Automated Labyrinth

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Motivation

• Labyrinth, originally by BRIO®

• Perfect tool for developing motor skills and patience

• Practically impossible for a human
Labyrinth Board Game
Goal

• Solve a difficult game
• Use low-cost sensors
• Create user-experience
Prototype

1. Acrylic sheet
   14” x 11” x 0.093”

2. All thread rods
   4x 22” x 3/8”

3. Baseboard
   20” x 18” x 0.75”

4. Solid Wood Labyrinth
Software

• **Xcode** - Integrated Development Environment
• **Cocoa API** – graphical user interface
• **OpenCV** – computer vision library
• **Arduino** - Integrated Development Environment
• **GIT** – distributed version control
Maze Analysis

- Hole Detection - Unnecessary
- Path Detection
Ball Detection

- Template Matching
- Region of Interest
- Dynamic IIR Filter
Kalman Filter

• Motion Tracking Algorithm:
  – Position ✓
  – Velocity ✓
  – Acceleration ✗

• Predict Ball Location and Motion
Kalman Filter

• Motivation
  – Feed less-noisy data to the system
  – Help image-processing detect location
  – Specify acceptable noise
  – Debug control system response
Kalman Filter

\[ x_k = F_k x_{k-1} + B_k u_k + w_k \]
Control System

• Once we know the distance between the ball and the target, how do we tell the servos how much to tilt?
PID Controller

- Proportional
- Integral
- Derivative
- Best option for mechanically unattributed systems
Proportional

- Kick
- Current error
- Distance from ball to target
Integral

- Nudge
- Sum of past/present error
- Sum of Error(0) to Error(t)
Derivative

• Dampening
• Difference of present and past error
• \( \text{Error}(t) - \text{Error}(t-1) \)
Electro-mechanical Subsystem
Embedded System
Nunchuk Manual Control
GUI

Automated Labyrinth

Image Processing

Left click on the board move the target
Right click on the ball to fix the ROI

Current: 86 113
SerialPort: usbserial-A900cdNk 115200

PID Control
- P: 14
- I: 0.12
- D: 200

Control Signals
- X: -215.81
- Y: 1702.11

Path Tools
- Position: <-, >, v, ^
- Target: +1, -1, +5, -5, +10, -10

Choose Path
- Original Path
- Build-A-Path

Reset
- Top Left & TPL
- X, Y
- Flat

PID Null Range
- Max x: 1.80
- Min x: 0
- Max y: 1.80
- Min y: 0
Results

• Automated Labyrinth not complete
• Mechanics of the Labyrinth not static
• Accurately guide the ball to a series of points
End

• Presentation, Videos & More information available online at http://cse.logicol.org

• Any questions?
Examples
Build-a-Path
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• Any questions?