ATHLETIC VIDEO ARCHIVE:

SENIOR CAPSTONE THESIS

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PART ONE: GOAL

The initial goal of the yearlong senior thesis was to design and create software and a system that would directly benefit the performance of athletes. This system would allow them to study and learn from their practices and workouts with the help of quality video analysis. Research showed that several solutions exist to the problem that is a lack of video analysis software, yet these are not directly tailored to athletics, specifically springboard and platform diving.

PART TWO: MOTIVATION

As a recent alumnus of the Indiana University diving program, I know how important it is to watch and re-watch video of practices and competitions. While focusing on executing a perfect dive, a diver must also concentrate on balancing, jumping, flipping, twisting, knowing where they are in space, and entering the water at the perfect angle, all while squeezing every muscle in their body. A thing or two is often compromised during that process, and it is with the help of video analysis that athletes can analyze even the finest of details in video and learn from their actions, ultimately allowing them to reach even greater levels of performance.

Since I have always been proud to be a part of the diving program at Indiana University, I was driven to learn as much as I could, mentally and physically. Originally from California, I was a long way from home, and the best way for me to update family and friends of my diving progress was to record clips of my dives and attach them to emails. Unfortunately, there was no simple way to get the video from the television onto my mobile device, so nearly all of the videos that I have exist from holding my mobile phone to a television screen. Needless to say, standing in front of a television and recording the screen does not create quality videos. From that point, I was the only person to have my "original" poor-quality video, and the only way to effectively study and let my coach or teammates study it was to email it to all of them. Recording video quickly became a pain for many athletes because of the amount of time spent grabbing their mobile devices, finding the video on the television, and then recording it, only to have a video lacking good quality.

PART THREE: RELATED WORK

Milestone Systems

In the fall of 2013, a new diving coach was appointed at Indiana University, and he sought out a new solution for a video system, all while I was brainstorming to create one. Milestone Systems offered a product that would be customizable to fit the needs of the diving program at Indiana. The company mainly offers video surveillance software in the field of security, but after some testing, the setup that we had seemed to run poorly. Whoever was in charge of this operation for the Indiana diving program appeared to be simultaneously recording video and

uploading it to a server, and then the system was attempting to play that video. Either the order of operations or the quality of hardware did not prove to offer a clean concept that ran seamlessly. Despite the excellent plan to create this concept, it was back to the drawing board to find a better solution.

Dartfish

Concerning video analysis and the sport of diving, one resource has been created that allows users to analyze videos, either one at a time or side-by-side for comparison between two clips. Dartfish was specifically created for sports and has many features, including frame-by-frame capability and controlling playback speed. In addition, it allows for angle calculation, which would help with analyzing the angle of knee bend right before a diver's propulsion from springboard or jump from platform. Diving coaches who strive to learn more about the sport and have many, many videos at their fingertips commonly use Dartfish. Recently, Dartfish developed a mobile application for the iPhone. On the downside, Dartfish can be challenging to use for users who are not very technology savvy, and there does not appear to be a simple way to get the video to numerous athletes with little effort on the coach/managers behalf.

Ubersense

Often in collegiate athletics, coaches are presented with tablets so that they can record and view their athletes' performances, whether in practice or in competition. A useful tool that can be accessed on mobile devices is the application known as Ubersense. This mobile app, available on iPhone and iPad, enables the user to shoot video and analyze that clip. An outstanding feature that can also be found within the Dartfish computer software is the power to compare a video clip, side-by-side, with another clip. Such a method of analyzing can be very advantageous by comparing a freshman athlete's technique to a senior athlete or Olympian. Ubersense is constructed for analyzing athletic video on a mobile device, but this application cannot be found on a desktop.

VLC Media Player

A viable solution to playing a variety of abstract media files is the popular VLC Media Player. Not directly designed for analyzing athletic video, VLC Media Player is most frequently used to play movies and can be used to stream video. One of the most alluring qualities that VLC has is its ability to play any type of video format, eliminating the need for video conversion software. Although VLC has great features, it does not offer something as simple as navigating backwards in a frame-by-frame fashion and is not particularly designed for analyzing video.

QuickTime Player

Although QuickTime Player was meant to be a media player, it may not often be used to analyze video. However, QuickTime has a feature that most people may not be aware of: frame-by-frame viewing. Analyzing video entails many things, but one of the most important tools that a media player must have is the ability to move frame-by-frame. Whether viewing media directly or within a web browser, a video can be played one frame at a time by simply pressing the left and right arrow keys on the keyboard. The QuickTime plug-in is widely available for all web browsers and will work with many video formats including QuickTime Movies (*.mov*), MPEG-4 (*.mp4* and *.m4v*), MPEG-2, MPEG-1, 3GPP, 3GPP2, AVCHD, AVI, and DV. Even if videos on a web page are not embedded within HTML but the file links have extensions corresponding to one listed previously, the video will be playable within the browser, which makes for a simple and painless experience.

PART FOUR: METHODS & APPROACHES

Use Cases

Initially, use cases were constructed to best identify the broad system and the system's requirements. Computer science faculty member Professor Dalkilic loaned me a book, Writing Effective Use Cases, by Allister Cockburn. With this book, I was able to gain a better understanding of how to communicate a project's purpose, requirements, end goal, and processes. Developing use cases is especially helpful when attempting to pinpoint whether or not a project is feasible. Most importantly, the use cases proved beneficial by putting words to a vision that was not yet born. Despite having the ability to summarize, in words, what the initial system was, use cases seemed to offer the best method of presenting information and helping others understand as well. The initial use case developed for the overall system is shown below.

Primary Actor: Diving coach and divers
Scope: Video Analysis Application
Level: Summary
Stakeholders and Interests:
Diver – obtain quality video clips of practice and meet performance
Diving coach – have database of video clips to analyze
Precondition: tablet is set up and possibly connected to television via HDMI cable
Minimal Guarantees: videos of practices are stored in database
Success Guarantees: user is able to slice individual diving clips from practice video and store these in database
Main Success Scenario:
1. Coach/Diver opens app and begins recording at start of practice
2. Delayed video is shown on television so that once dive is completed and correction is given by coach, diver can watch their dive (~10 sec)
3. Divers/Coach want to re-watch dive during practice in slow-motion, so they go to tablet and find clip then watch it in slow-motion
4. Once diver is done looking at the dive they did, they are able to choose the delay for shown video (live, 5, 10, 15, 20 seconds are options)
5. At conclusion of practice, coach stops recording
6. Recording of practice is sent to database

Extensions:
1a. Person forgets to open app and begin recording practice
1a1. Someone realizes it is not on and recording and turns it on
2a/4a. Video is being shown at live, too little, or too much of delay
2a1/4a1. Diver selects proper amount of delay
5a. Coach forgets to end recording
5a1. Once someone remembers, they end recording
5a2. Before user sends video to database, they trim the (assumingly large) clip so there is not pointless data in database

Seeking Assistance

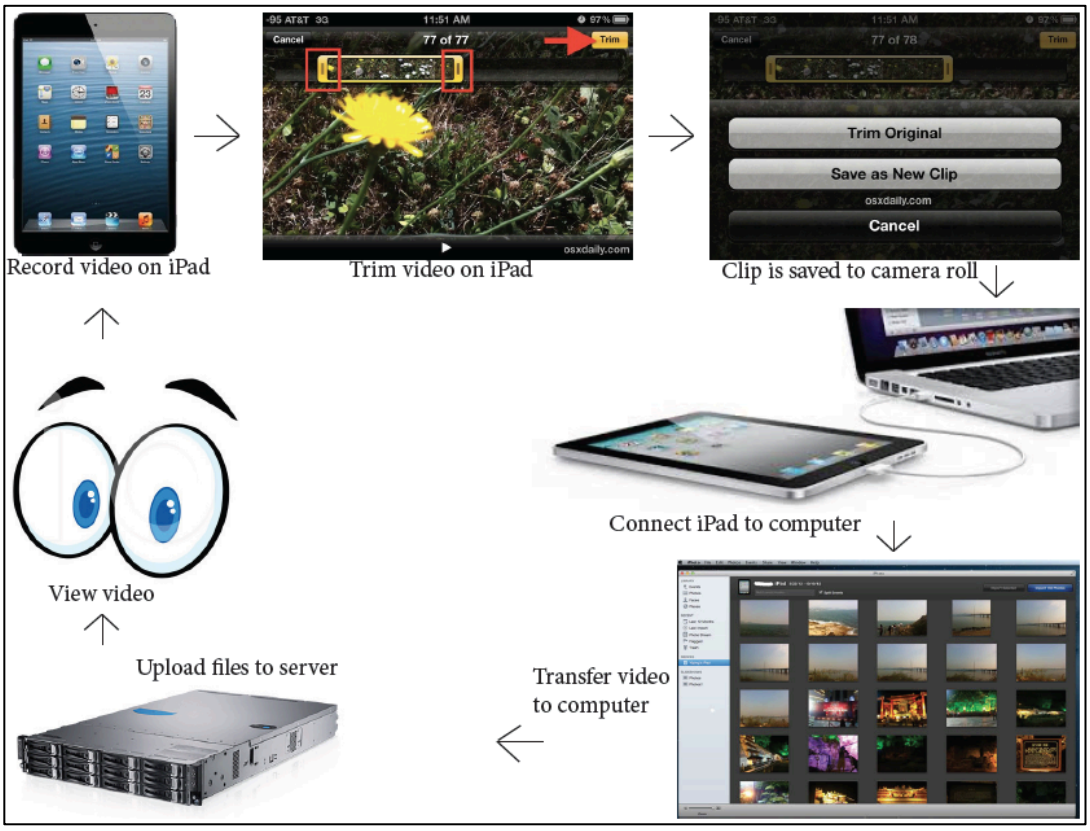
Considering I had the opportunity to acclimate to my surroundings over the past four years, I was highly familiar with the facility where the proposed system would be implemented. At a certain point, Professor Dalkilic and I decided that it would be in our best interest to pick up a couple undergraduate honors computer science students and a doctoral student, Mark Jenne, for whom he also acted as a mentor. Effectively communicating details of the diving facility to these new comrades who had never been there before was challenging, ultimately leading to us having to venture to the diving well and introducing them to the environment. At that time, we spent quite some time addressing possible implementation versus plausible implementation, in terms of the end goal of the project.

Effective Design

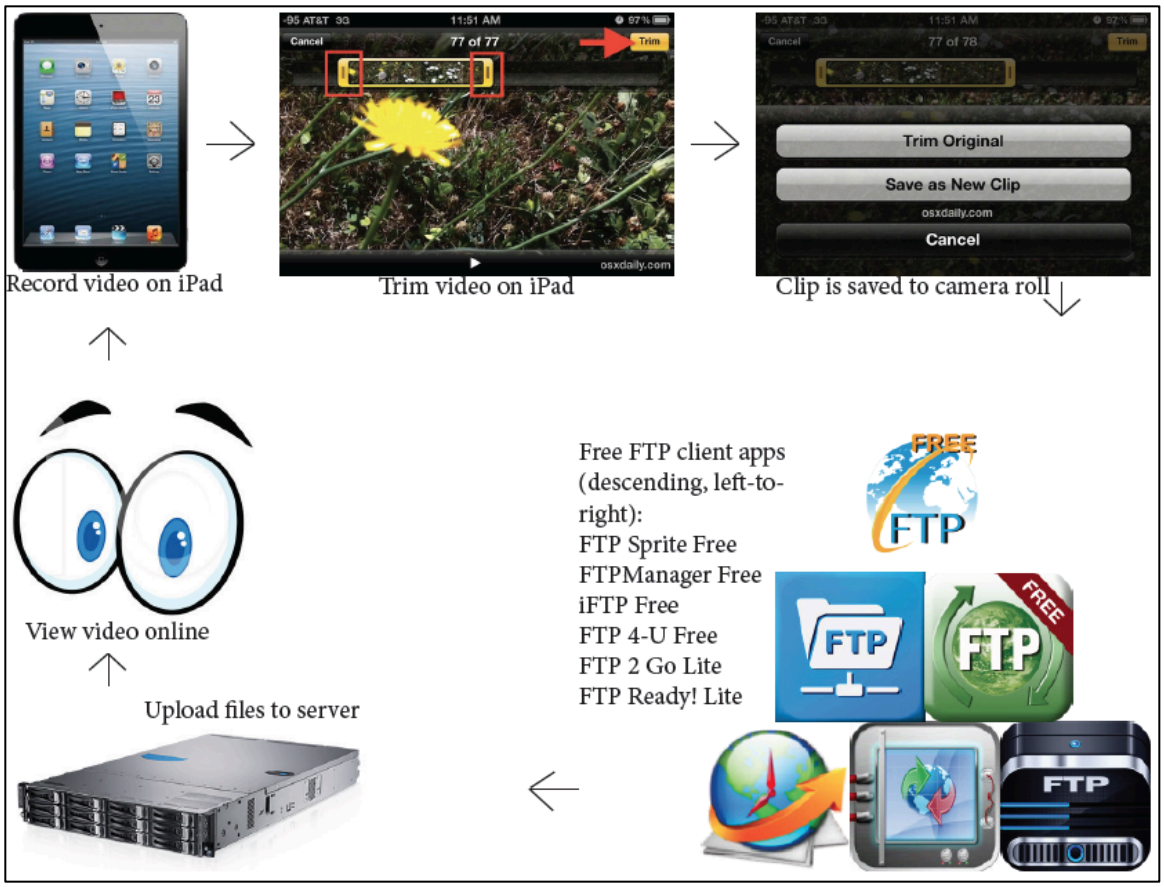
Mark, Professor Dalkilic's doctoral student, and I began working together in hopes to construct a smaller system that would make for a better video analysis

process. We no longer needed other developers, and Mark proposed that I purchase and read one of his favorite books: Head First Design Patterns. This book helps software engineers with designing software in the most effective ways, and all of the code that is used in the book is in Java. As we initially planned to create an Android application, learning Java was highly necessary to the development of this project. Reading this helped me tap into the mindset of creating reusable code so that, potentially, others can easily identify the operations within the code and others may easily add on to what I have created. The standard process for uploading a file to a web server can be seen in the diagram below.

Construct Client



Once I felt as if I had a decent grasp on Java, Mark recommended that we simulate a client-server application that we would use to send video to a server. I did some research and worked with the Apache Commons file transfer protocol (FTP) library to develop an FTP client. The client connected to my personal server and uploaded a file with any name the user specified at run-time or within the code. All files were tested, and transferring of movies was even possible, although transferring any large, high quality file evaluates to some waiting time. Running this simple FTP client demonstrated to be straightforward and easy, but this was only a small piece of the end process that fit between other ones. The improved process to uploading videos to a web server can be seen in this next diagram.



Brainstorm

As I had heard Professor Dalkilic mention at some point in time, one of the largest issues that we may encounter is having too many options. Having options is wonderful, but when there are limitless opportunities along the path of creating a system that was once a vision, things actually become difficult. After spending time reflecting and working with Mark, I decided that the most simple of ideas are often overlooked, even if they may be exactly what we need. The vision of a user-friendly video system was inspired by a problem that I had possessed as a member of the diving program, and the sole issue was obtaining good, quality video from the pool into the hands of athletes and coaches. Something that previously mentioned programs had in common was that they did not offer an effortless way to access video on the computer and phone without having to download an application or foreign software.

For the sake of differing operating systems, creating a mobile application was not ideal, so the most consistent tool that people use to access information is a web browser. At that point, the only major difference in accessing a web page is whether or not a user is on a personal computer or mobile device. Optimizing a web page to work with a mobile device would be the most important step in ensuring a

promising user experience. This way, everyone can easily access videos whether they are sitting at home, at work, walking from class, or leaving practice. After analyzing the situation further, I developed a use case for a prototype that would not focus on the gathering of video but the availability of video since there are already options for harnessing video, in one way or another. Thus, I developed a use case that was targeted towards a diving video archive and then expanded to an archive hosting all sports of Indiana University, which is found below.

Primary Actor: Coaches and their athletes
Scope: Athletic Video Archive
Level: Summary
Stakeholders and Interests:
Athlete – have saved clips for analyzing to heighten performance
Coach – easily view all of his or her athletes' progress and performances
Team Manager – helping out and contributing to success of program and athletes
Precondition: coach has an iPad, typically presented by the university
Minimal Guarantees: videos are recorded on iPad while some are uploaded to server for viewing
Success Guarantees: a bountiful amount of clips are stored on the server so that people with the user name and passphrase can view the clips online
Main Success Scenario:

1. Coach, team manager, or teammate records an athlete's performance on the iPad
2. User opens file transfer protocol (FTP) client application on iPad
3. User logs in to server with credentials provided by Indiana Athletics
4. The user selects which video files to upload to their specified sport directory
5. User uploads files
6. Renaming of files can be done, making it easy for users to find specific video clips

Extensions:
1a. Video is not recorded so that clip cannot be saved and uploaded
2a. FTP application is not downloaded
2a1. An FTP application must be downloaded from the app store
3a. Credentials for server do not work
3a1. Team manager or coach must contact responsible party within IU Athletics
4a. The wrong directory is accessed
4a1. User must go back to previous directory to find correct directory
4b. The wrong files are uploaded
4b1. User must delete file(s) and upload correct file(s)
5a. User cannot upload files
5a1. Contact system administrator
6a. Person naming files makes an error
6a1. They will go back and fix the error themselves

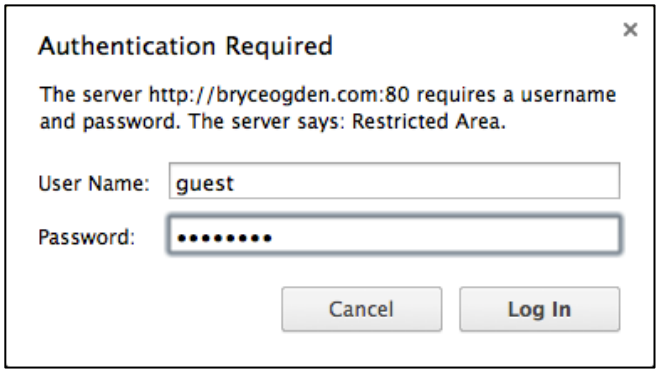
PART FIVE: FINAL CONCEPT

Video Archive

After countless hours of reflecting and researching, I aimed to create an online tool that could be easily accessed and could serve as a resource for student-athletes and their coaches. I found that giving people access to view a web directory with videos was the best option, not only because of the sheer simplicity in the idea but because of how easy it would be to manage it. I began with the sport that I was a part of, and after tampering with it, it evolved into a sub-directory that was listed among all sports of Indiana University Athletics. Considering this was designed as a resource and tool for faculty and athletes of Indiana University Athletics, Mark suggested that a login page exist.

Security

Creating a login page was moderately straightforward because I had experience with implementing a simple login with a *.htaccess* file in a browser. This file stands for "hypertext access" and allows for directory-level configuration in web servers. Within the file, I included some lines to prevent anyone from having access to the *.htaccess* file, which is necessary for proper security. Once adding a *.htpasswd* file to hold all valid credentials for the video directory, all of the essential measures had been taken to safeguard the athletics video archive.



HTAccess

Nowadays, *.htaccess* files are used to direct a uniform resource locator (URL) to the homepage so that a user does not have to actively type in the website extension (e.g. "bryceogden.com/athletics" as opposed to "…/athletics.html"). My method of execution for separating different sports' videos within Indiana University Athletics and keeping the web page up to date was accomplished by simply listing the files in the directory for the URL. If a user were looking inside of their computer's "My Documents" folder, they would see a list of files, so essentially, the same thing is occurring online but with a web server. Whenever someone adds

a file, the web page is updated, yet the main page that lists all of the sports teams at Indiana University should remain relatively static.

Layout Customization

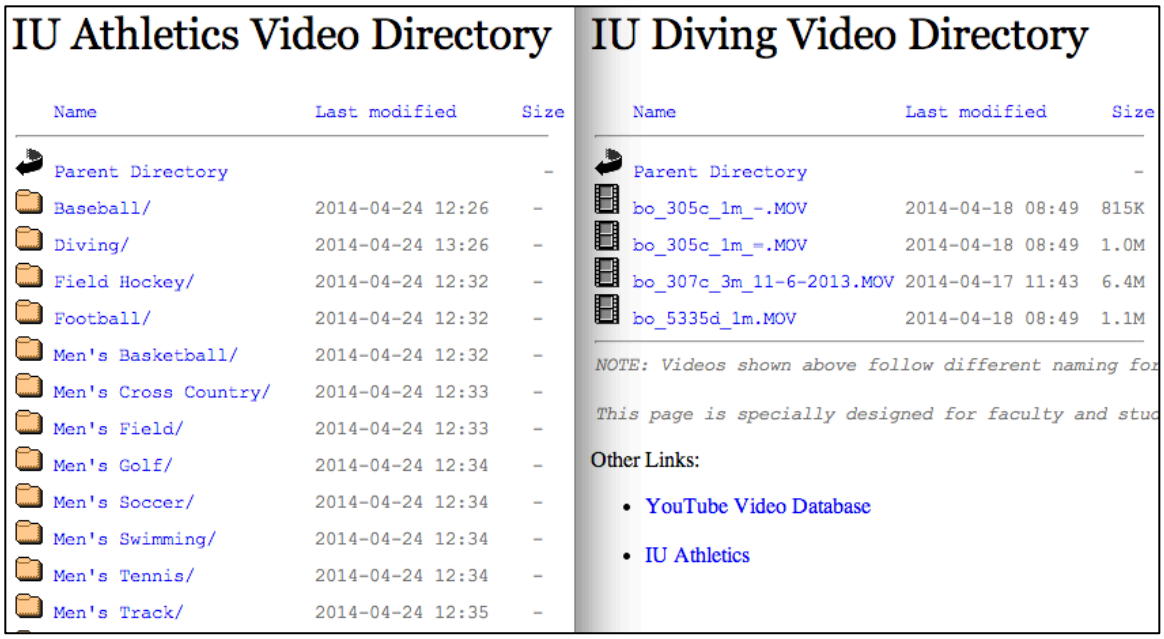
Solely viewing a directory in a web page does not allow for an acceptable user experience, so I modified the layout and design of the page with HTML and CSS. Adding a *header.html* and *footer.html* was moderately easy, but some things on the web page, were not entirely editable. Within the CSS, I configured the web page for a mobile device and increased the size of page contents so that a user did not waste time by zooming in to read or pressing the wrong link.

Functionality

If not all, most coaches of Indiana University are bestowed an iPad so that they can record video of their athletes. An essential tool to this process is an FTP client, and many different FTP client applications can be found on the Apple App Store. I have been working with a couple of the many free apps, while others can found that are priced at one and five U.S. dollars. This athletic video archive was created and implemented on my personal website, but for this service to genuinely work, a separate server with adequate storage space for high-quality video and moderate internet trafficking would have to be set aside, most likely by IU Athletics. Once this is implemented, coaches and managers can be assigned credentials to login to the FTP server and upload video to their relative sport's folder, and an example can be found at "http://www.bryceogden.com/athletics" by using "guest" and "password" as user name and passphrase. On top of this, sample videos have been uploaded to the "Diving" directory.

Utilization

Video files that have been recorded from an Apple device typically share the *.mov* extension, so when the files are opening in a web browser, they are played with the QuickTime plug-in. QuickTime allows for the user to pause by pressing 'spacebar' on their keyboard and also move frame-by-frame, forward and backward. In terms of mobile functionality, since these videos open in QuickTime and were shot with an Apple device, they will easily open in an Apple iPhone, iPod Touch, and iPad from Safari. A preview of the home directory and diving directory page can be found below.



IU Athletics Video Directory

Name	Last modified	Size
Parent Directory		-
Baseball/	2014-04-24 12:26	-
Diving/	2014-04-24 13:26	-
Field Hockey/	2014-04-24 12:32	-
Football/	2014-04-24 12:32	-
Men's Basketball/	2014-04-24 12:32	-
Men's Cross Country/	2014-04-24 12:33	-
Men's Field/	2014-04-24 12:33	-
Men's Golf/	2014-04-24 12:34	-
Men's Soccer/	2014-04-24 12:34	-
Men's Swimming/	2014-04-24 12:34	-
Men's Tennis/	2014-04-24 12:34	-
Men's Track/	2014-04-24 12:35	-

IU Diving Video Directory

Name	Last modified	Size
Parent Directory		-
bo_305c_1m_-.MOV	2014-04-18 08:49	815K
bo_305c_1m_=.MOV	2014-04-18 08:49	1.0M
bo_307c_3m_11-6-2013.MOV	2014-04-17 11:43	6.4M
bo_5335d_1m.MOV	2014-04-18 08:49	1.1M

NOTE: Videos shown above follow different naming for

This page is specially designed for faculty and stud

Other Links:

- YouTube Video Database
- IU Athletics

PART SIX: OBSTACLES & CONCLUSION

All throughout the project, we successfully encountered obstacles that thwarted our initial plan. At some point, the goal was to create a simple video editor that took a large clip and was able to generate smaller clips, like having a two-hour practice and turning that into many clips of individual dives that took place in that practice. Shortly after that, Mark and I altered the goal to create an FTP client that uploaded video files onto a server that would simulate a piece of the software, which would only amount to a fraction of the intended system. Both of these projects were attempted in Python, but that led to countless errors when trying to install helpful modules. Now, files that are uploaded into the athletic video archive prove to work best in Google Chrome and Mozilla Firefox. Since users were meant to view videos using QuickTime Player, someone must have QuickTime installed. Lastly, the mobile browser with the most consistent success seemed to be Safari, which is the generic for the iPhone.

Despite all of the obstacles associated with technology, the two largest factors were time and money. With a large enough supply of these factors, nearly anything can be deemed accomplishable. Nevertheless, I am thoroughly happy with how the project turned out, as it encompasses the one reason for why I chose to pursue a degree in Informatics: it solves a problem. This problem of not having easily accessible video now has one solution and has been simplified to provide coaches, team managers, and athletes with a satisfactory user experience. Whether or not I decide to continue my quest in the field video analysis, targeted at athletics, I have successfully developed a process and tool that serves as a simple solution in an area that I am most passionate.

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