Fotoball

CSC509: Project Document

April 23, 2015

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Rev 1.0

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Contents

Chapter 1: REQUIREMENTS

1.1 Introduction

The purpose of this document is to specify the hardware and software requirements of the Fotoball project. The project was derived with the idea that camera technology could be much further woven into the fabric of sports, specifically football, than it currently is.

The most recent camera upgrades to the way games are broadcast involve “skycams” where a camera is suspended by a series of cables above the field and remotely controlled to provide a bird’s eye view of the action. There have also been brief experiments involving “helmet cams” where a small camera is mounted to a player’s helmet to provide first-hand game action. After some research, it was realized that very little has been done involving attaching cameras directly to the football. The only previous attempt of note was a side-mounted camera that takes a still image after each rotation and ultimately pieces together a choppy video that is oriented in the wrong direction.

Our project will involve mounting two cameras to each end of the football to be able to capture a front and rear view of where the football is heading and where it came from. The data captured by each camera will then be wirelessly streamed to a user’s mobile device, most likely a smart phone. From there the video can be saved, edited, and shared however the user chooses.

There are two potential markets of interest for the product. The first is as a recreational device for kids and young adults to be able to film fun videos and share with their friends. Much like the GoPro has revolutionized extreme sports like skiing, surfing, and rock climbing, we feel this product could do the same for football. The second market of interest is in high-level televised NFL and college games. This is more of a challenge since the ball would have to adhere to extremely specific guidelines, but the benefits the fan watching on television could be huge.

1.2 Glossary

Alpha testing - a simulated or actual operational testing by potential users/customers or an independent test team at the developers' site.

Android - a mobile operating system developed by Google and run on many different devices

C++ - a general-purpose programming language.

GoPro - a compact, often wearable, camera that is popular in the use of filming in extreme situations that would render a traditional camera unfit

iOS - Apple’s mobile operating system run on all Apple mobile devices

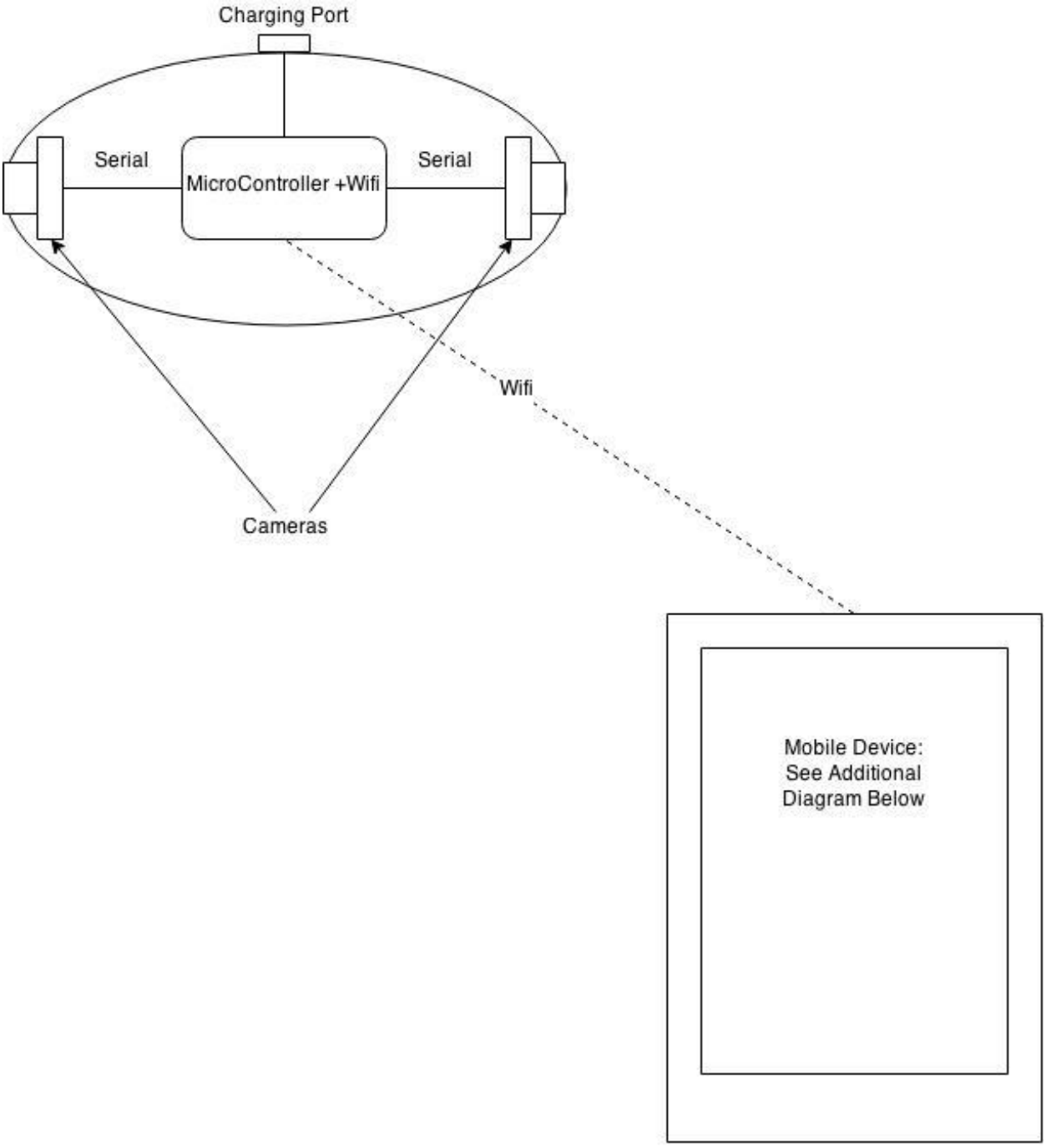
Java - an object-oriented programming language that is maintained by Oracle Corporation

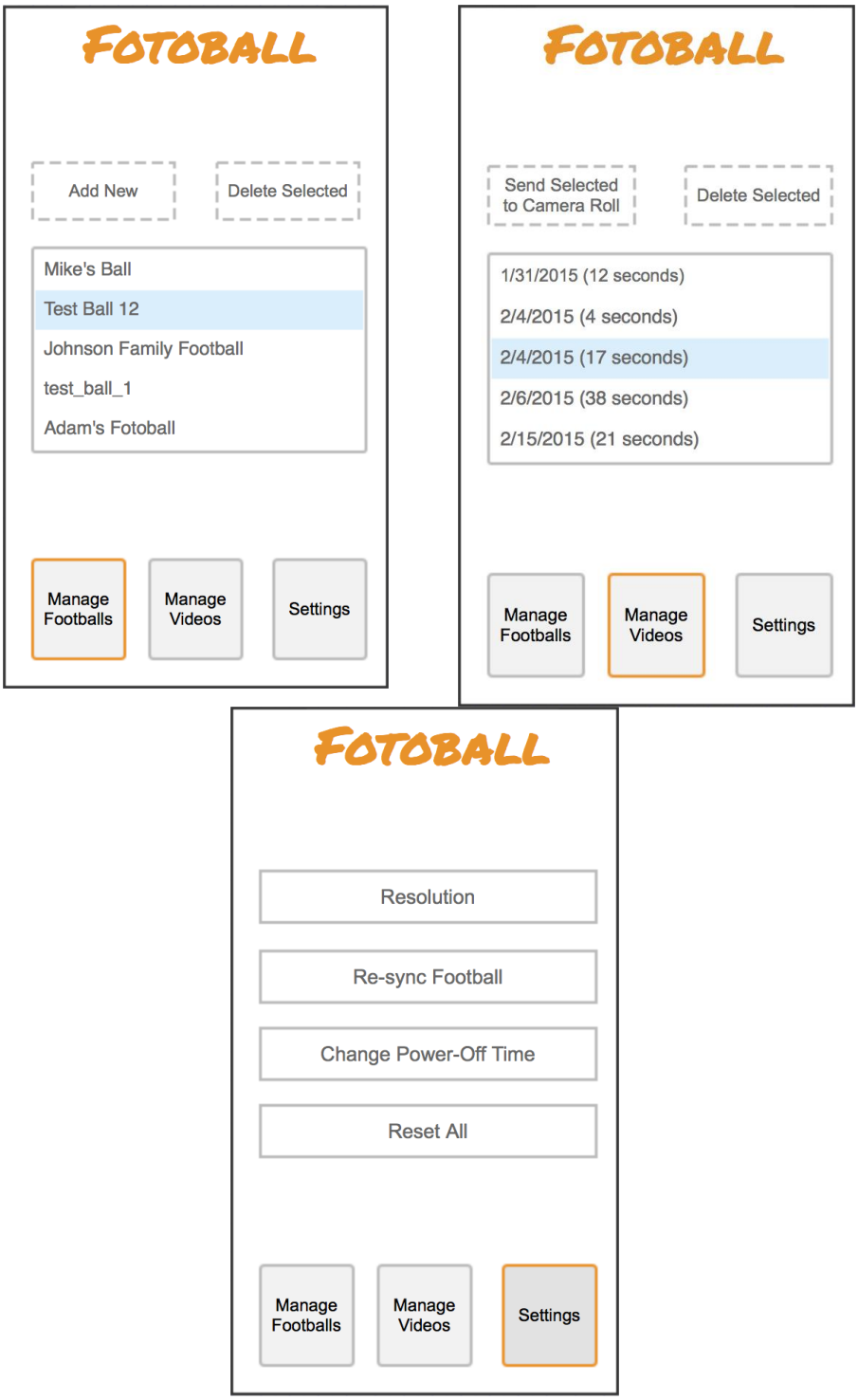
Microcontroller - a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

Resolution - the degree of sharpness of a computer-generated image as measured by the number of dots per linear inch in a hard-copy printout or the number of pixels across and down on a display screen.

Serial - the process of sending data one bit at a time, sequentially, over a communication channel or computer bus.

1.3 System Models




FOTOBALL
Add New
Delete Selected
Mike's Ball
Test Ball 12
Johnson Family Football
test_ball_1
Adam's Fotoball
Manage Footballs
Manage Videos
Settings
FOTOBALL
Send Selected to Camera Roll
Delete Selected
1/31/2015 (12 seconds)
2/4/2015 (4 seconds)
2/4/2015 (17 seconds)
2/6/2015 (38 seconds)
2/15/2015 (21 seconds)
Manage Footballs
Manage Videos
Settings
FOTOBALL
Resolution
Re-sync Football
Change Power-Off Time
Reset All
Manage Footballs
Manage Videos
Settings

1.4 Constraints

Time:

Product and code design will be completed by 02/19/2015

Prototype completion will be completed by 03/13/2015

Alpha testing will be completed by 03/26/2015

Testing model will be completed by 04/09/2015

Final test will be completed by 04/16/2015

Final presentation will be completed by 04/23/2015

Hardware:

The microcontroller needs to weigh under 25g.

The microcontroller needs to communicate via Wi-Fi.

The microcontroller needs to store video locally.

The camera needs to weigh under 20g.

The electronics need to be powered for at least 4 hours.

Software:

The mobile application will be programmed in Java.

The firmware will be programmed in C/C++.

1.5 System Evolution

There are several critical functions that the first iteration of our system must have.

1. The hardware must be attached to the ball in a way that keeps the ball as close to its originally properties as possible. Weight needs to be consistent, the overall shape needs to remain the same, and the ball must remain balanced. There is a certain amount of leeway with which to work, but not a lot. If the ball does not behave and act like a regular football, the rest will be meaningless.

2. The video data must reliably transmit to the user's mobile device. If a throw is not recorded and becomes "lost" the user will get frustrated and likely stray away from the product. Internal storage is an option currently being considered as an attempt to act as a backup should this happen. Internal storage will also be an option to act as a backup should this happen.

3. The image must be stabilized enough to make the video an acceptable quality. This is perhaps our biggest challenge, and likely why this product does not currently exist. Our system needs to compensate for every movement of the football as it rotates and wobbles, and ultimately return a smooth video.

4. The software will have to be compatible with both Apple and Android devices. To not support one of these platforms would be ignoring too big of a market segment for the endeavor to be worthwhile.

As the system evolves, there are additional features that would fit in nicely. One idea is to add additional sensors capable of measuring the speed, location, rotation, and orientation of the ball. This data could then be extrapolated and used to provide "throw quality" feedback that will tell user how far the ball went, the ball's velocity, and how tight of a spiral it was.

Another goal is to gradually improve the quality of components to provide higher resolution video and even audio.

1.6 Requirements Specification

Hardware:

The electronics shall be lightweight.

The electronics shall not affect footballs throw.

The electronics shall be able to transmit data wirelessly.

Security and Safety Requirements

The electronics shall not be accessible by any unauthorized devices.

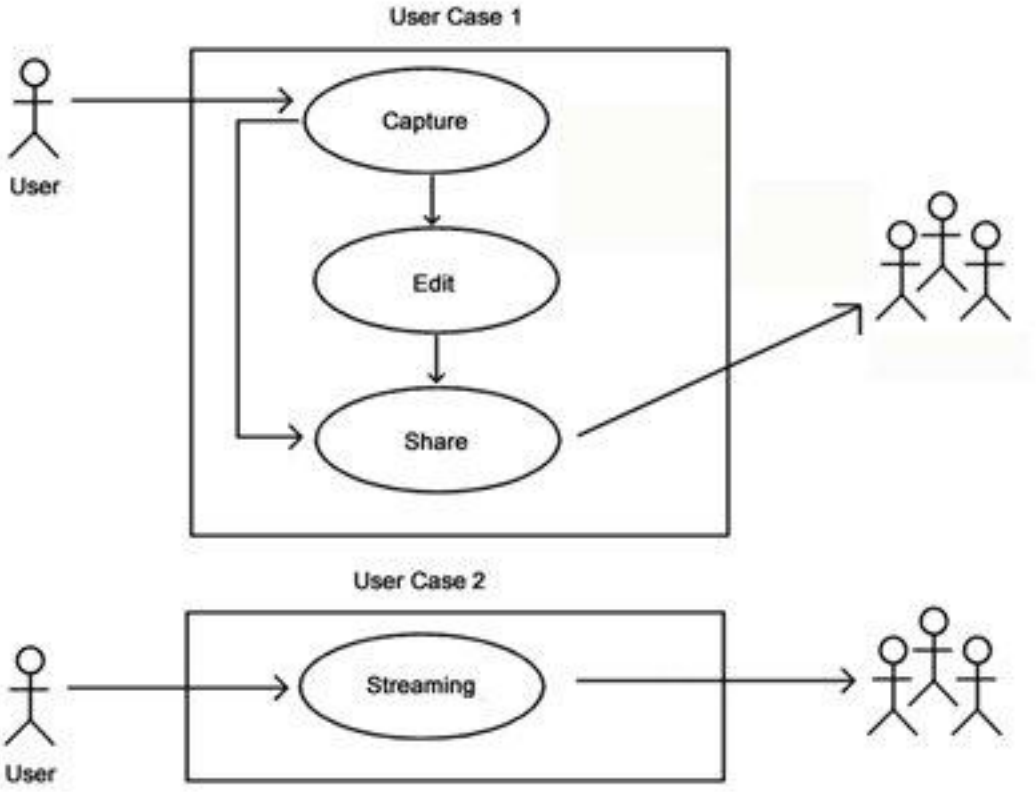
Database Requirements

The software shall be able to save video locally.

1.7 Functional Requirements Definition

The Fotoball device will be used mainly with these two objectives in mind:

- Recreational purposes. - User will be able to capture, edit, and share still images or videos from their mobile devices.
- Live streaming. - The two cameras attached to the Fotoball device will make the user feel like he/she is part of the action.



Additional features could be added for training drills purposes, such as gathering information (throwing and rotational speed, tossed angle, etc.), which will help the user to improve his/her "throw quality."

1.8 Management Issues

Schedule

Date	Process
February 19	Product + Coding Design
March 13	Prototype Completion
March 26	Alpha Testing
April 09	***Testing Model (in class)***
April 16	Final Test
April 23	***Presentation of Final Project***

Technical Skills

- Hardware expertise
- Coding skills
- App development

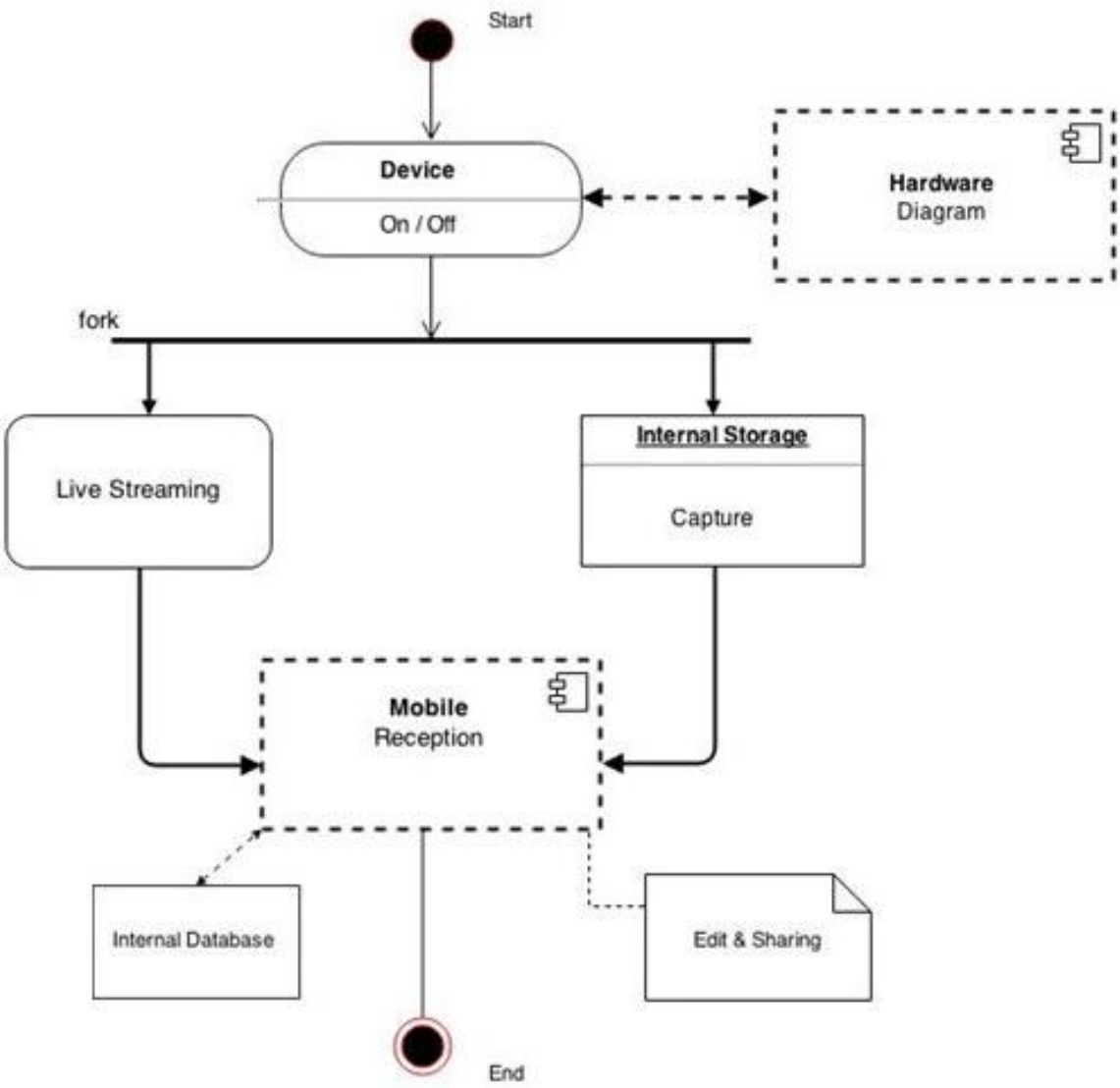
1.9 Disasters

- If we must face any of those circumstances, a backup plan has been elaborated to overcome these issues. We are considering the following scenarios and how we plan to deal with them:
  - Not getting all the required hardware on time to construct a high quality product: we have proposed a schedule which will allow us enough time to work around any issue.
  - The image/video streaming to the user's mobile device gets lost or interrupted: an internal storage option will be added as a backup solution.
  - The image/video streaming gets too blurred during the action: a real-time digital image stabilization technique will be used to counteract the motion.

Chapter 2: CONCEPTUAL MODELS

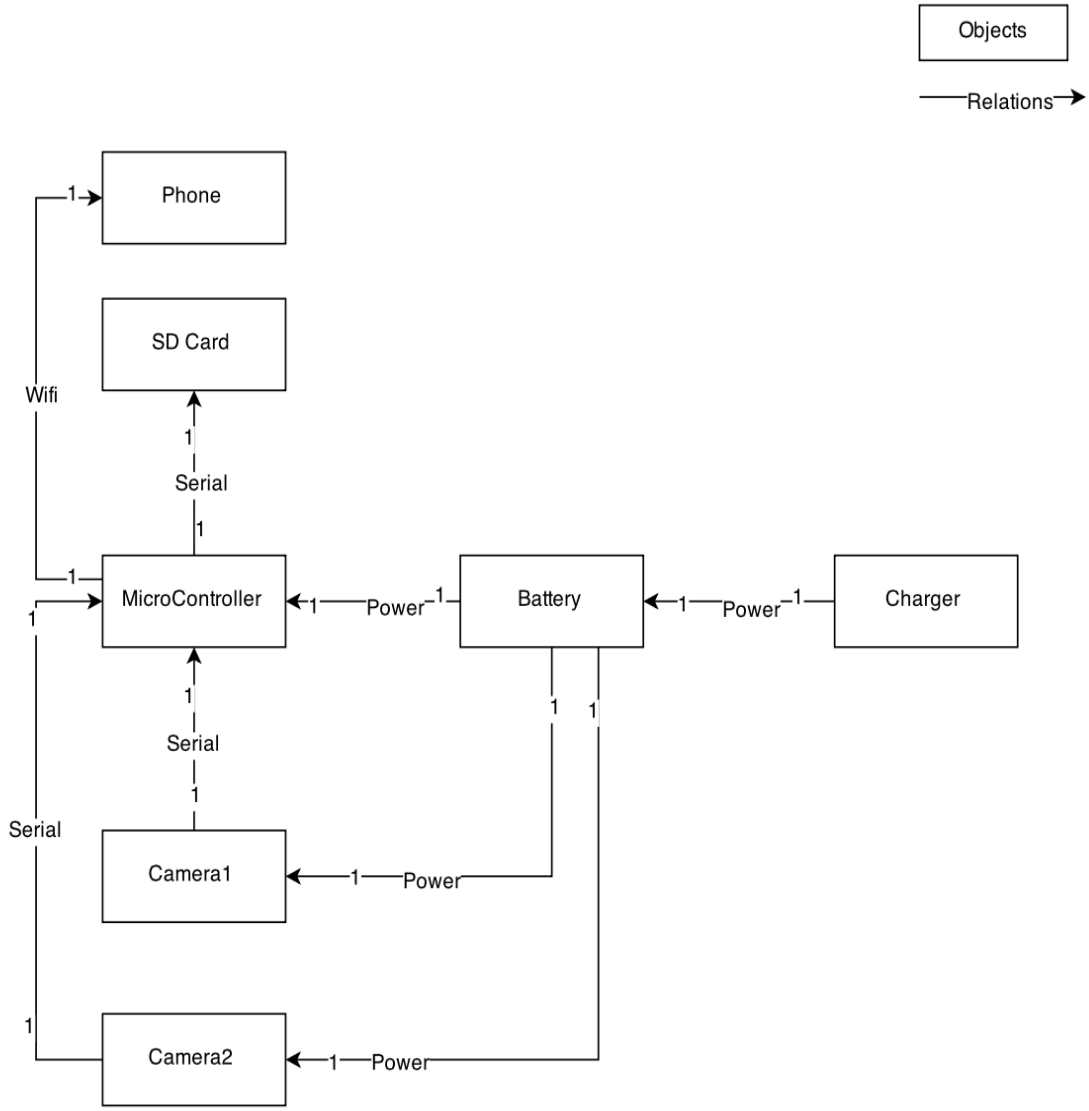
2.1 Overview Model

The following represents the overall flow of the system. From the Fotoball hardware, to the users mobile device, to the internal database.



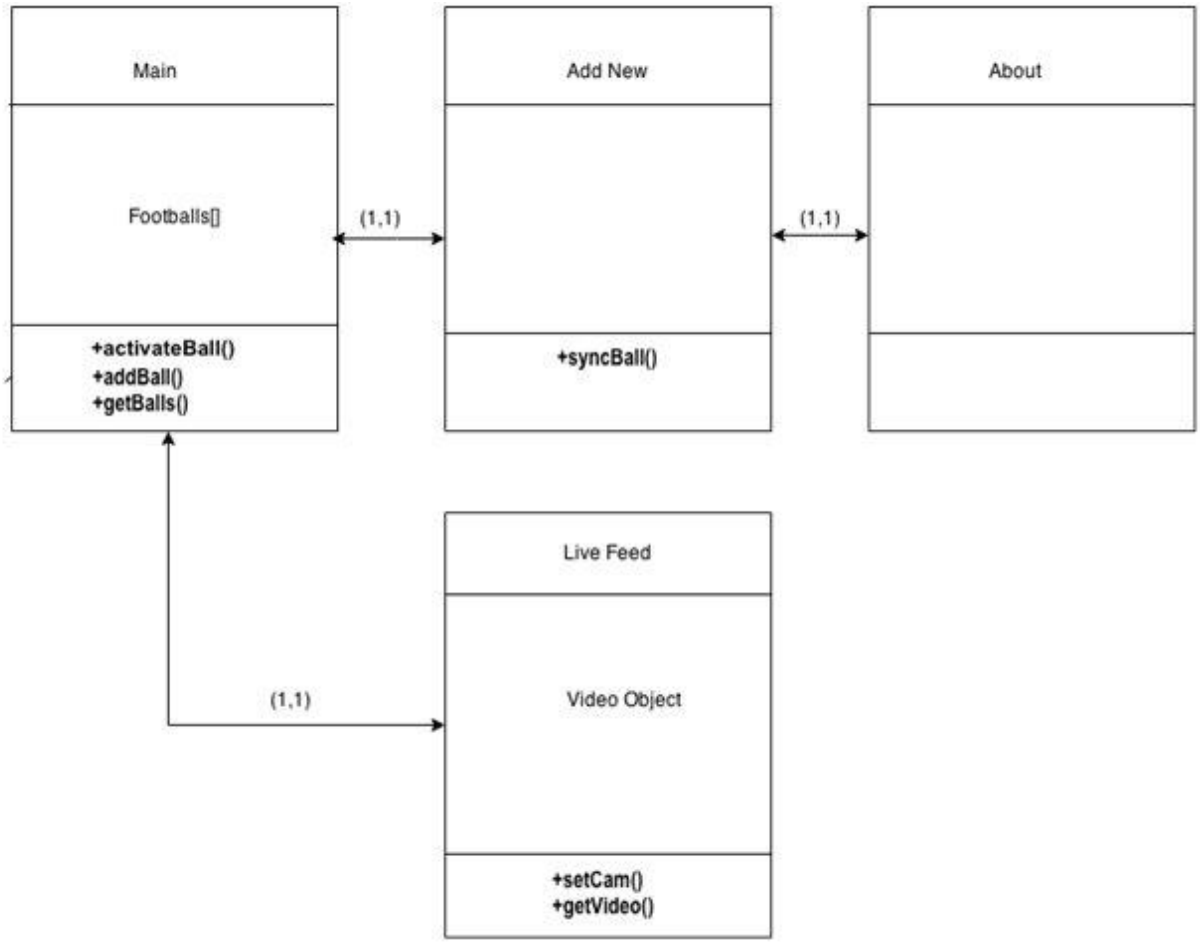
2.2 Hardware Conceptual Model

Basic flow of the hardware system showing which components will connect to which other components.

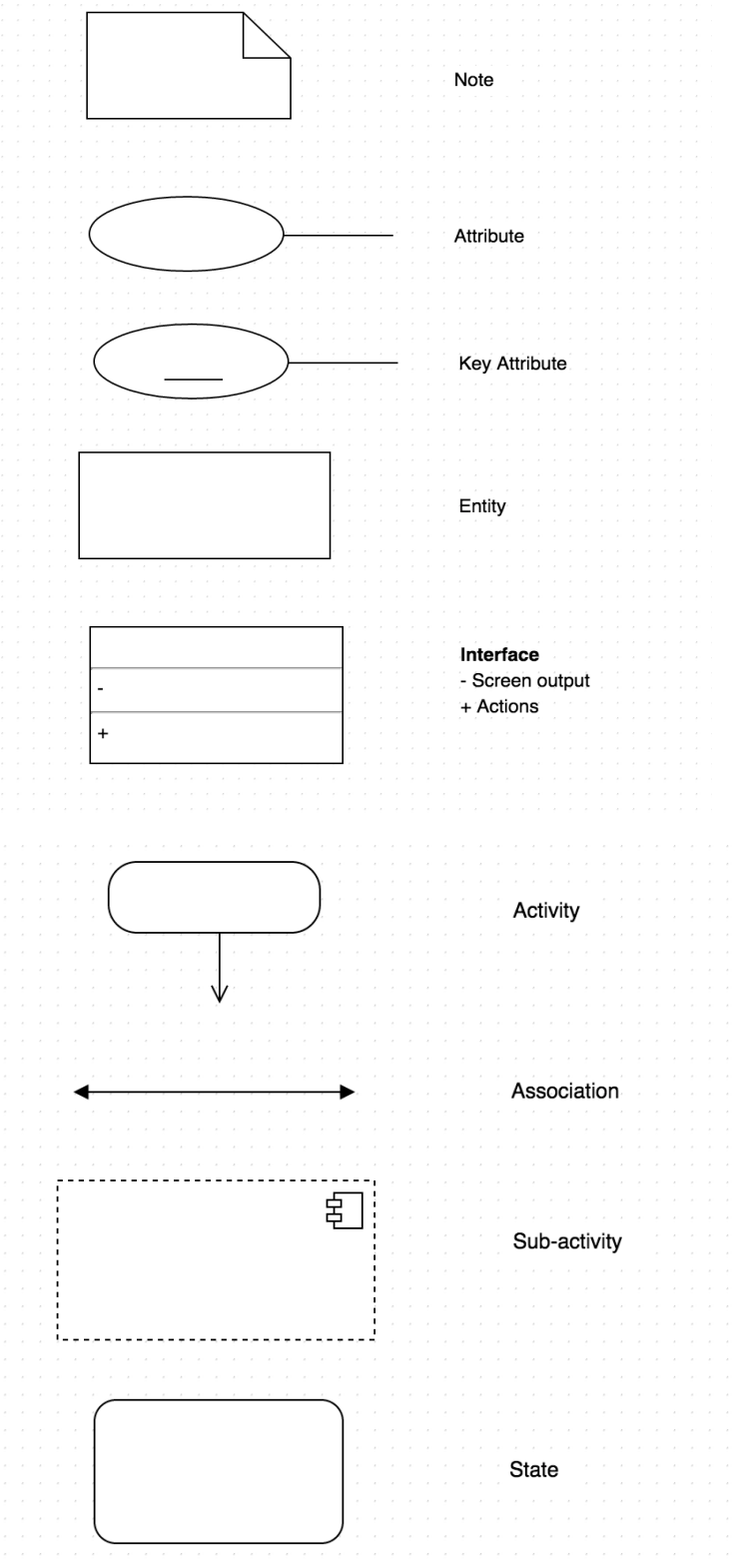


2.3 Software Conceptual Model

The main classes and views that make up the application are shown here, with each class's objects represented in the middle and each class's major methods represented in the bottom.



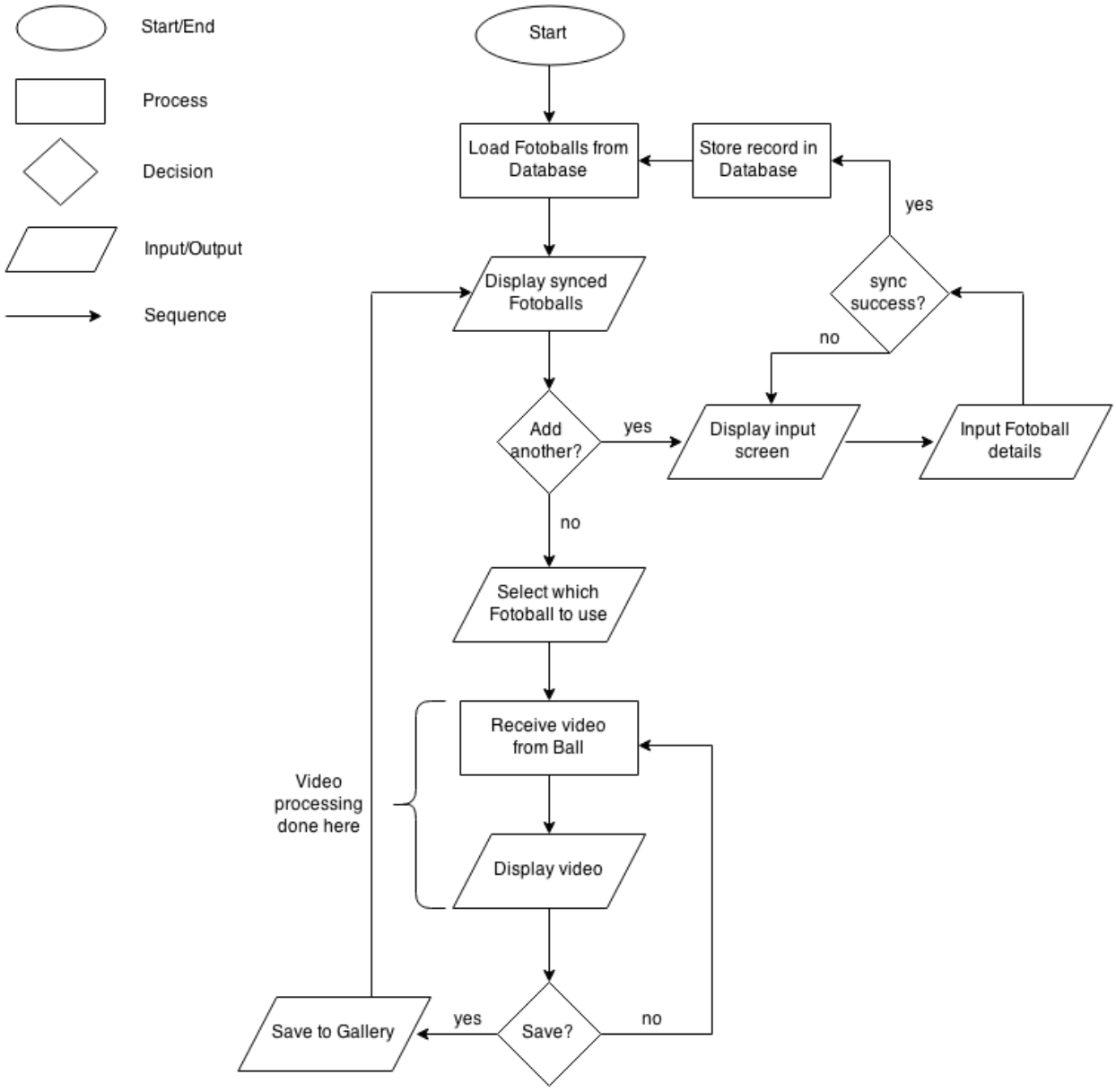
2.4 Legend


Note
Attribute
Key Attribute
Entity
Interface
- Screen output
+ Actions
Activity
Association
Sub-activity
State

Chapter 3: SEQUENCE DIAGRAM

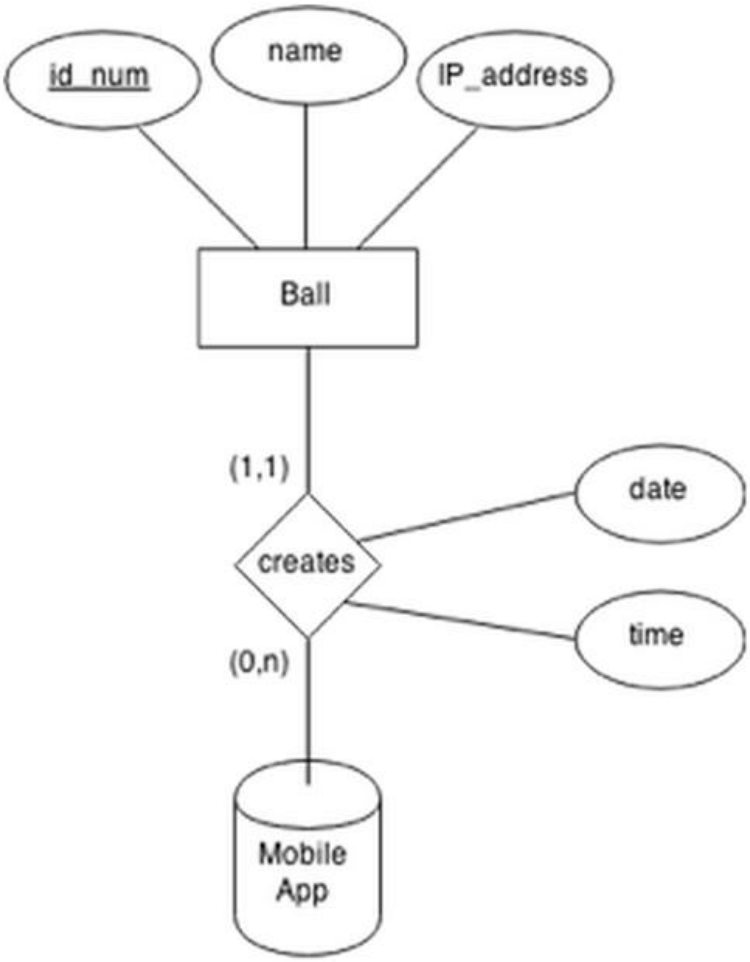
3.1 Sequence Flow Diagram

The following chart represents the flow of control through the software system. All videos will be saved to the internal media gallery of the parent device.



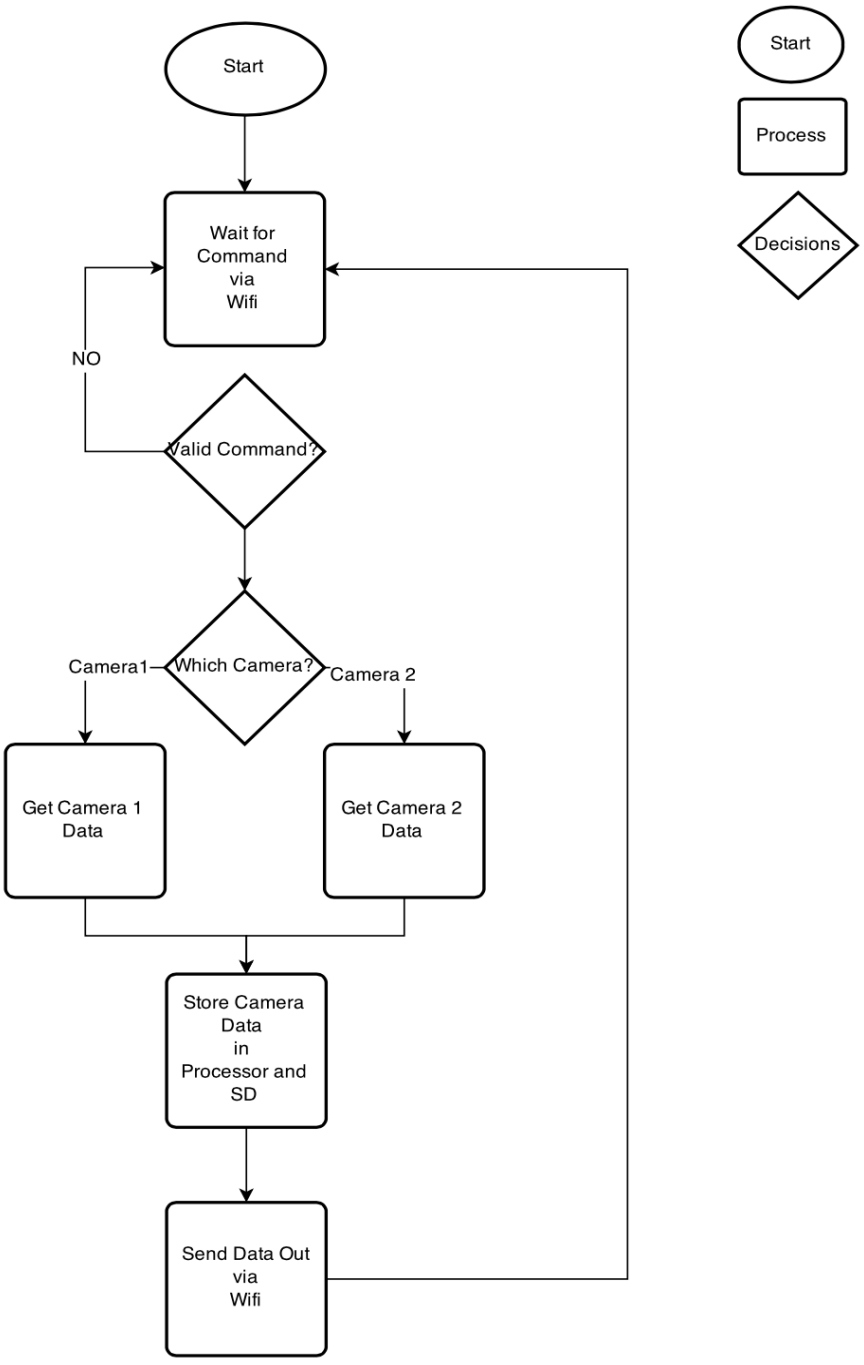
3.2 Database Diagram

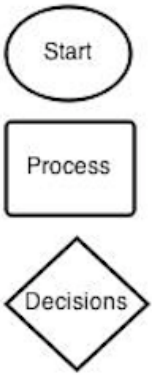
The database will connect the ball information with the mobile application. Anywhere from zero to n balls will be allowed to be created and the time and date of each creation will stored, as well as the relevant ball information.

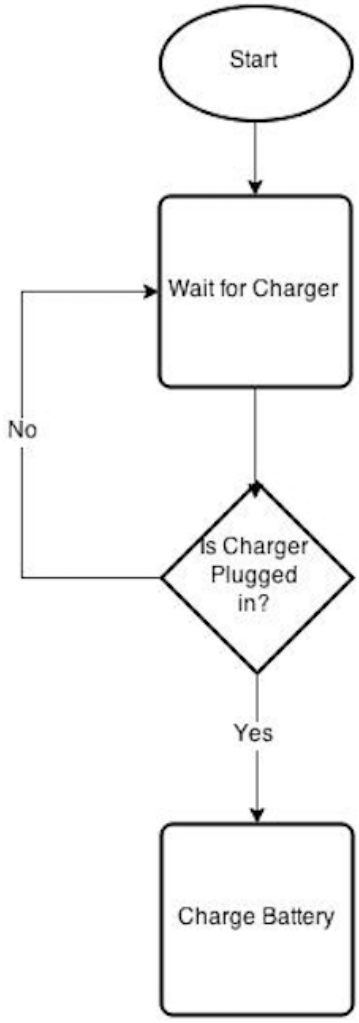


3.3 Hardware Sequence

This represents the sequence of flow from the hardware system's perspective. Cameras will be switched manually via hardware.



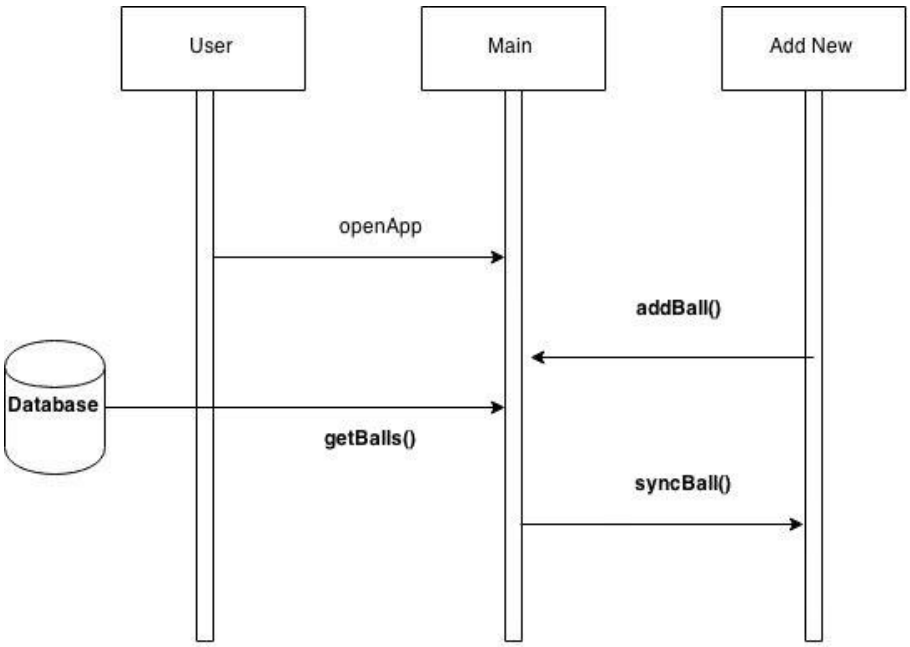

Start
Process
Decisions


Start
Wait for Charger
No
Is Charger Plugged in?
Yes
Charge Battery

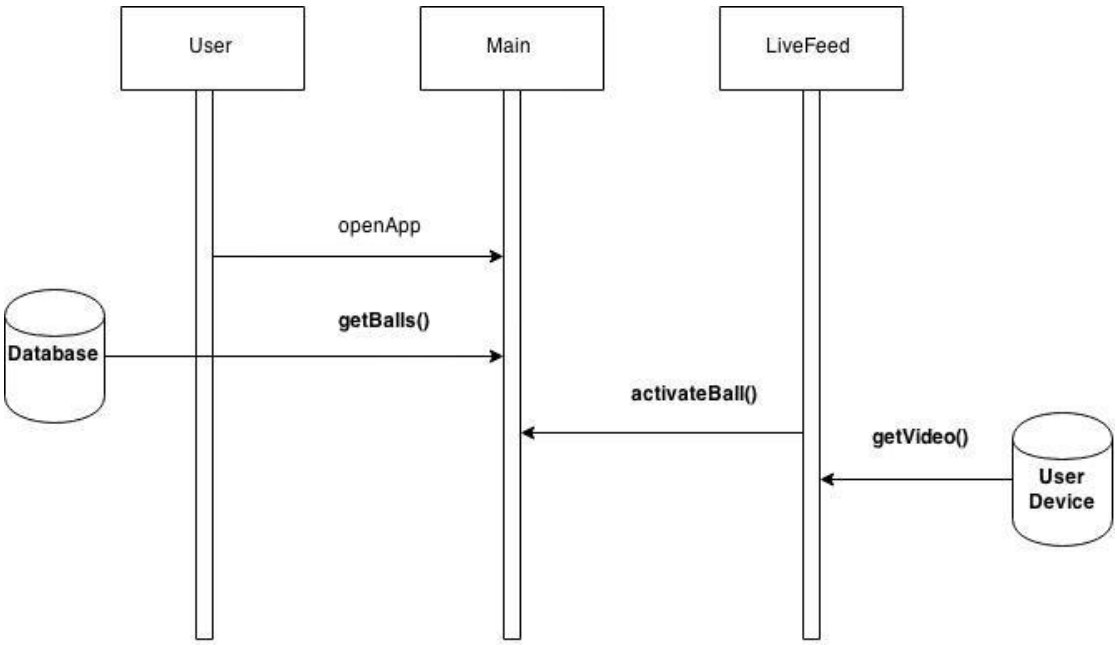
3.4 Use Case

This App shows the user interaction with the user and the football

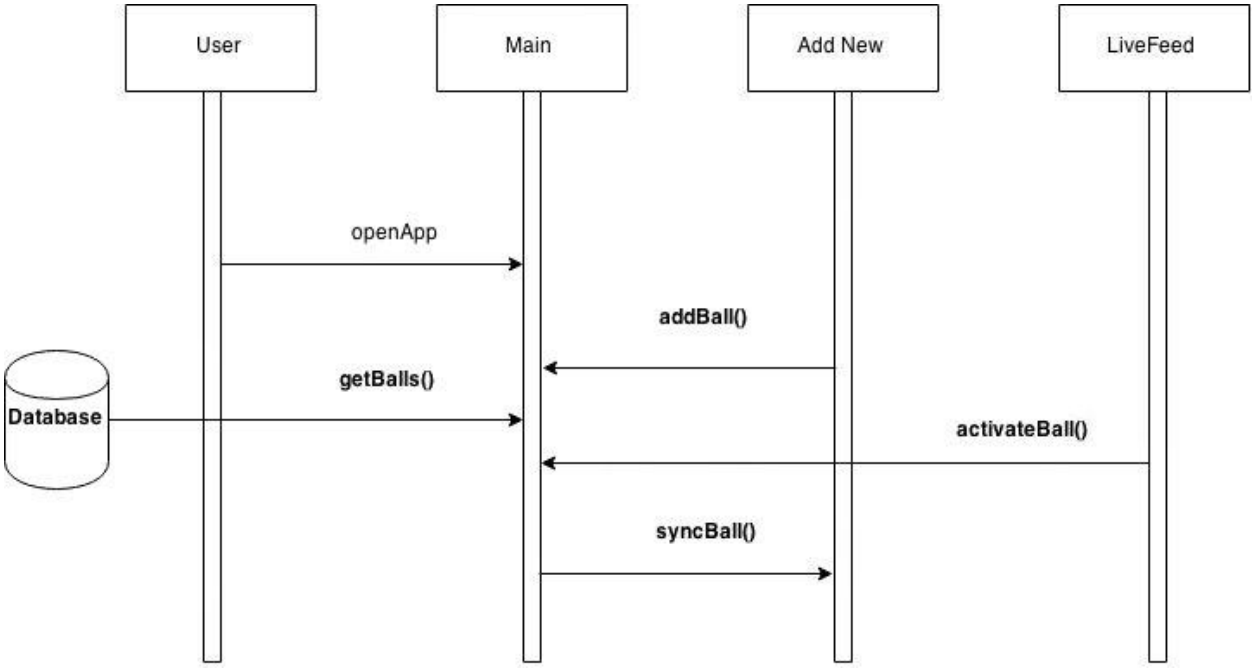
Use Case 1: User checking a new Fotoball



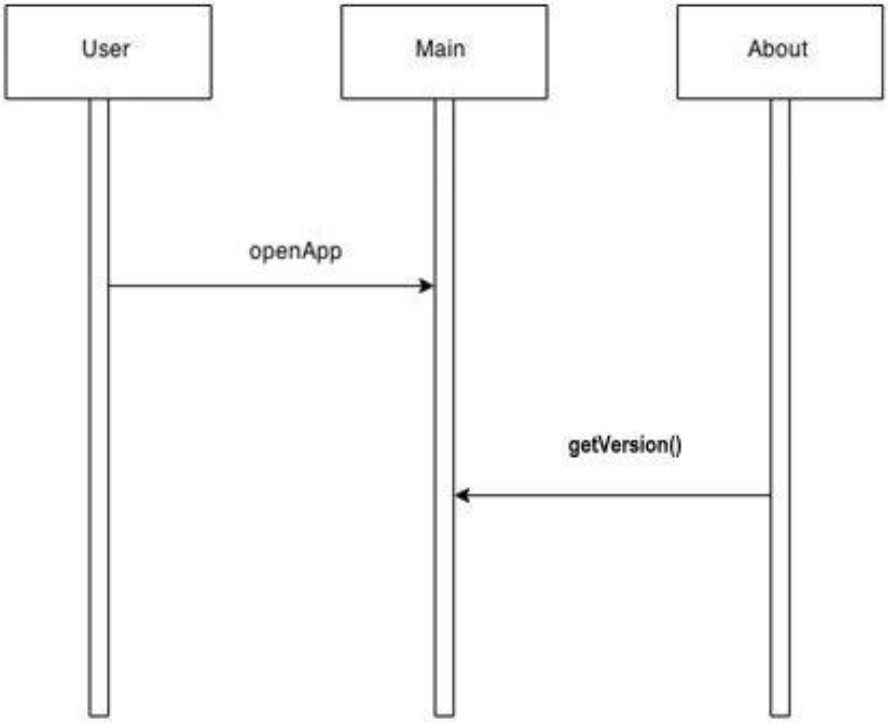
Use Case 2: User checking a live stream from the list of sync'ed Fotoball streams and save it on his personal device



Use Case 3: User adding a new Fotoball and selecting a live stream



Use Case 4: User checking the About information



Chapter 4: CLASS MODELS

4.1 Main Class Description[1]

Name	Main
Base Class	<none>
Purpose	Display the list of synced Fotoball streams and provide the option to select a ball or load a new streams
States	Active, Inactive
Constructors	Default: empty list Fotoball array: load existing Fotoballs
Mutators	activateBall() addBall()
Accessors	getBalls()
Fields	Fotoballs[]

activateBall() Method Description

Prototype	private void activateBall(Object)
Purpose	Connects to a given Fotoball stream
Receives	a Fotoball object
Returns	nothing
Remarks	Will throw an exception if unsuccessful

[1] prepared by AbrAhAm

addBall() Method Description

Prototype	private void addBall()
Purpose	Connects to the AddNew view
Receives	nothing
Returns	nothing
Remarks	This method will link to the AddNew class

getBalls() Method Description

Prototype	private Object[] getBalls()
Purpose	Queries the Fotoball database and displays the list of synced Fotoball streams (if any)
Receives	nothing
Returns	array of Football objects
Remarks	Will display a message if no Fotoballs are found

4.2 AddNew Class Description[2]

Name	AddNew
Base Class	<none>
Purpose	Provides an interface to connect a new Fotoball
States	Active, Inactive
Constructors	Default only
Mutators	syncBall()
Accessors*	getName() getIP() getPort()
Fields	Name: string IP: long integer Port: integer

syncBall() Method Description

Prototype	private void syncBall(String name, long ip, int port)
Purpose	Uses inputted data to connect with an external Fotoball
Receives	name, IP address, port number
Returns	nothing
Remarks	Will throw an exception if unsuccessful

*No description for three getters since they are fairly self-explanatory

[2] prepared by Rick

4.3 LiveFeed Class Description[3]

Name	LiveFeed
Base Class	<none>
Purpose	LiveFeed displays the video image being transmitted by the Fotoball and provides user options to change views or to capture video data
States	Active, Inactive
Constructors	Default: no camera loaded Ball Object: sends one Fotoball object to be used
Mutators	setCamera()
Accessors	getVideo()
Fields	video_feed

setCamera() Method Description

Prototype	private void setCamera(int camNum)
Purpose	Specify which camera to use
Receives	camNum - an integer specifying which camera to turn on
Returns	nothing
Remarks	This method will also make sure every other camera is turned off, so only one is live at a time

getVideo() method Description

Prototype	public Object getVideo()
Purpose	To extract the video in use and save it to the device gallery
Receives	nothing
Returns	The current video object from the LiveFeed screen
Remarks	Will throw an exception if the video is unable to be returned

[3] prepared by Adam

4.4 About Class Description[4]

Name	About
Base Class	<none>
Purpose	Display creator information, version details, and link to website
States	Active, Inactive
Constructors	Default only
Mutators	none
Accessors	getVersion()
Fields	version: float

[4] prepared by David

Chapter 5: TESTING & INTEGRATION PLAN

5.1 Introduction

5.1.1 Purpose - The main purpose of the system integration and testing is to validate the hardware and software.

This is to make sure the product released is ready to be used by the public. The Integration phase includes test cases for each module, as well as testing to ensure that every module ties together properly.

5.1.2 Scope - The integration testing routines follow the "White Box" approach to test and integrate the software. The white box approach will help us to understand the behavior of each module and to build quality software. Integration is carried on a modular approach.

5.2 Modular

5.2.1 Validation Requirements

5.2.1.1 Validation Requirements

Requirement Number	2.1
Requirement Name	Validation Requirements
Requirement Description	Validation is handled via the mobile device's internal security system
Pre-conditions	
Procedures	Since our system will not verify individual users, just individual balls, validation can be piggy-backed to the mobile system's verification. The app will live within the device's existing ecosystem, thus transferring any user clearances to the device's operating system. If a user is provisioned to use the device, they are provisioned to use the application.
Post Conditions	The system will return the message: user the validation is completed.
Test Results	PASS

5.2.2 User Interface Requirements

5.2.2.1- User Interface - GUI

Requirement Number	2.21
Requirement Name	User Interface – GUI for Fotoball
Requirement Description	All users can access the GUI for Fotoball
Pre-conditions	The user must have the application installed on the phone.
Procedures	1. Using your mobile device, locate the Fotoball application 2. Click on the application 3. The user will be see the Main Fotoball screen.
Post Conditions	The Fotoball GUI can be controlled by the user
Test Results	PASS

5.2.2.2 User Interface - To Allow authorized individuals to view the Fotoball

Requirement Number	2.22
Requirement Name	User Interface
Requirement Description	Allow authorizing individuals to live stream from Fotoball
Pre-conditions	The user must be logged into the system.
Procedures	1. On the Main screen, click activate ball. 2. Now the user will be asked for the required Fotoball details 3. Enter the details and proceed
Post Conditions	The system will display a message that confirms the Fotoball access and live stream
Test Results	PASS

5.2.3 Performance Requirements

5.2.3.1 - Performance Requirements - Booting up/ live stream authentication

Requirement Number	2.31
Requirement Name	Performance Requirements – Booting up and Live stream authentication
Requirement Description	Users will be able to boot into the hardware through Fotoball application and access the live stream.
Pre-conditions	User must have the required access details for Fotoball. Measuring it using a chronograph
Procedures	1. Open the application 2. Click on the activate ball 3. Enter the required Fotoball authentication 4. Click on submit (<5 seconds)
Post Conditions	The system will verify the details and show the live stream from Fotoball device
Test Results	PASS

5.2.3.2- Performance Requirements – Accessing video and live streaming it back to the application

Requirement Number	2.32
Requirement Name	Performance Requirements – Accessing video and live streaming it back to the application.
Requirement Description	The User will be able to access the video and live stream it from the Fotoball hardware into the application.
Pre-conditions	User must have the Fotoball hardware and authentication requirements for accessing live stream. Have a time measurements device available. (chronometer)

Procedures	1. Open the application in mobile device 2. Click on the activate ball option 3. Using your chronometer, be ready for calculating the performance 4. Enter the required Fotoball authentication and click submit 5. Start the chronometer simultaneously when you click submit 6. Measure the time taken from accessing the live stream to the application (It should be less than 5 seconds)
Post Conditions	The System will be in live feed window
Test Results	PASS

5.2.4 User Platform Requirements

5.2.4.1 Test User Platform Requirements

Requirement Number	2.41
Requirement Name	User Platform Requirements
Requirement Description	The User platform is to be initially tested in a desktop environment using an Android-like simulator
Pre-conditions	The User needs a Device with an Android Operating System
Procedures	1. Find an Android device or simulator 2. Verify that it is running Android version 5.0 or later 3. Connect the Device to the System. 4. Install the application initially from an external source that is provided to the user
Post Conditions	• If the Application is successfully installed, it will open. • If the Application is not successfully installed, it will prompt the user “Application installation failed”
Test Results	PASS

5.2.5 Fotoball Device Access requirements

5.2.5.1 Test Fotoball Device Access requirements- full name

Requirement Number	2.51
Requirement Name	Fotoball Device Access requirements
Requirement Description	The Fotoball device will contain specific name and IP address to access it. The user will need to know the details of the Fotoball to access it
Pre conditions	The User needs to be in Main page
Procedures	1. Enter the Name 2. Enter the IP Address. 3. Enter the valid information (network, port number) 4. Click Submit after entering the above information.
Post Conditions	The User will access the Fotoball live stream if all the information matches it.
Test Results	PASS

5.2.5.2 Test User Account Requirements - Registered Fotoball

Requirement Number	2.52
Requirement Name	User Account Requirements – Registered Fotoball
Requirement Description	The User account contains registered Fotoball device.
Pre conditions	The User needs to be in the Main menu and add a Fotoball device to their account
Procedures	• The User needs to fill valid information for the rest of the form to register the Fotoball device
Post Conditions	• The Default User is assigned to a Fotoball device
Test Results	Fail. Manual input not yet functional.

5.2.6 Hardware Requirements

5.2.6.1 Power Test

Requirement Number	2.61
Requirement Name	Power Test
Requirement Description	Verify that Fotoball is able to be charged and retain charge
Pre-conditions	Battery < 50% charged
Procedures	1. Power on Fotoball 2. Open the Fotoball 3. Check if the power LED lit 4. Use volt meter measure across +5V and Gnd and check the power for camera 5. Plug in Fotoball to a charger 6. Check battery voltage 7. Wait for 2 minutes 8. Check if battery voltage went up.
Post Conditions	Battery > 50% charge
Test Results	PASS

5.2.6.2 Communication Test

Requirement Number	2.62
Requirement Name	Communication Test
Requirement Description	Ensure Fotoball is able to wirelessly sync with mobile device
Pre-conditions	Fotoball not connected
Procedures	1. Power on Fotoball 2. Wait for 2 minutes 3. Check if you can see the Fotoball wireless SSID 4. Connect to Fotoball wireless SSID 5. Ping Fotoball IP address.
Post Conditions	Fotoball connected
Test Results	PASS

5.2.7 Database Requirements

5.2.7.1 Type Check Test

Requirement Number	2.71
Requirement Name	Type-Check Test
Requirement Description	Ensure Fotoball database is immune to invalid input
Pre-conditions	
Procedures	1. Connect to Fotoball database via backend 2. Attempt to input erroneous data types for each relation of each table
Post Conditions	No invalid inputs allowed
Test Results	PASS

5.2.7.2 Concurrency/Stability Test

Requirement Number	2.72
Requirement Name	Concurrency and Stability Test
Requirement Description	Ensure each Fotoball element can only be accessed by one external source at a time
Pre-conditions	At least 1 Fotoball loaded into database
Procedures	1. Connect to Fotoball database via backend 2. Attempt to access/change information from source A 3. Attempt same access from source B
Post Conditions	Source B access is denied
Test Results	PASS

5.3 System Integration

5.3.1 Integration Phase -1 - Testing system components independently

The first step of system integration plan will consist of making sure each one of the system components are working as given in the requirement specification. This consists of making sure the hardware and software are thoroughly testing and integrated. In the Fotoball Application, the main system components is fully operational and tested independently before trying to integrate or try to test any interaction with any of the other mayor system components. The phase-1 will validate the system have all the necessary components to start with a formal system integration. The integration phase will include, testing the application, hardware and the database independently

Phase 1 Integration Testing:

- Testing the application installation
- Testing GUI and classes that do not have dependencies
- Testing the hardware to make sure it is working
- Testing database installation and finding tables are created.

5.3.2 Integration Phase -2 – Database and Communication

The Phase 2 of the system integration will consist of integrating the database system with the application. As part of this phase, we will test the communications interfaces. In addition, this phase includes testing the functionality and the interaction between the server and the application

Phase 2 Integration Testing:

- Testing Wireless communication between the application and hardware
- Testing Server

5.3.3 Integration Phase -3 Functionality and Performance

The Phase 3 of the system integration will consist of testing the functionality of integrated modules and performance. As a part of this test, we will conduct the performance test of the live stream from the hardware to the system GUI.

Phase 3 Integration Test

- Testing Functionality
- Testing Performance

5.3.4 Integration Phase -4 –Complete system Integration software and hardware

The Phase 4 of the system integration will test and integrate all the system components as a one whole system. This will include testing both the hardware and software component together

Phase 4 Integration Test

- Testing Wireless between all systems simultaneously (Hardware/Software)
- Testing client to database request
- Testing database to Fotoball
- Testing system performance requirements.

5.4 Testing Schedule

Test Schedule ID:	FbT-0001
Product ID / Name:	Fotoball
Product Version:	v1.0
Created On:	Document created on April 01, 2015
Review On:	Document reviewed on April 08, 2015
Reviewed By:	Cipoletta, David Herrera, AbrAhAm Jilling, Adam Rejeleene, Rick
Current Status:	PASS

Test Step	Start Date	End Date	Responsibility / Comments
1. Hardware Requirements	Jan 29, 2015	Feb 19, 2015	PASS

2. Fotoball Device Access requirements	Feb 23, 2015	Feb 26, 2015	PASS
3. User Interface	Mar 02, 2015	Mar 05, 2015	PASS
3.1 GUI installation	Mar 02, 2015	Mar 05, 2015	PASS
3.2 Login access	Mar 02, 2015	Mar 05, 2015	Not yet implemented
4. Database Requirements	Mar 09, 2015	Mar 12, 2015	PASS
5. Performance Requirements	Mar 23, 2015	Mar 26, 2015	PASS
5.1 Live Streaming Authentication Performance	Mar 23, 2015	Mar 26, 2015	PASS
5.2 Live Streaming Performance	Mar 23, 2015	Mar 26, 2015	PASS
6. System Integration	Mar 30, 2015	Apr 02, 2015	PASS
6.1 Testing system components independently	Mar 30, 2015	Apr 02, 2015	PASS
6.2 Database and Communication	Mar 30, 2015	Apr 02, 2015	PASS
6.3 Functionality and Performance	Mar 30, 2015	Apr 02, 2015	PASS
6.4 Complete system Integration software and hardware	Mar 30, 2015	Apr 02, 2015	Partial PASS

Review / Approve the Final Test Report	Apr 13, 2015	Apr 16, 2015	Final test will be performed a week prior the last day of class
Test Step	**Start Date**	**End Date**	**Responsibility / Comments**

Chapter 6: PROBLEMS ENCOUNTERED

The Project went very well as the original specifications but due to time constraints, we were unable to develop the full product.

There were no major changes from the original specification till the proposed prototype.

Below is a summary of the encountered challenges for this project.

Hardware:

> Although the capability exists to transmit video via Wi-Fi there are certainly many problems that arose that were not anticipated.

Power Consumption:

> After extensive research on microcontrollers with Wi-Fi capabilities, we found that low power Wi-Fi microcontrollers are used to control simple I/O and are not meant to handle complex image processing.
>
> This led us to using a microcontroller with SoC (system on a chip). These microcontrollers have relatively high power consumption since they have to process the image data, then encode it, and then stream it out.
>
> Due to the high power consumption, the battery we have to use must be a high capacity and high voltage. This impacts the weight of Fotoball since the Fotoball will now be a bit heavier.

Latency:

> Since we are using microcontrollers to do the image processing and encoding, there is a latency to the video broadcast. The latency is not significant but it is certainly something we did not plan on originally.

Signal Strength:

> Since the ball will communicate via Wi-Fi, we have to use small antennae to fit into the ball. This causes the signal strength to drop slightly.

Time Constraints:

Certainly we did not explore some of the options such as streaming two cameras at once and implementing image stabilization. This is due to time and money constrains. One of the Software development kits for streaming video cost $3000. Additionally we ran out of time to implement the second camera.

libGDX:

The original plan was to use a development framework called libGDX to write one program and port it to both the iOS and Android platforms. Something with this capability sounds too good to be true and we soon learned that it was. Too many sacrifices needed to be made to be able to use libGDX and we decided it was in our best interest to write two separate projects for each. We started with the iOS version and coded it as most iOS are - in Xcode with Swift.

Apple webView:

Apple provides a framework called WKWebKit which is designed to allow easy porting of web-based information into a native application. Since Swift is such a new language, there are still significant changes that are introduced as each new version comes out. Sure enough, an update was released on April 21 that disable the previously working video stream connection, and we were left with two days to fix it before presenting.

Saving video:

This was a combination of time and changes in hardware, but we were unable to implement the feature allowing the recording and saving of videos.

Image Stabilization:

The original plan was to create a video stabilization algorithm to compensate for the rotation and wobble of a moving football. This proved to be too big of a problem to solve in the required timeframe. The algorithm would find and save a certain location of pixels and then use them to counter-rotate the image to produce a smooth result. For this to be implemented, the first step is to be able to save and extract the video footage frame-by-frame in order to be manipulated. Since this was not implemented it made the stabilization algorithm impossible to implement as well. Stabilization remains a key feature that we plan to work on in the future.

Chapter 7: FOTOBALL PROJECT FINAL SUMMARY

Phase 1 of the Fotoball project has concluded. As expected, some key features were not implemented but the basic functionality is in place. The original plan to use the libGDX cross-platform framework to develop for Android and iOS simultaneously proved unsuccessful. We adjusted by creating an iOS app to start and are developing the Android app separately. Also, we were unable to implement the video saving aspect due to another framework and time constraints. From a hardware standpoint, we decided to start with a single camera rather than two, this time due to cost and time constraints. Finally, the issue of stabilizing a rotating image was too great a problem to solve in the required time period.

As for what was implemented, there is a prototype Fotoball, complete with an onboard camera, circuit board, wifi controller, and charging mechanism. There is also a functional iOS application capable of receiving the video being transmitted from the ball. The app is capable of running on any iOS platform of 7 or later and any iPhone from 5 or later.

In hindsight, we would likely have started with a development platform that we were already familiar with. We spent roughly three weeks learning the libGDX environment before realizing it was not suitable for our project. This was time that could have been better spent elsewhere.

It's still unclear to us if it's better to start programming earlier next time. The benefit of waiting until after all the design documents have been completed is you know exactly how to structure everything. Starting earlier before those documents are done provides a lot more time but will ultimately result in more changes to the code. I think it depends on your process to determine which way is better.

Overall, it was a successful endeavor into a project that really none of us had any familiarity we with. Our team meshed very well together in that we had unique skill sets for different areas of the project. This is a project that we will likely continue on with and see how far we can take it. The original discussion was for a Fotoball to be used in an NFL or major college game and we see no reasons to abandon that vision yet.