4.2 Design Exploration

4.2.1 Design Decisions

For our project, we must design three essential components to have a successful product. These include an accurate system that can track the height of a softball, a quick processing time that allows for an audio output the second it realizes the pitch is too high, and an application that can be deployed from a phone that is seamless and easy for the user experience.

Accurate System - An accurate system is the most critical design decision we have to make in order to have success with our project. If the system is inaccurate, there will be no use for any of our users as the human eye would be better and more accurate. The entire purpose of our system is to track the height of a softball, so without focusing on this detail, our project would be nonfunctional.

Quick processing time - Quick processing time is another important aspect of our project. If the processing time is too slow, our project is also useless because as a user of our project, they need to be able to hear that the pitch is illegal the second it becomes illegal, or they will lack the need for the system.

Application for phone - An application is also an important aspect of our project to allow users to actually operate the system. The application will allow users for an easy setup to get the system up and running and allow for the other design aspects (Accurate System and Quick processing time) to work seamlessly together.

4.2.2 Ideation

We came up with an application after talking to users of our project. The application would make an easy and robust way for users to use our system and not require much time to set up at all. This would also make our pitch detection system available to anyone that wanted to try it out whenever and wherever they are located without having to go and buy special equipment.

A few of our other ideas included:

Multiple camera systems set up around the outside of the ballpark. This would allow for easier integration and maybe even more accurate to the exact millimeter of measurement.

A sensor in the ground that would alert the umpire that the pitch was illegal and allow for the umpire to be the one to call “Illegal”.

A player-focused detection where they had a clip on camera and a gyro wristband in order to track that the pitch was illegal and alert the users.

An in-play component where there was a chip inside of the ball that would alert the umpire the pitch was illegal.

One singular camera that would then alert the umpire that the pitch was illegal via vibration or light so he could make the illegal call.

4.2.3 Decision-Making and Trade-Off

We chose to do a round-table discussion which evaluated each proposed option for our pitch detection system. During this discussion, we identified the pros and cons of each idea, considering factors such as ease of user setup, cost, accuracy, durability, scalability, and overall feasibility. We also heavily favored our clients' wishes along with the initial interview we conducted with players.

While we considered using tools such as weighted decision matrices, we ultimately opted not to rely on formal tools. Instead, we continued our conversation and maintained an open dialogue until a clear direction emerged. This iterative discussion allowed for deeper consideration of practical trade-offs and ensured that all perspectives were heard, leading us to a well-rounded decision that best meets the needs of our intended users.

Moving forward towards the deployment of our application, we may choose to incorporate more structured tools, such as a weighted decision matrix, to help us further evaluate and weigh our options. This would provide a more systematic approach to refining our solution, ensuring that we continue to prioritize factors such as user needs, feasibility, cost, and scalability as we move from concept to implementation. By doing so, we can maintain alignment with our goals while making data-driven decisions that optimize the effectiveness and usability of our pitch detection system

Pros

Argument	Weight
Is precise to within one ball diameter	3
It is easy to set up hardware (hand the phone up)	4
Addresses the user needs by calling pitches relatively cl	3
Other solutions do not exist	3
More consistent than an umpire	3

Cons

Argument	Weight
Is not precise to < a ball diameter	1
Is not easy to calibrate	3
Could be affected by Sun	3
Could be too technically complex to process quickly	3
More expensive than an umpire	3

4.3 Proposed Design

4.3.1 Overview

Our design uses a camera to watch a slow-pitch softball pitch as it happens. As it records the pitch, it determines the height of the pitch, and determines if the max height of the pitch is legal (between 6-12 feet). If a pitch is determined to be “illegal” or outside of these bounds, it will play a sound to alert the users that an illegal pitch was thrown. This will then be repeated for the softball game.

Our first component is the camera system, which we intend to be from a phone setup along the fence of a softball diamond. The phone will be out of play, on the outside of the fence, but still able to record each pitch. A setup process of identifying home plate, the pitcher’s mound, and showing a softball to allow for accuracy in our device.

The next component is our internal processing. This is the bulk of our “code” in this project, that determines the location, height, and legality of a pitch. We use libraries like “OpenCV” to help with this process, and then send our decision to our output.

Our final component is our output device. This is could either be on our phone or an external BlueTooth speaker. This simply takes our processing decision and either plays or doesn’t play a sound. The full design is outlined in Figure 4.3.1 below.

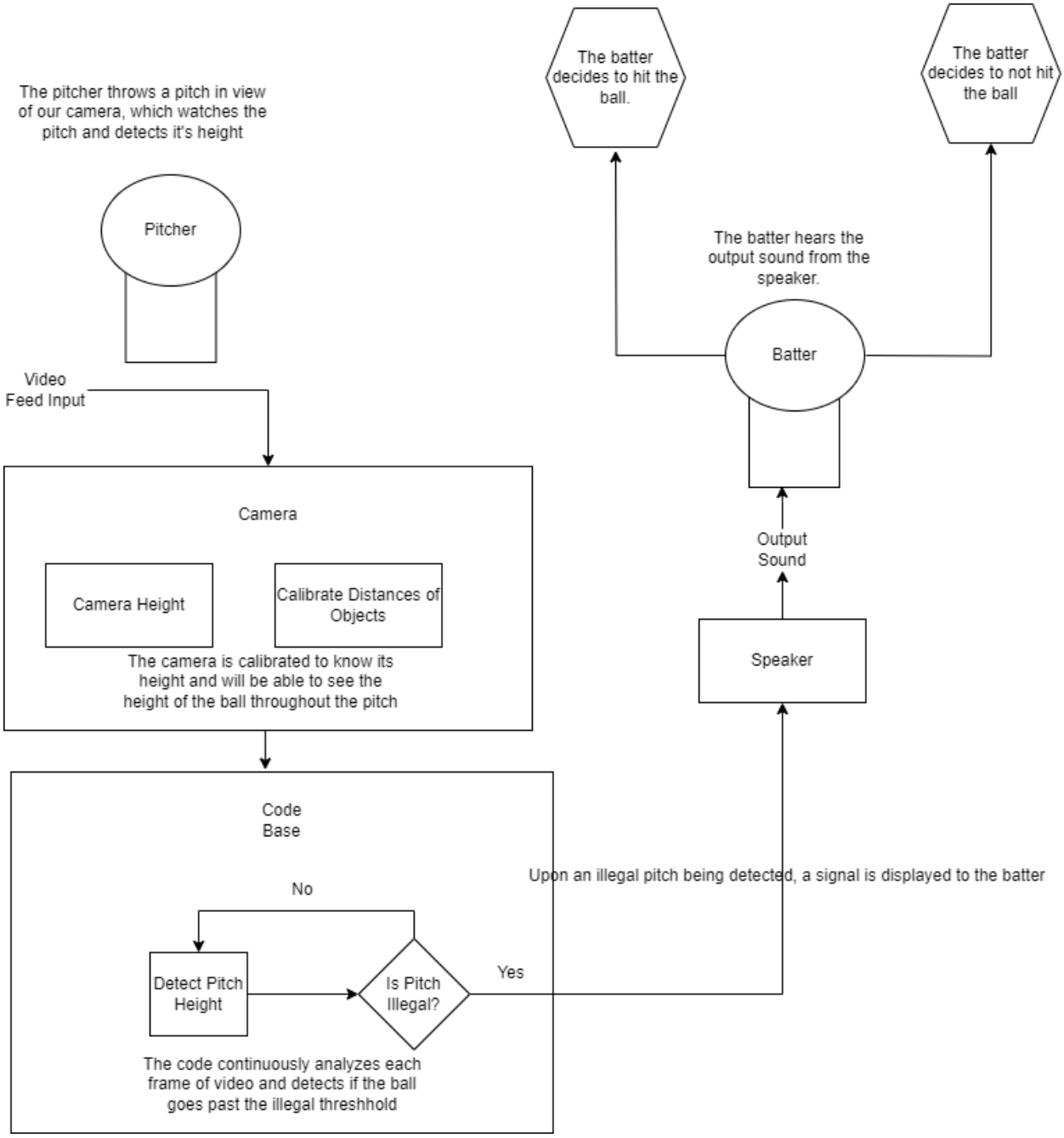

Figure 4.3.1

4.3.2 Detailed Design and Visual(s)

Our design includes a phone mounted to the outer fence of a softball field. The phone will have our Perfect Pitch app installed on it. Our app is made with the QT framework integrating OpenCV to perform real-time image processing for height determination basic design pictured in figure 4.3.2.2. The camera must then be calibrated by camera height, distance from camera to plate, and mount to ensure precise measurements and connected to a wireless speaker wire. With the phone set up, the application will run a script that plays

audio when the ball goes over or under a specified height range. The phone will be set up in one of the green boxes in Figure 4.3.2.1.

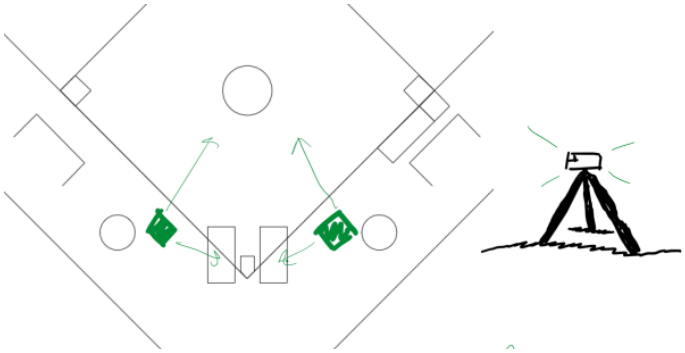

Figure 4.3.2.1

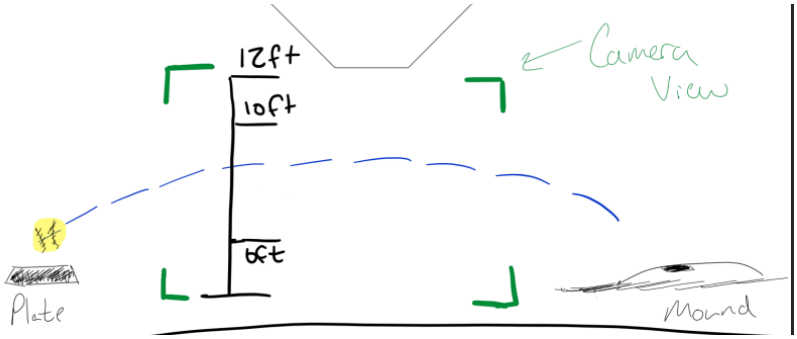

Figure 4.3.2.2

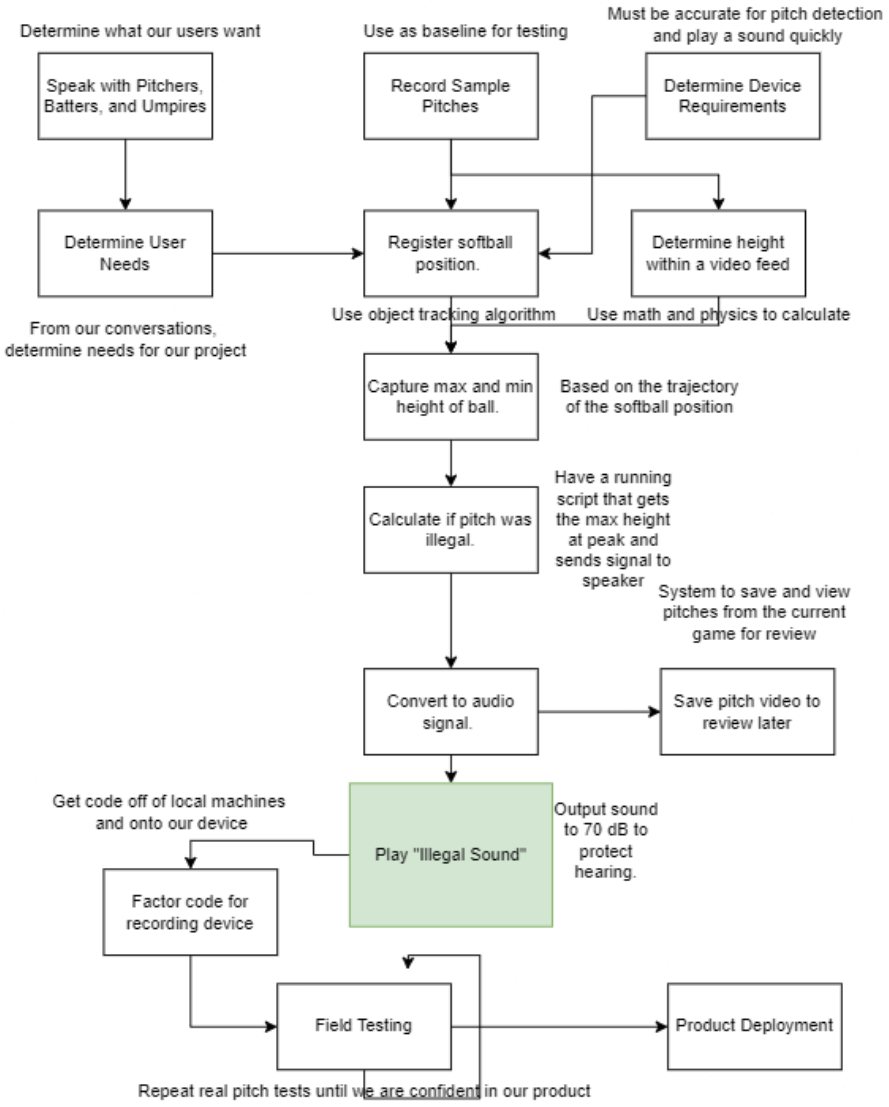

Figure 4.3.2.3

4.3.3 Functionality

The users of the game should be hands-off with the device after set-up. Pitchers will throw the ball and given their pitches' performance, an audible sound will be played so the batter can react to an illegal pitch. The umpire is also responsible for recalibrating the ball's color after every inning to ensure correct readings.

4.3.4 Areas of Concern and Development

Currently, our design is on track to meet our user needs. It is at the point where it can accomplish all of our tasks to varying degrees of success, but we are able to see where we need to go moving forward. The largest areas of concern we have moving forward are:

1. Device performance
    a. How well will our code perform on various phones when running our application? Our code runs fantastically in a development environment on our computers, but

we are a little concerned for how universally the performance will scale between devices.

2. Device Accuracy
    a. Our code is able to track a softball position and height to decent success, but not to the accuracy of 4 inches that we are shooting for. This is another area of concern for us moving forward.
3. Device Simplicity
    a. We want our device to be usable with one camera and have a minimal setup and calibration process. We are slightly concerned on how possible this will be to achieve our desired accuracy.

To solve these problems and concerns, we are currently focusing a lot of our efforts on research and development. We are seeing what libraries are out there that solve these problems, and implementing test versions to see how we can solve one problem at a time. We also bring these up to our advisors each week to see what problems we can solve, and what concerns are irrelevant.

4.4 Technology Considerations

We are currently planning on using phones for our camera and application. There are multiple strengths and weaknesses that come along with using a phone for object detection and tracking.

Strengths:

1. Allows users of all kinds the ability to use our product as there is no needed extra hardware
2. Users won't have to worry about purchasing anything for the system to run as expected
3. Seamless set up for the user

Weaknesses:

1. Quality of the video may not be as good as a high quality camera
2. Could be a little slower processing time than it would be if we had something like a raspberry pi
3. Each phone is different so we need to be extra careful with how our tracking is done

4.5 Design Analysis

So far our design is able to track a softball throughout the motion of a pitch and give a height estimate within about 1-2 feet of accuracy. We have also developed app prototypes on an iPhone using the framework QT and will begin to migrate our code over there shortly. Our proposed design has been working so far, but it will require fine-tuning (specifically in the height tracking and softball calibration).

For our future planes, we are continuing to hone our accuracy for detection and height and will continue to test our code on various phone devices. We feel that our current design will allow us to reach our goals, we just need to spend more time improving our components. The OpenCV library is working as expected for our object tracking needs, and we do not feel the need to change our usage right now.