Preliminary Design Review

Team 1
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October 12, 2016
The Team

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The Problem

• In baseball, the strike zone is from the batter’s knees to halfway up the torso
• Determining strikes and balls, without a professional umpire, is difficult and inaccurate
• Strikes and balls are a core aspect of the game of baseball
• Incorrectly called pitches lead to angry players

Photo courtesy of nextlevelballplayer.com
Current Solutions

• Expensive
  • Multiple High Speed Camera Systems in Major League stadiums
• Inaccurate
  • Coach “umping” from behind mound
  • Catcher “umping”
  • Chair in Whiffle ball
Solution

Design a system contained in the home plate that automatically determines balls and strikes by utilizing sensors to determine the baseball’s location.
System Requirements

- Determine strikes with 15% error or less when pitch is within one ball length of edge of strike zone
- Accurately detect pitches up to 2 meters high, 1.5 meters wide
- Detect pitches at speeds up to 70 mph
- Battery lasts for 1 game (3 hours)
- Must give strike/ball feedback in real time (within 2-3 sec)
- Self-contained (no external components)
- Perform correctly in regular weather conditions (e.g. cloudy, sunny)
- Physically robust (withstand impacts of normal play)
Sensors

- Ultrasonic transmitters and transducer
  - Inexpensive
  - High susceptibility to noise
  - Inaccurate location data due to noise
- Radar
  - Expensive
  - High susceptibility to noise
  - High computational requirements
  - Would require many custom parts
- Stereoscopic cameras
  - Inexpensive
  - High data rate
2 Camera System

- 2 camera stereoscopic system using image processing to determine 3-dimensional location of ball above plate
- Utilize multiple frames of single pitch to determine path of the baseball through the plane of the strike zone
2 Camera System

- Cameras will point directly upwards from front, outer edges of home plate
- High frame rate will ensure at least two frames capture a ball traveling 70 mph at the bottom of the strike zone
Challenges

- Determine location of ball in 3D space using 2D images
- Locate ball within images given varying backgrounds
- Identify and ignore non-pitches (e.g. a bat, other thrown ball, or a player)
- High computational workload to process many frames per second
Design: Block Diagram (Physical)
Design: Block Diagram (Logical)

- Cameras
- Processor
  - Background subtraction
  - Ball location
  - Ball/strike decision
- App
  - Database
  - GUI
Design: Hardware selection

• Need cameras that can take pictures at 60fps @ ~480p
• Need a processor who can communicate with the cameras
  • ~2MB of external RAM will be required
  • Algorithms needs to take finish in (1 / fps) time
    • Ex. 1 / 60fps = 16.6ms before next frame.
Design: Camera selection
Design: Camera selection

- Camera
  - Omni-Vision has a large selection of cameras
  - Up to a couple MP
  - Many can go up to 120fps
Design: Processor selection

- Processors:
  - Regular CPU (single-core uProc)
    - Easy to program and test.
    - Easy to add RAM
    - Very hard to implement stereo-cameras
  - XMOS-based CPU (multi-core uProc)
    - Easy to program and test.
    - Reasonable to implement stereo-cameras
    - Difficult to add RAM
  - FPGA
    - Parallel execution is a big plus
    - Reasonable to implement stereo-cameras
    - PCB/Software might be harder to implement.
# Estimated Costs

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<th>Unit</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Cost</th>
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<tbody>
<tr>
<td>FPGA</td>
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<td>Cameras</td>
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<tr>
<td>Bluetooth</td>
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<td><strong>Total Cost</strong></td>
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Distribution of responsibilities

- **Jason: Power supply/Bluetooth**
  - Establish stable power supply to all systems
  - Connect and configure Bluetooth module for processor
- **Matt: Camera control/synchronization**
  - Identify and implement hardware protocol
  - Ensure video feeds are linked frame by frame
- **Justin: Low level processing, TX/RX**
  - Implement image processing to identify frames that contain ball
  - Handle strict time requirements to match frame rate
- **Tim: High level processing, app (GUI/database)**
  - Implement image processing to locate ball in 3D space
  - Create mobile app that displays results of pitch analysis to user
Proposed MDR Deliverables

- Demonstration of image collection
  - Create two synchronized video feeds using cameras and collect with processor
- Demonstration of core image processing algorithm in MATLAB
  - Returns x, y position of ball above plate given two .MOV files