Discrete Time System

Talk to a Teacher Project
http://spoken-tutorial.org
National Mission on Education through ICT
http://www.sakshat.ac.in

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Objectives

- **Convert between state space and transfer function descriptions**

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- **Discretize a continuous time system**

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System Requirements

- OS: Ubuntu Linux 12.04

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- **OS: Ubuntu Linux 12.04**
- **Scilab 5.3.3**

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Prerequisite

- Basic knowledge of Scilab

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- **Basic knowledge of Scilab**
- **If not, please refer to the Scilab tutorials available on http://spoken-tutorial.org**

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The state space model

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$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

State Space Model

The state space model

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx + Du \end{aligned}$$

is specified by

```
--> sys3 = syslin('c',A,B,C,D)
```

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State Space Model

The state space model

$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

is specified by

```
--> sys3 = syslin('c',A,B,C,D)
```

for prespecified matrices A**,** B**,** C **and** D **of suitable sizes**

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State Space Model

Define (for example) matrices

$$A = \begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

$$C = -3B^T$$

$$D = 2$$

State Space Model

- **Check whether poles of `sys4` (by '`plzr`')**

State Space Model

- **Check whether poles of** `sys4` **(by** `'plzr'`**)**
- **are same as eigenvalues of** A **(by** `'spec'`**)**

State Space Model

The ‘`ss2tf`’ command can be used

State Space Model

The '`ss2tf`' command can be used

- to obtain a transfer function

State Space Model

The 'ss2tf' command can be used

- **to obtain a transfer function**
- **of a state-space system sysSS**

State Space Model

The ‘`ss2tf`’ command can be used

- **to obtain a transfer function**
- **of a state-space system sysSS**
- **For example:**

$$\rightarrow sysTF = ss2tf(sysSS)$$

State Space Model

- Use **ss2tf** function for `sys3` defined earlier

State Space Model

- Use ss2tf function for `sys3` defined earlier
- sysTF is a new variable for which '`denom`' command is applicable (and not applicable to sys4)

Exercise:

Find a state space realization of the second order transfer function defined below:

- $$G(s) = \frac{9}{s^2 + 6s + 19}$$
- **Hint: use** ‘`tf2ss`’

Exercise:

For the new system (in state space form), say sysSS, check if

- The eigenvalues of the matrix A and the poles of the transfer function `G(s)` are the same
- Use the A, B, C, D matrices of the system sysSS to obtain the transfer function

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Exercise:

- **Check if the answer is the original one**

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Discrete Time System

We now define a discrete time system

- It is customary to use ‘z’ for the variable in the numerator and denominator polynomials

Discrete Time System

- Recall that the variable ‘z’ has a shortcut

Discrete Time System

- **Recall that the variable ‘z’ has a shortcut**
  - **Instead of** `z = poly(0,‘z’)`

Discrete Time System

- **Recall that the variable ‘z’ has a shortcut**
  - **Instead of** `z = poly(0,‘z’)`
  - **Use:** `--> z=%z`

Discrete Time System

- We now define a first order discrete time system

Discrete Time System

- **We now define a first order discrete time system**
- **We use the '`syslin`' function for this**

Discrete Time System

- We now define a first order discrete time system
- We use the ‘`syslin`’ function for this
- We specify the domain to be discrete time

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Discrete Time System

- **We now define a first order discrete time system**
- **We use the '`syslin`' function for this**
- **We specify the domain to be discrete time**
- **Instead of continuous time**

Discrete Time System

- **For checking the** `step` **response, we have to define the input explicitly as** `ones`

Discrete Time System

- **For checking the** `step` **response, we have to define the input explicitly as** `ones`
- **Instead of** `csim`**, we have to use the '**`flts`**' function to simulate this system**

Discrete Time System

- It is helpful to discretize a given continuous time system

Discrete Time System

- **It is helpful to discretize a given continuous time system**
- **This is done using the `dscr` function**

Discrete Time System

Let us

- discretize the system ‘sysG’

Discrete Time System

Let us

- discretize the system ‘sysG’
- with a sampling period of 0.1

Discrete Time System

- Notice that we obtain the discretized system in state space representation

Discrete Time System

- **Notice that we obtain the discretized system in state space representation**
- **We can convert this to a transfer function representation in discrete time using the `ss2tf` function**

Summary

In this tutorial, we have learnt to:

- Convert between state space and transfer function descriptions
- Define a discrete time system and plot its Step response
- Discretize a continuous time system

About the Spoken Tutorial Project

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- **More information on this Mission is available at http://spoken-tutorial.org/NMEICT-Intro**

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