Feedback Control in Ball Beam Dynamics

- Experimenting Delay Effects

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Background & Terminology

- What is “feedback control”?
- Sensors
- Stability / Instability
- Cruise Control
Block Diagram Convention (Controlled)

Comparator

Desired Speed

Error signal

Controller

Control signal

Sensor (Encoder)

Feedback

DC Motor

Actual Speed

Plant
Block Diagram Convention (Uncontrolled)

- Desired Speed
- Comparator
- Error signal
- Controller
- Control signal
- Plant
- Actual Speed
- Feedback
- Sensor (Encoder)
- DC Motor
Block Diagram—Motor (PID Controller)

Desired Speed
20 RPM

Sensor (encoder)

National Instruments
NIM ENC
Encoder Input

-0.001533980787886 *60/2/pi

Gain

Derivative

50 s
s+50

RPM

Controller

Gain 1

Gain 2

Gain 3

Saturation

Scope

National Instruments
NIM DAC
Analog Output

Voltage

Position Error

Integrator

National Instruments
NIM ENC

Derivative

du/dt

RPM Error

20

Constant

Controller
Speed Control of the Motor-Experiments

Speed Control with P-Controller. Desired = 20 RPM

Speed Control with PI-Controller. Desired = 20 RPM
Position Control of the Motor-Experiments

Position Tracking with P-Controller, Red = Actual, Blue = Desired

Error = ±15°!!

Position Tracking with PID-Controller, Red = Actual, Blue = Desired

Error = ±3°
No Delay – Ball At Start

Introduction to Ball Beam Dynamics
What is Delay and Where is it?

- Time that it takes to receive a signal

- Where:
  - Remote surgery
  - Human reaction delays
  - Chemical processes
  - Robotics
  - Tele-operation
  - Missiles and targets
  - Light delay (circuits, all electronics)
Delay Effects

- How would you implement delay?
- Why does delay lead to instability?
- Compensation of undesirable effects
  - Wait before you act (observe trends)
  - Be less aggressive when compensating
  - Advanced controller development (research)
SRV02 - Experiment #3
BB01 - Ball & Beam
Double PV Controller: Experiment vs. Simulation
Run: Setup_SRV02_Exp3
0.2 Second Delay – Ball At Start
Delay—Graph

Delay effect from start

- Time (sec)
- Position (cm)

Kv_{bb} = 0.006, Kp_{bb} = 0.01

Delay effect from start

- .2 seconds
- No delay

Kv_{bb} = .006  Kp_{bb} = .01
No Delay – Ball At Equilibrium
0.1 Second Delay – Ball At Equilibrium
0.2 Second Delay– Ball Equilibrium
Max Delay for Kv_bb

0.1 Second Delay

0.2 Second Delay

0.3 Second Delay

Kv_bb
Getting Better

- **Optimization**
  - Energy efficient
  - Quickest result
  - Safest voltage

- **Improving the Controller**
  - New degrees of freedom—P, PI, PID controllers
  - Have the computer guess—Penalize the guess

- **Gain, Too Much of a good thing?**
  - Kp=1, Kp=1000
Thank you