MultiMedia Retrieval (M(M)R)
Control systems

Lecture 3, 2017-2018, term 1

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based on Mohammed Gulam Ahamad’s slides
Disclaimer :P

• We’re working with real world data. For this, we have no magic recipes. At best, we have some best practices.
• We have ideas; but, it’s best if you actively develop ideas yourself.
• We provide basic knowledge, guidelines, and food4thought.
Last lecture:
Some complementary remarks

• Why are we learning this?
• What does it as to do with MultiMedia Retrieval?
• What is the relation between pattern recognition (and machine learning) and MultiMedia Retrieval?
Remember POTS

- Plain Old Telephone Service
- One of its characteristics: Restricted to a narrow frequency range of 300–3400 Hz, called the voice frequency (or voice band), which is much less than the human hearing range of 20–20,000 Hz.
Paralinguistic features

- The **voiced speech** of a typical adult male will have a **fundamental frequency** from 85 to 180 Hz, and that of a typical adult female from 165 to 255 Hz.\(^1\)\(^2\) Thus, the fundamental frequency of most speech falls below the bottom of the "voice frequency" band as defined above. However, enough of the **harmonic series** will be present for the **missing fundamental** to create the impression of hearing the fundamental tone.
Compression techniques

- MP3
- JPG

- but, also encryption @ WOII
Frequency vs. time domain signal processing

- moments
- morphological signal processing
News of the day
Prerequisites

For Classical Control Theory
• Differential Equations
• Laplace Transform
• Basic Physics
• Ordinary and Semi-logarithimic graph papers

For Modern Control theory above &
• Linear Algebra
• Matrices
What is Control System?

1. A system controlling the operation of another system.
2. A system that can regulate itself and another system.
3. A control System is a device, or set of devices to manage, command, direct or regulate the behaviour of other device(s) or system(s).
Definitions

**System** – An interconnection of elements and devices for a desired purpose.

**Control System** – An interconnection of components forming a system configuration that will provide a desired response.

**Process** – The device or system under control. The input and output relationship represents the cause-and-effect relationship of the process.
Definitions

**Controlled Variable**– It is the quantity or condition that is measured and Controlled. Normally *controlled variable* is the output of the control system.

**Manipulated Variable**– It is the quantity of the condition that is varied by the controller so as to affect the value of *controlled variable*.

**Control** – Control means measuring the value of *controlled variable* of the system and applying the *manipulated variable* to the system to correct or limit the deviation of the measured value from a desired value.
Definitions

**Disturbances** – A disturbance is a signal that tends to adversely affect the value of the system. It is an unwanted input of the system.

- If a disturbance is generated within the system, it is called *internal disturbance*. While an *external disturbance* is generated outside the system.
Types of Control Systems

Natural Control System
- Universe
- Ecology
- Human Body
  - motor skills
  - immune system
  - active vs passive behavior

Manmade Control System
- Vehicles and Aeroplanes
- Industrial Robots
- Multimedia Retrieval systems!
Types of Control Systems

- Manual Control Systems
  - Room Temperature regulation Via Electric Fan
  - Water Level Control

- Automatic Control System
  - Room Temperature regulation via airco
  - Human Body Temperature Control
Types of Control Systems

Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.

- Output has no effect on the control action. No feedback – no correction of disturbances
- In other words output is neither measured nor fed back.

Examples: Washing Machine, Toaster, Electric Fan
Types of Control Systems

- Since in open loop control systems reference input is not compared with measured output, for each reference input there is fixed operating condition.

- Therefore, the accuracy of the system depends on calibration.

- The performance of open loop system is severely affected by the presence of disturbances, or variation in operating/environmental conditions.
Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.

Examples:- Refrigerator, Iron
Types of Control Systems

Multivariable Control System

Comparator

Controller

Process

Measurements

Temp
Humidity
Pressure

Outputs
Types of Control Systems

Feedback Control System

• A system that maintains a prescribed relationship between the output and some reference input by comparing them and using the difference (i.e. error) as a means of control is called a feedback control system.

• Feedback can be positive or negative.
Types of Control Systems

Linear vs. Nonlinear Control System

- A Control System in which output varies linearly with the input is called a linear control system.

\[ y(t) = -2u(t) + 1 \]

\[ y(t) = 3u(t) + 5 \]
Types of Control Systems

Linear vs. Nonlinear Control System

- When the input and output has nonlinear relationship the system is said to be nonlinear.
Types of Control Systems

Linear vs. Nonlinear Control System

- Linear control systems do not exist in practice.

- Linear control systems are idealized models fabricated by the analyst purely for the simplicity of analysis and design.

- When the magnitude of signals in a control system are limited to range in which system components exhibit linear characteristics the system is essentially linear.
Types of Control Systems

Time invariant vs. Time variant

• When the characteristics of the system do not depend upon time itself then the system is said to time invariant control system.

\[ y(t) = -2u(t) + 1 \]

• Time varying control system is a system in which one or more parameters vary with time.

\[ y(t) = 2u(t) - 3t \]
Types of Control Systems

Continuous Data vs. Discrete Data System

• In continuous data control system all system variables are function of a continuous time $t$.

  \[ x(t) \]

• A discrete time control system involves one or more variables that are known only at discrete time intervals.

  \[ X[n] \]
Types of Control Systems

Deterministic vs. Stochastic Control System

• A control System is deterministic if the response to input is predictable and repeatable.

• If not, the control system is a stochastic control system.
Types of Control Systems

Adaptive Control System

• The dynamic characteristics of most control systems are not constant for several reasons.

• The effect of small changes on the system parameters is attenuated in a feedback control system.

• An adaptive control system is required when the changes in the system parameters are significant.
Types of Control Systems

Learning Control System

• A control system that can learn from the environment it is operating is called a learning control system.
Types of Control System

Control Systems

Natural Man-made

Manual Automatic

Open-loop Closed-loop

Non-linear linear

Time variant Time invariant

Time variant Time invariant

Non-linear linear
Examples of Control Systems

Room Temperature Control

Heating Loss/Gain from Outside

Desired Temp → +

Heater/Air-con

House

Room Temp → −

Temperature Sensor
Examples of Modern Control Systems
Examples of Modern Control Systems

(a) Automobile steering control system.

(b) The driver uses the difference between the actual and the desired direction of travel to generate a controlled adjustment of the steering wheel.

(c) Typical direction-of-travel response.
Examples of Control Systems

Insulin/Glucose Dynamics
Examples of Control Systems

**Insulin delivery control system**

The blood glucose and insulin levels for a healthy person.
Examples of Modern Control Systems

Open-loop & Closed-loop Models of Blood Glucose Control

(a) Open-loop (without feedback) control and (b) closed-loop control of blood glucose.
Examples of Control Systems

A Model of Heart Rate Control System
Examples of Modern Control Systems

Control of Anaesthesia

- Propofol-threshold mechanism:
  \[ T_{\text{threshold}} = T_{0_{\text{thres}}} - \sigma C_{\text{artery}} \]

- Brain temperature
- ICP
- Reference ICP (5-15 mmHg)
- Controller for intracranial decompression
- Controller for propofol anaesthesia
- Propofol infusion rate

Steps:
1. Induce therapeutic cooling;
2. Predict brain temperature;
3. Calculate minimum concentration;
4. Administer propofol.

Temperature setting
Examples of Modern Control Systems

Intensive Care

- Syringe pump of diuretic
- Mechanical ventilator
- Cooling blanket

- Pharmacokinetics of diuretic
- Circulatory dynamics
- Biothermal regulatory dynamics

- Syringe pump of sedative
  - Pharmacokinetics of sedative
Examples of Control Systems

Smart grids are distribution networks that measure and control usage.
Examples of Modern Control Systems

A computer control system.
Examples of Modern Control Systems

The Utah/MIT Dextrous Robotic Hand: A dextrous robotic hand having 18 degrees of freedom, developed as a research tool by the Center for Engineering Design at the University of Utah and the Artificial Intelligence Laboratory at MIT. It is controlled by five Motorola 68000 microprocessors and actuated by 36 high-performance electropneumatic actuators via high-strength polymeric tendons. The hand has three fingers and a thumb. It uses touch sensors and tendons for control.

(Photograph by Michael Milochik. Courtesy of University of Utah.)