks.com/help/control/examples/creating-discrete-time-models.html
- *Pole placement design:* https://in.mathworks.com/help/control/ref/place.html?searchHighlight=place&s_tid=doc_srchtitle

Elements of the software for familiarisation (beyond Expt #6)**:**

a. Functions/keywords: c2d; expm; and associated matrix operations.

b. Tools: Symbolic math toolbox: https://in.mathworks.com/help/symbolic/index.html?searchHighlight=symbolic%20math&s_tid=doc_srchtitle

Project:

The discretised state open-loop space representation for an armature controlled DC motor is described by:

$$\mathbf{F} = \begin{bmatrix} 1.0 & 0.1 & 0.0 \\ 0.0 & 0.9995 & 0.0095 \\ 0.0 & -0.0947 & 0.8954 \end{bmatrix} \quad ; \quad \mathbf{g} = \begin{bmatrix} 1.622 \times 10^{-6} \\ 4.821 \times 10^{-4} \\ 9.468 \times 10^{-2} \end{bmatrix}$$

corresponding to a sampling time of 0.01s. State feedback gain matrices are to be designed for three *distinct applications*, for which the closed loop discrete time eigenvalue specifications are respectively as follows:

Application #1. $0.1,\ 0.4 \pm j0.4$
Application #2. $0.4,\ 0.6 \pm j0.33$
Application #3. All three eigenvalues at the origin.

- Design state feedback gain matrices for each of the three applications.

- For each case, discuss the response of the closed loop system for zero input, and with initial state vector as:

$$\mathbf{x}_0 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}^T$$

For observations and discussions:

- Record and discuss time domain responses for the zero input case, with reference to specific dynamic features characteristic of each application.

- Subsequently, examine the responses for different step and ramp inputs. The dynamic behaviour (and features) for each case should be discussed in the context of the eigenvalues.

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