Module 1 : Signals in Natural Domain
Lecture 8 : Classification of Systems

Objectives

In this lecture you will learn the following

We shall classify systems under the following categories and tabulate their system properties

- Continuous-time systems
- Discrete-time systems
- **Hybrid** : Continuous-Discrete systems
- **Hybrid** : Discrete-Continuous systems

Properties of discrete variable systems

We have classified systems into three classes - Continuous-time systems, Discrete-time systems and Hybrid systems. Now that we have introduced some system properties, let us see what properties are relevant to which classes of systems.

Let us first consider examples of different classes of systems.

Continuous-time systems Continuous-Continuous systems 1.Tree swaying in the wind: Wind - described by its speed, direction - is a continuous-time input. Movement of branches is continuous-time output signal.	**Discrete-time systems** Discrete-Discrete systems 1.Logic circuits: Discrete logic inputs are processed to give discrete logic outputs.
Hybrid systems Continuous-Discrete systems 1.Eye: sees continuous image, but sends a discrete map to the brain 2.Computer microphone: Sampler converts a continuous time signal into a discrete time signal.(Sampler forms an important system in today's digital world - we shall look at this in great detail later in the course)	**Hybrid systems** Discrete-Continuous systems 1.Brain : gets a discrete map from the eye, and completes a smooth, continuous picture 2.Computer speaker and sound card - a digital music output given by the computer is smoothed out and played as a continuous waveform.

Properties of systems

In early parts of this course, we shall concern ourselves with mainly the first two classes, viz. Continuous-time and Discrete-time systems, but later we shall also deal with Hybrid systems as well. So, we find it worthwhile here to take a look at what properties the systems of various classes **can** have:

Property	**Continuous input - Continuous output**	**Discrete input- Discrete output**	**Continuous- Discrete input/ Discrete- Continuous output**
Memory	Yes If input and output are of the same type	Yes If input and output are of the same type	No However, we can define a restricted version of memory if there is a correspondence in the input and output variables (e.g.: continuous and discrete time)
Causality	Yes If input and output are of the same type	Yes If input and output are of the same type	No A restricted version of causality can be defined: "If the inputs are same upto an instant corresponding to a discrete variable, then the outputs of a causal system are same
Shift invariance (Time invariance)	Yes If input and output are of the same type	Yes If input and output are of the same type	No We can define shift invariance in cases where the inputs are shifted by certain quanta corresponding to the spacing in discrete variables.
Stability	Yes	Yes	Yes
Linearity	Yes	Yes	Yes

Note that this is a table of properties which the system **can** have; they are not necessary properties of a system. Hence, we can find a Continuous-time system that is stable (though there may be Continuous-time systems which are unstable), but it is impossible to apply the concept of memory to a discrete-continuous system without modifying the concept itself.

Conclusion:

In this lecture you have learnt:

- Memory, causality and shift invariance are defined only if the input and ouput signals are of the same type i.e. both continuous or discrete.
- Stability and linearity do not require the input and output signals to be of the same type.

Congratulations, you have finished Lecture 8.