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Lecture Four:

System-Representation-and-Classification

1. System Representation:

A system is a mathematical model of a physical process that relates the input signal (source or. excitation signal) to the output signal (response signal).

Let x and y be the input and output signals, respectively, of a system. Then the system is viewed as a mapping of x into y. this transformation is represented by the mathematical notation

$$y = Tx \tag{1}$$

where T is the operator that produces output y from input x, as illustrated in Fig.1.

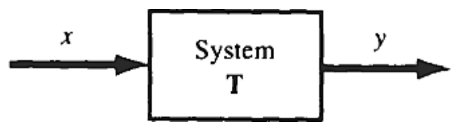

Fig. 1. System Representation

2. System Classification

2.1 Continuous-Time and Discrete-Time Systems

If the input and output signals x and y are continuous-time signals, then the system is called a continuous-time system. If the input and output signals are discrete time signals or sequences, then the system is called a discrete-time system.

2.2 Linear Systems and Nonlinear System

If the operator T in Eq. (1) satisfies the following two conditions, then T is called a linear operator and the system represented by T is called a linear system;

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- Additivity:
  Given that T x_1 =y_1 and T x_2 = y_2, then

$$T[x_1 + x_2] = y_1 + y_2 \tag{2}$$

For any signals x_1 and x_2.

- Homogeneity (or scaling)

$$T[\alpha x] = \alpha y \tag{3}$$

For any signals x and any scalar α.

Any system that does not satisfy Eq. (2) and/or Eq. (3) is classified as a nonlinear. Example for linear system is the input-output relationship (Ohm's law) of a resistor is

$$y(t) = Rx(t)$$

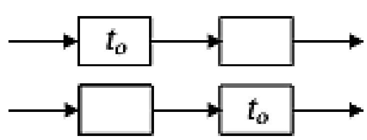
Examples of nonlinear systems are

$$y = \cos x$$

2.3 Time Invariant Systems and Time Varying Systems

If the system satisfies the following condition, then the system is called a time-invariant or fixed system:

$$T[x(t - t_0)] = y(t - t_0) \tag{4}$$



Where t_0 is any real constant. Equation (4) indicates that the delayed input gives delayed output. A system which does not satisfy Eq. (4) is called a time-varying system.

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2.4 Causal and Non-causal systems

A system is called causal if its output y(t) at an arbitrary time $t = t_0$ depends on only the input x(t) for $t \leq t_0$. That is, the output of a causal system at the present time depends on only the present and/or past values of the input, not on its future values. Thus, in a causal system, it is not possible to obtain an output before an input is applied to the system. A system is called non-causal if it is not causal. Examples of non-causal systems are

$$y(t) = x(t + 1)$$