Slow Pitch Softball Detector

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What is Slow-Pitch Softball?

Team Based
Recreational Activity

General Rules >>>>>

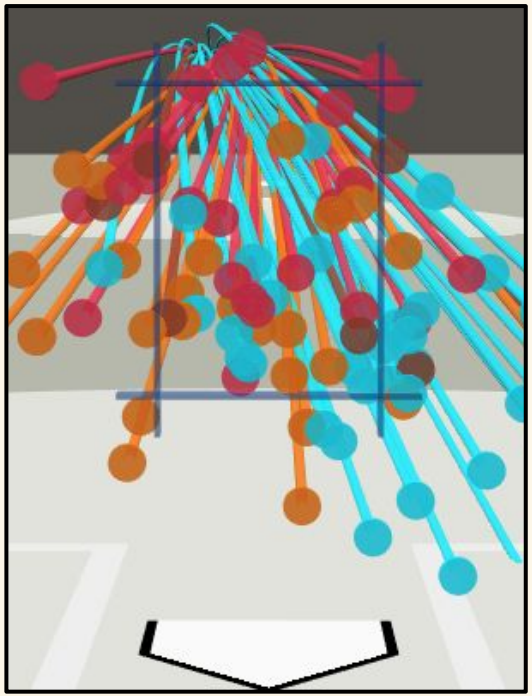
- Teams alternate between batting and fielding
- A pitcher will “slow-pitch” a ball to a batter
- When a batter hits the ball, he must make it around 4 bases to score a “run”
- The team with the most runs wins

Problem Statement

- Pitches need to have a height within 6ft-10ft to be legal
- Inaccurate illegal calls are a large factor in the outcome of the game
- Different umpires can call the same pitches differently
- Players and spectators get upset with calls
- Arguments arise between players and umpires

Illegal Pitch Clarification

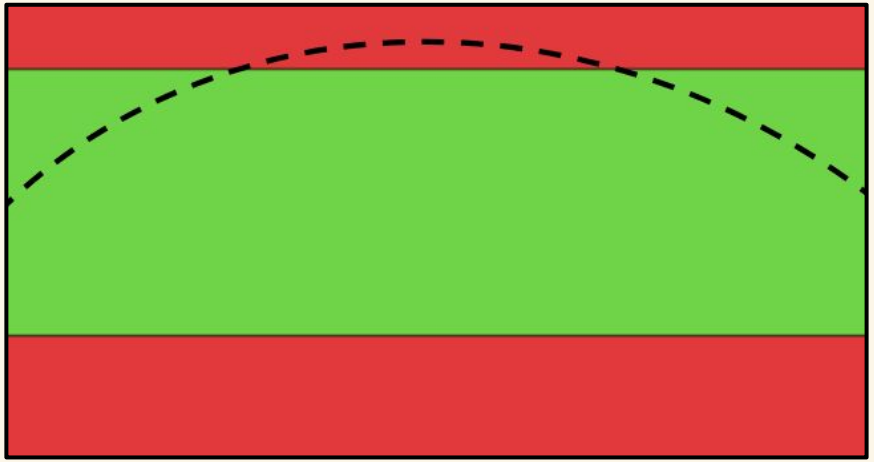
Balls and Strikes



V

S

Legal and Illegal



Project Requirements

Technical

- Track the softball to within 3.82” of accuracy (The diameter of the ball)
- Illegal pitch calls must be made as fast if not faster than an umpire. (As close to peak at possible)
- Must have a fast enough camera to process a pitch, at least 30fps
- The camera must have a resolution high enough to accurately process each frame, at least 1080p

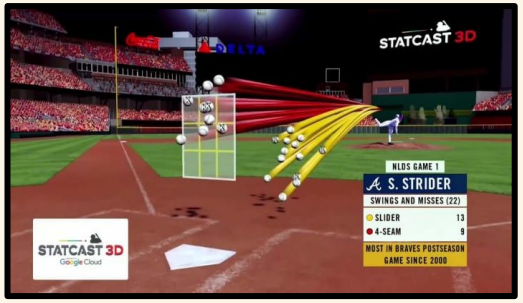
Non-Technical

- Detect an illegal pitch lower than six feet and higher than 10-12 feet
- An audible signal must be made loud enough for everyone to hear upon detection of an illegal pitch
- Be usable in a location where it is not in danger from the game or interfere with the game
- Our device must be portable

Product Research

Market Gap:

- Current solutions available for softball tracking cost thousands of dollars
- Very few products tailored specifically for slow-pitch softball
- No mobile apps currently exist that analyze illegal slow-pitch softball pitches



Users

Pitchers

Umpires

Batters

User: Umpires

Umpires

User wants:

- Fair, accurate, and consistent illegal pitch calls.
- Keep their job
- Have safe playing environment

User takeaways:

- A method for reviewing calls
- Less arguments with players
- Doesn’t affect job security
- More lenient on calls

User: Batters

Batters

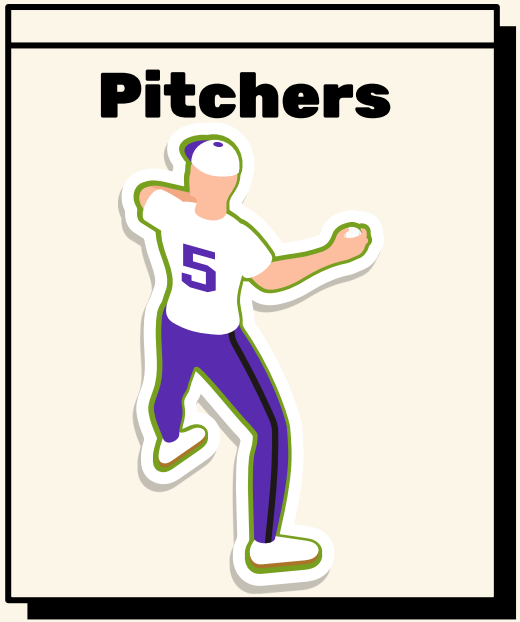
User wants:

- Timely, accurate, and consistent illegal pitch calls
- Hear illegal call indicator

User takeaways:

- Timing of illegal call has a big impact on decision to swing
- Accurate calls can change the outcome of the game

User: Pitchers



User wants:

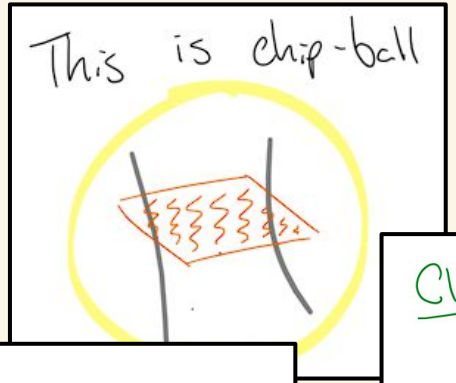
- Fair, accurate, and consistent illegal pitch calls.
- To avoid injuries
- Nothing to interfere with their pitches/game
- Hear illegal indicator

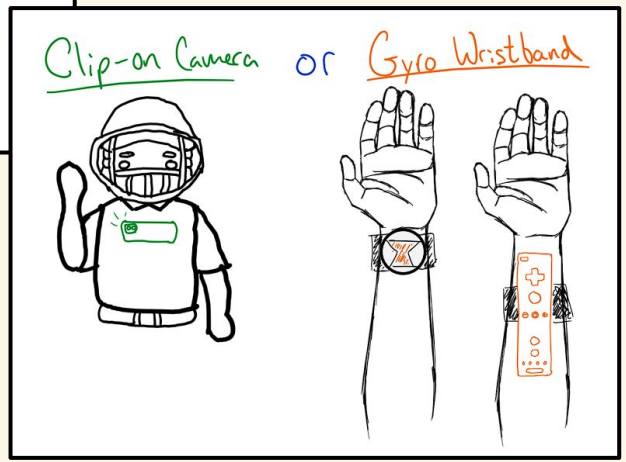
User takeaways:

- Fair, accurate, and consistent calls
- A practice tool for pitching
- Less arguments with an umpire
- Safety from low pitches

Initial Design Phase

- Player Focused
  - Clip-On Camera
  - Gyro Wristband
- Sensor Based
  - Ground Sensor
  - Chip in the Ball

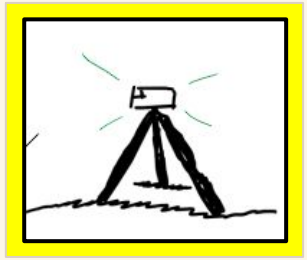


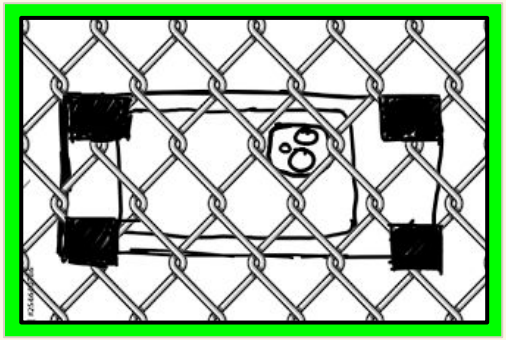


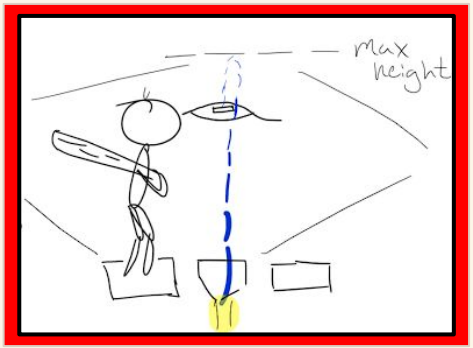
Chosen Design

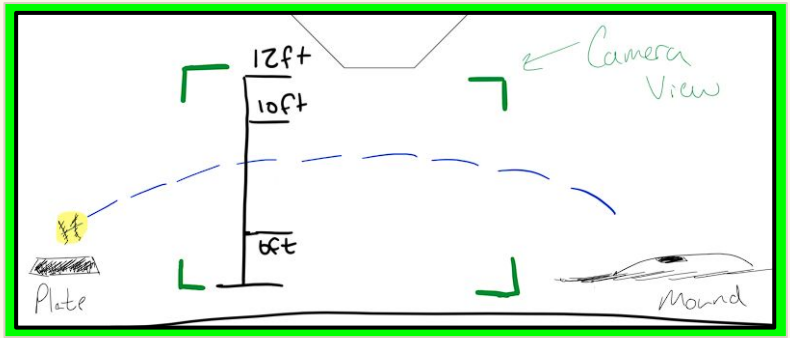
- Camera System
  - On fence or Tripod
  - Phone camera and application

  - **Side View**
  - Behind Plate View

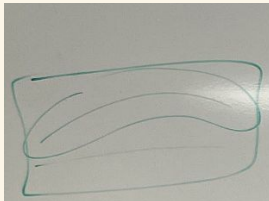








Method Validation



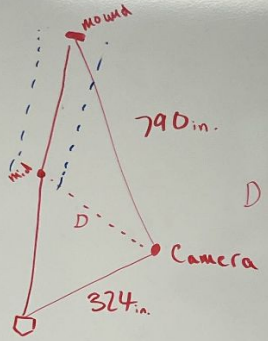
arc segments!!

Angular Size of ball = 2 arctan(Ball Diameter / 2 · distance)

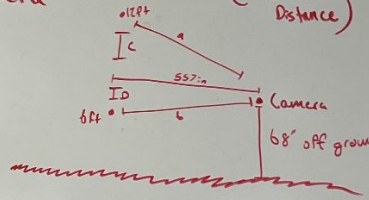
→ 2 · arctan(3.81 / 2 · 557)

Segment = ASOB / FOV

→ ASOB / 75° = .0052



$D = \frac{790 + 324}{2} = 557$ in.



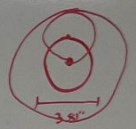
$a \text{ or } b = \sqrt{(557)^2 + (C \text{ or } D)^2}$

a ≈ 562 in

b ≈ 557.01

If tracking w/: 10 pixels

$\frac{10}{20.1} \quad \frac{x}{3.81} \approx 1.9'' \rightarrow 2''?$ ☺



Pixels Occupied by Ball = .0052 × 3840 = 20.1 (6ft pitch)

Measured Values

- Camera Position:
  - Camera Height off the ground: 68”
  - Horizontal distance from home plate: 27’ (324”)
  - Horizontal distance from the mound: 65’-10” (790”)
- Camera Specifications:
  - 4K resolution: 3840 x 2160 pixels.
  - Horizontal field of view (FoV): 75°.
- Pitch Information:
  - Home Plate to Mound: 48’-9” (585”)
  - Ball diameter: 3.82”
  - Horizontal distance to the midpoint of a pitch:
  - (324 + 790) / 2 = 557”
- Tracking Accuracy:
  - 10 pixels = .0195° angular error

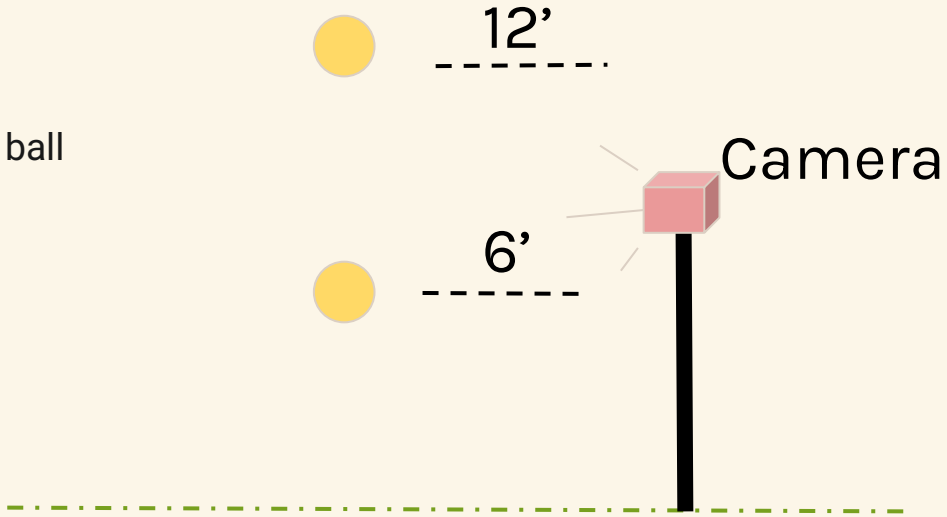
Angular Size of the Ball

Goal: Determine how many horizontal pixels the ball occupies in the image.

Angular Size = 2 x Arctan(Ball Diameter / (2(Straight-Line Distance))

- Ball diameter: 3.82 inches
  - Distance: Straight-line distance to the ball
    - 6 ft: 557.01”
    - 12 ft: 562.16”

- Angular Size Results:
  - At 6 feet: 0.39°
  - At 12 feet: 0.38°



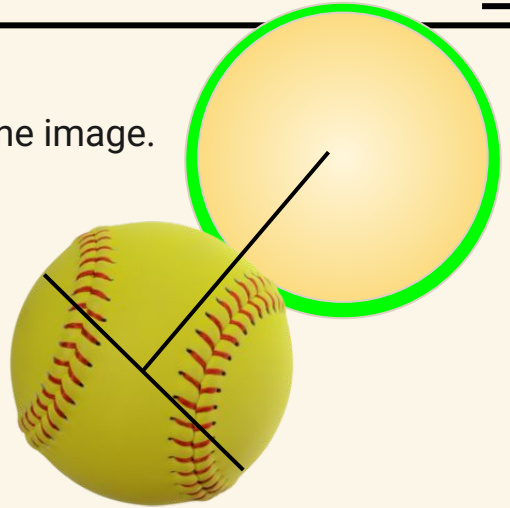
Angular Size → Pixels

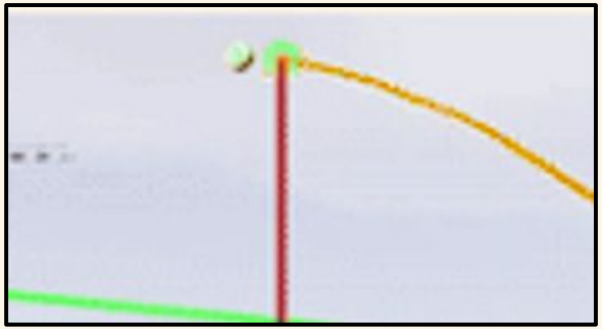
Goal: Determine how many horizontal pixels the ball occupies in the image.

Pixels = (Angular Size of Ball / FoV) x (# of Pixels)

- Camera Specs
  - **Field of View** (FoV) 75° (horizontally)
  - **# of Pixels** = 3840 pixels (horizontally)

- Pixels Occupied by the Ball
  - At 6 feet: (.39 / 75) x 3840 → **20.1 Pixels**
  - At 12 feet: (.38 / 75) x 3840 → **19.9 Pixels**





Softball Tracking - Approa

Methods for Softball Tracking (OpenCV):

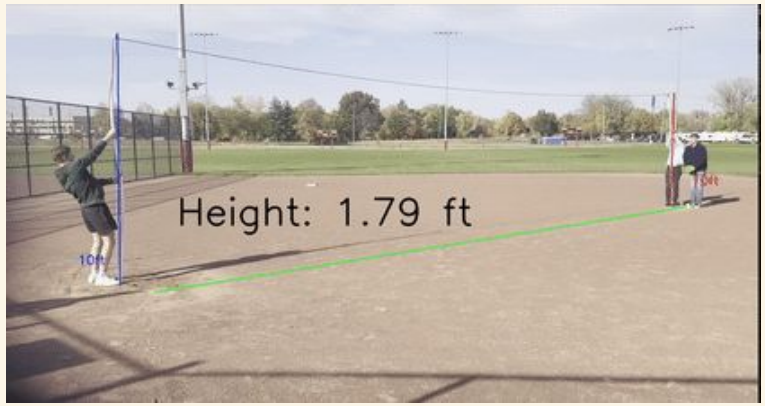
- Color mask ✅
- Dilation and smoothing of mask ✅
- Frame motion differential✅
- Pitch Identification ✅

Softball Tracking - Challenges

- Weather plays a big role in the color of the softball
- Have to consider other player's clothes and foreign objects in the background
- Bright lights can potentially "hide" the ball from the camera

Height Tracking

- Use a fixed height at home plate and the pitcher's mound for a baseline height
- Measure the ball position relative to the baseline heights



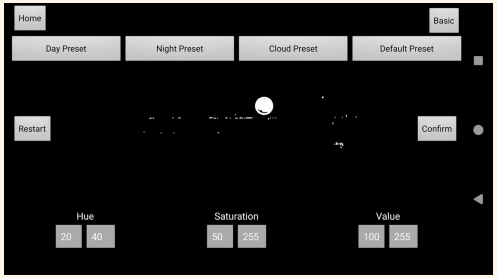
Python Prototype: Proof of

Color Calibration

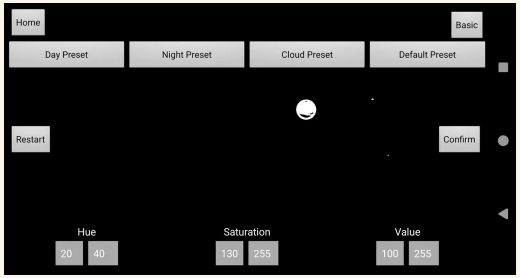
- Users will hold a softball in frame
- “Simple” calibration mode for quick user-friendly calibration
- We recommend our “Advanced” calibration
    - Manually input HSV values

Default Calibration

Advanced Calibration

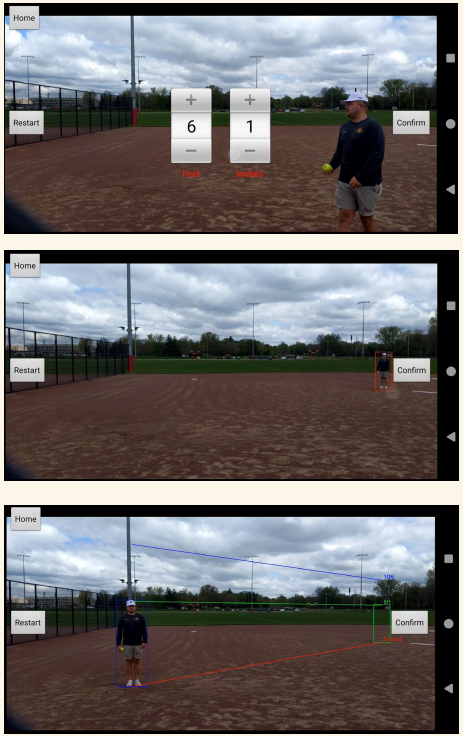


Finished Calibration



Height Calibration

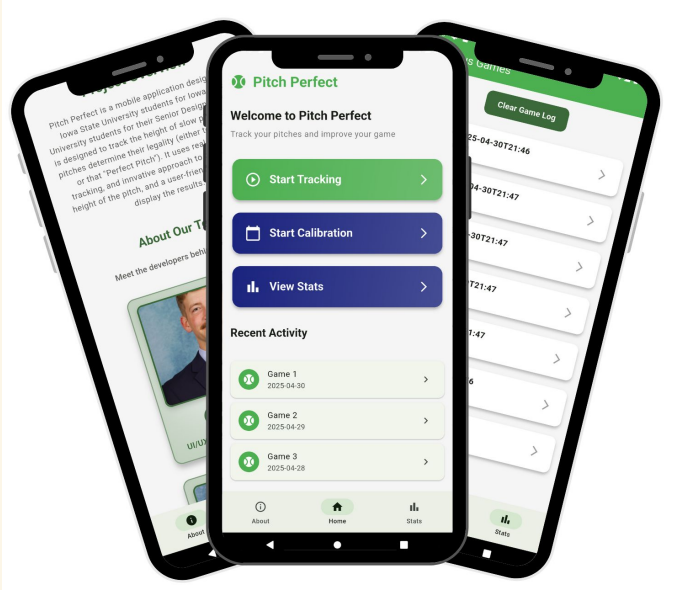
- Users will set up phone outside of field
- Users will determine home plate and pitcher's mound locations
- Two potential height calibration methods are available to a user
    - Two Person
        - Users draw boxes around a player standing at the mound then at home plate
        - The app takes a picture of the user at home plate and the mound, then they draw boxes on the picture



Mobile Application

Flutter framework- Dart

- Create one app to deploy to multiple platforms (Only on Android currently)
- One singular code base
- OpenCV not directly supported within Dart
- OpenCV ran within native Java in Android

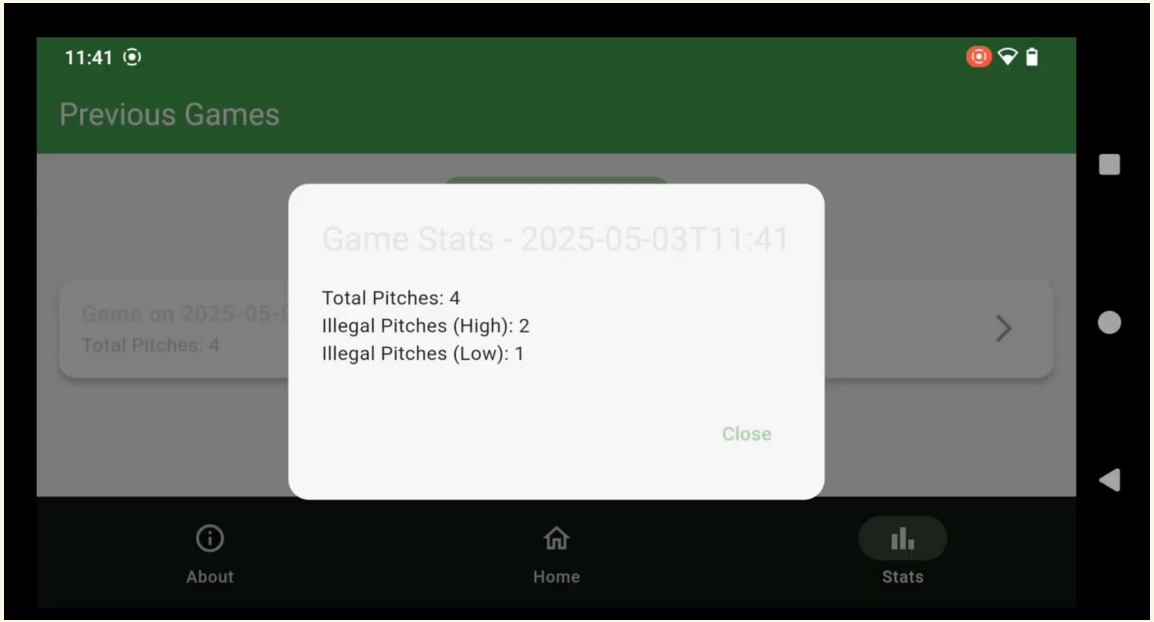


Low Pitch

High Pitch

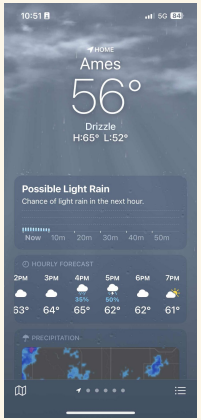
Legal Pitch

Statistics Page



Testing Plan

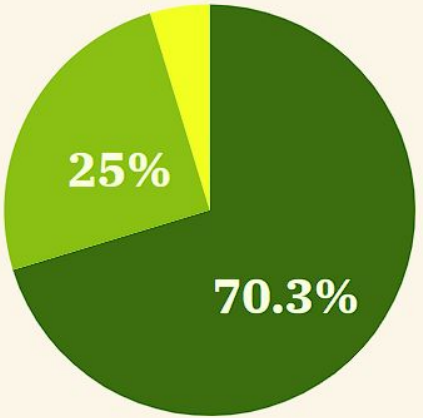
- Indoor Testing
  - Test each component in our rooms as we add them
  - Make sure our logic works in a very simple and controlled environment
- Field Testing
  - Take our application to a softball field
  - Throw pitches in a variety of lighting conditions
- Game Testing
  - Take our application to a real slow-pitch game
  - Compare our results to that of an umpire



Rain or Shine:
We Test!

Testing Results

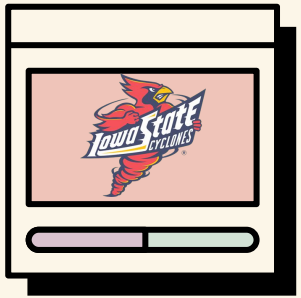
- **Environment**
  - Lighting
    - Ideal at night and consistent cloudy days
    - Struggles in changing conditions
  - Background
    - Softball Yellow is a typical color worn during games
    - Advanced Dandelion Locator (ADL)
    - Shifting background causes noise
- **User**
  - Despite the 6’-10’ft rule book → 8’-13’ft was the zone
  - Pitches in the 7-8ft range were incorrectly called illegal low
  - **Umpire leniency** vs **Computer Rigidity**
  - **Reality** vs **Perception**



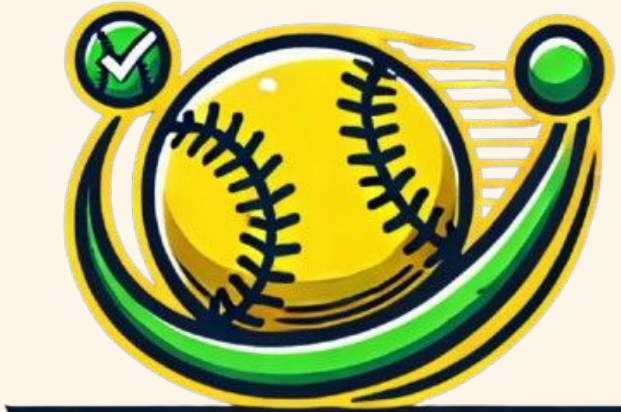
Called Low - Was Fair
Called Fair - Was High
Perfect Call

Future Plans

- Adjust ball tracking to be more object focused rather than color
  - Avoid potential distractions in frame
- Further develop pitch detection algorithm to better rule out noise
- Streamline calibration process
  - There are many steps involved in our setup
  - Advanced mode calibration is complex
- iPhone implementation



Thank You!



"It’s not singing, it’s softball"