

Preliminary Design Review

Team 1 Preliminary Design Review 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.

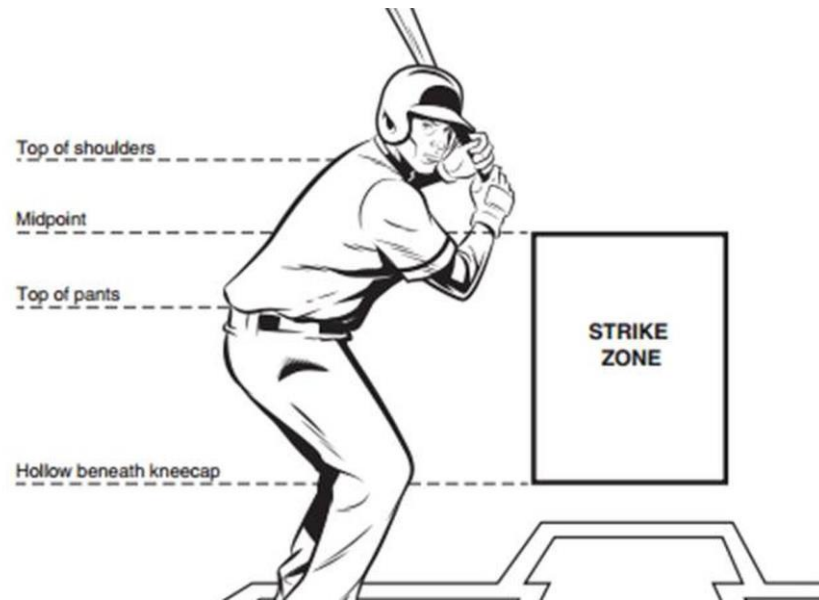


Photo courtesy of lpdpt.com

System Requirements

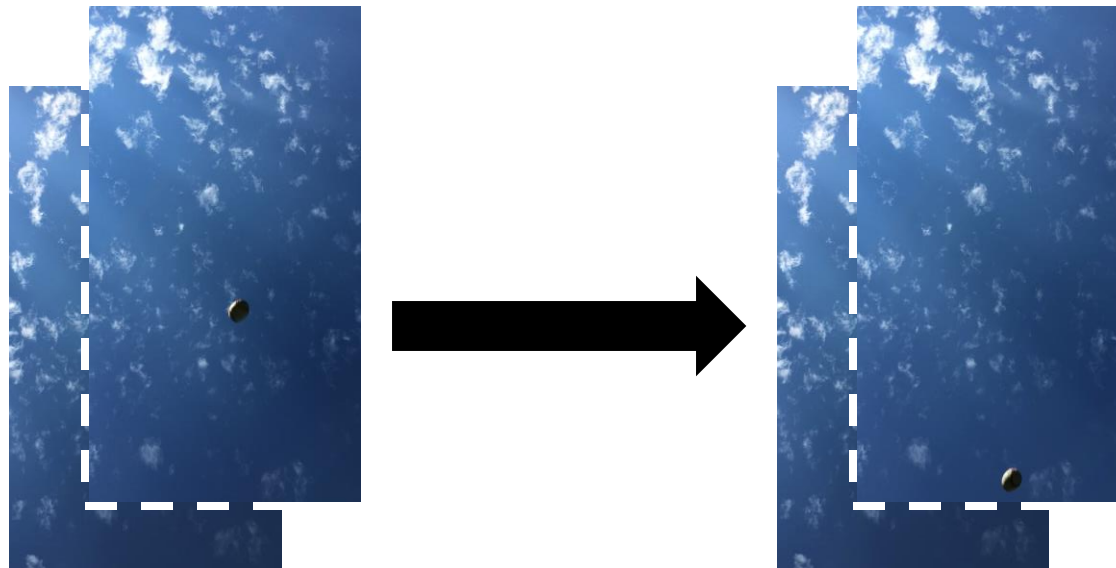
- Determine strikes with 15% error or less when pitch is within one ball length of edge of strike zone
- Accurately detect pitches up to 2 meters high, 1.5 meters wide
- Detect pitches at speeds up to 70 mph
- Battery lasts for 1 game (3 hours)
- Must give strike/ball feedback in real time (within 2-3 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

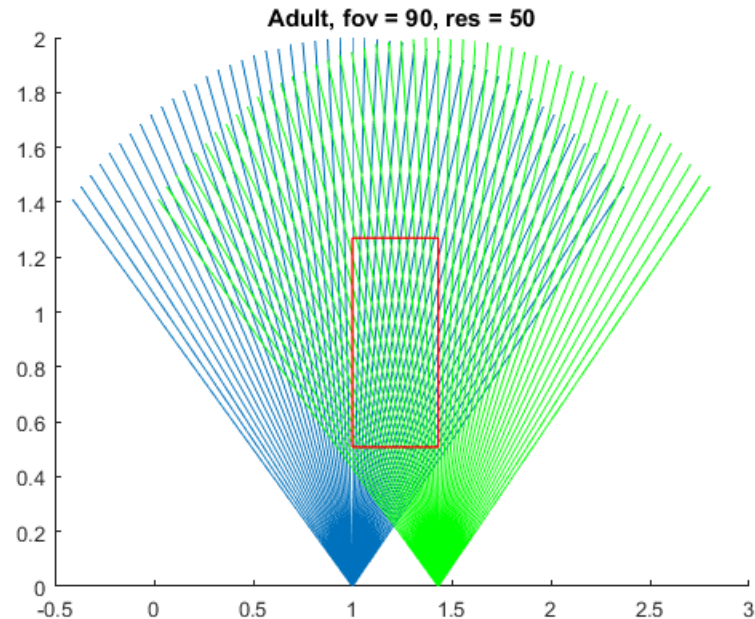
2 Camera System

- 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

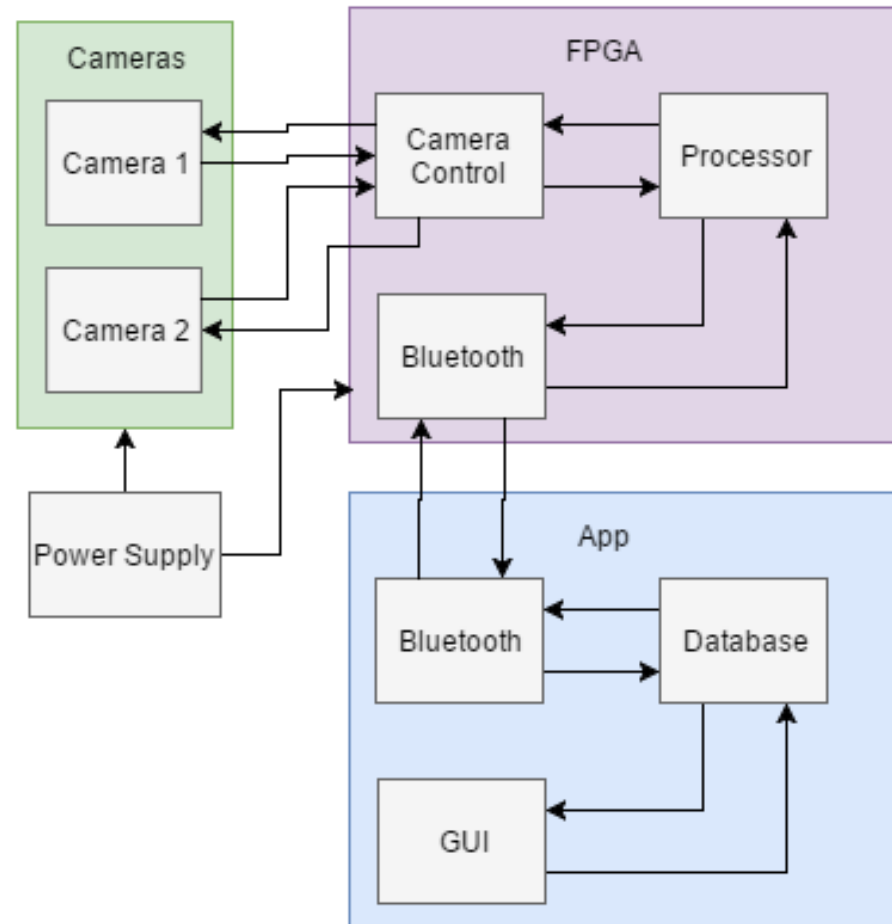
- Cameras will point directly upwards from front, outer edges of home plate
- High frame rate will ensure at least two frames capture a ball traveling 70 mph at the bottom of the strike zone



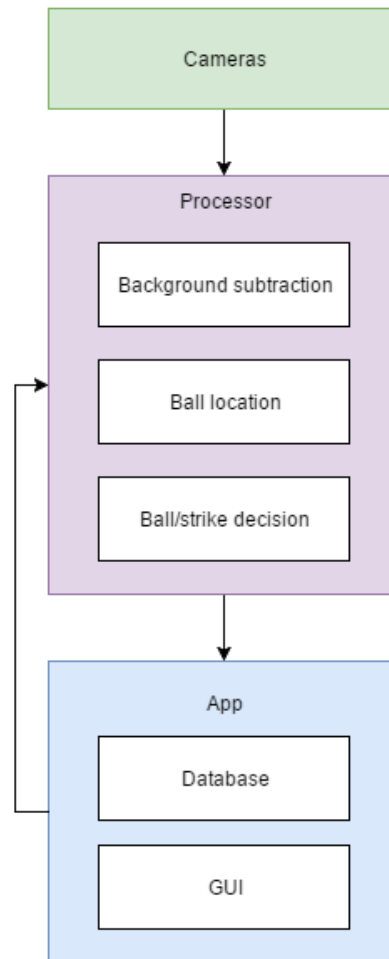
Challenges

- 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)



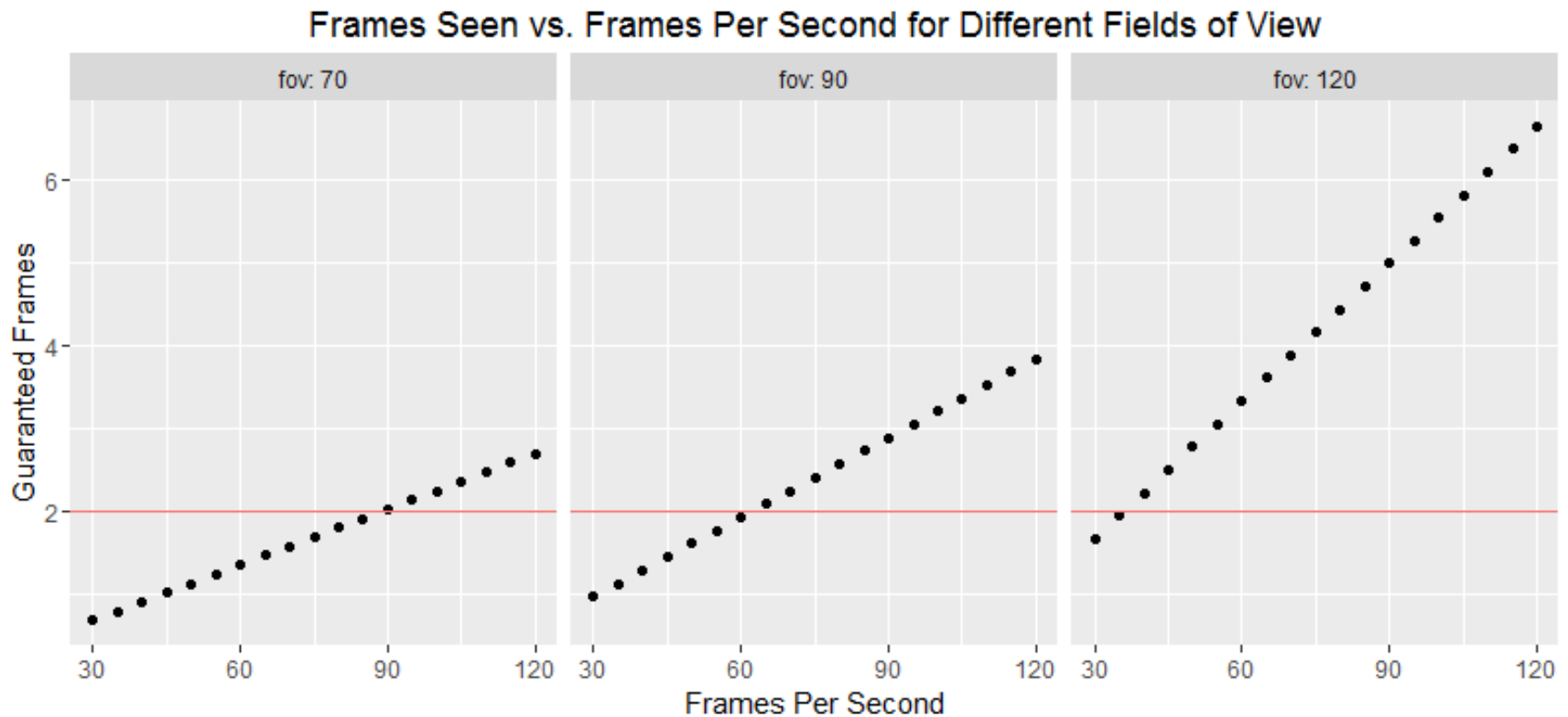
Design: Block Diagram (Logical)



Design: Hardware selection

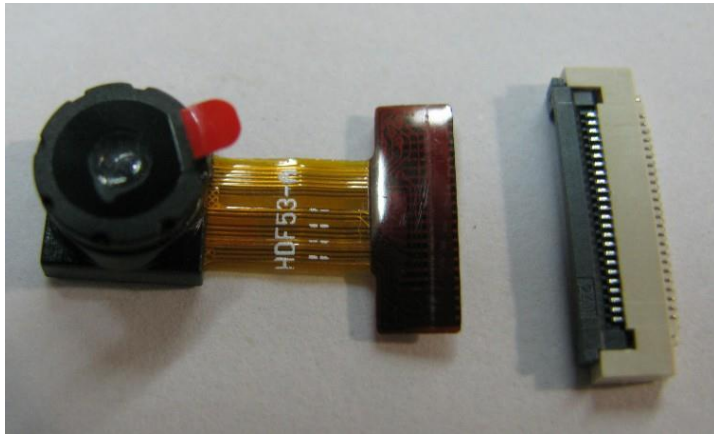
- Need cameras that can take pictures at 60fps @ ~480p
- Need a processor who can communicate with the cameras
 - ~2MB of external RAM will be required
 - Algorithms needs to take finish in (1 / fps) time
 - Ex. $1 / 60\text{fps} = 16.6\text{ms}$ before next frame.

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

Unit	Quantity	Unit Cost	Cost
FPGA	1	\$10	\$10
Cameras	2	\$30	\$60
Power Supply	1	\$10	\$10
Bluetooth	1	\$10	\$10
Total Cost			\$90

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