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Poze:
A Website to Enhance the At-Home Workout Experience

Xuewei Ouyang
Advisor: Dr. Robert Fish

Abstract

Poze is a product that aims to provide live feedback to young women exercising to fitness videos on their own. Due to the difficulty many young women face in balancing maintaining a fit lifestyle with busy schedules and limited budget, many of the current options for working out are less than ideal. Poze hopes to address this issue by offering a more optimal and affordable option for women to effectively workout at home. This paper details the development of the business concepts behind Poze and the implementation of the website and program itself, which uses the webcam to track and analyze the user's movement as she follows along to a workout video and then responds with appropriate audio feedback.

1. Introduction

Despite the alarming cries of the obesity pandemic in the U.S. and a rate of 1.9 million diagnoses of diabetes per year, being health-conscious and active is a trend on the rise among millennials today [16]. From gluten-free products at WholeFoods, workout at the new chic fitness boutique like SoulCycle, or participate in a detoxing juice cleanse, health-consciousness has become glamorous. The major drawback of this "health" fad, however, is that many of these products or services are expensive and therefore inaccessible to a lot of general population. With

just one class at SoulCycle costing $34 [7], it is unsurprising that young adults in college or just out of college struggle to maintain a healthy and fit lifestyle with their limited budget and time.

Technology, however, has made it possible for people to workout right in their homes for free rather than trek to the nearest gym or fitness boutique. The fitness industry is no longer limited to these physical locations, but has spread to online channels such as Youtube, on which fitness gurus have over two million subscribers working out to their free fitness videos [20]. The huge range in types of workouts available ensures that everyone can find a suitable workout routine whether its Pilates, yoga, or some other cardio or strength-building exercise. In addition, these users do not need to have any kind of experience or familiarity with the exercises. In just ten minutes, a Youtube user who is completely new to Pilates can complete a full leg Pilates routine. Another huge benefit of working out to Youtube videos is the convenience. Not only can the user choose when to exercise and the length of time of the workout, but she also does not have to leave her room. The only distinction between this online medium and a physical location, however, is the lack of guidance during workouts. This becomes problematic as workouts then become less effective when users are not doing moves at the correct tempo or begin to cheat. In addition, incorrect form can also potentially lead to injury.

From personal experience as well as feedback from other women who exercise to workout videos on Youtube, we realized that it is difficult for young women to get personalized guidance when exercising on their own, which ultimately decreases the effectiveness of the workout. In addition, since many women who use these videos often lack experience with Pilates or yoga, they are at greater risk for injury because their form may be incorrect. As a result, our goal for Poze was to give young women the feedback they need as they follow along to Youtube

yoga and Pilates videos so that they can maintain a healthy and fit lifestyle with a limited budget and a busy schedule.

The remainder of the paper will be structured as follows: before going into the details about the technology behind Poze, the paper will first focus on some of Poze's competitors and how Poze's key novel concept and our business model will make it successful and profitable. Then, it will discuss the process of creating Poze and will explain many of the reasons behind our design choices. Finally, the paper presents an evaluation of our product based on our original goals and explores future possible research areas to improve or expand on Poze.

2. Related Work

2.1 Competitors

Poze's main competitors that have similar goals of helping young women maintain a healthy and fit lifestyle can be divided into three main categories: fitness clubs, Kinect/Wii fitness games, and workout DVDs. Fitness clubs and gyms are effective because one can receive in-person feedback and guidance from a personal trainer or fitness instructor. Personal trainers, however, cost an average of $50 per hour [6] and instructors of expensive fitness classes can rarely provide one-on-one attention. Additionally, the commute to the gym and the inflexible schedule of fitness classes are major drawbacks for those with busy schedules.

Workout DVDs and Kinect/Wii fitness games provide the option of exercising at home according to one's own schedule, but, nonetheless, still have drawbacks. Workout DVDs such as Jillian Michaels's*, 30 Day Shred,* allow users to follow along to workout routines led by expert fitness instructors on the TV in their living rooms [11]. The fitness instructors in the workout DVDs, however, are not able to provide any personal feedback during the workout and are limited to providing only generic motivation. Kinect and Wii fitness games, on the other hand,

can provide live feedback during workouts. The Kinect in particular has a similar concept to Poze in that it uses a camera to track body motions and analyzes the user's movement to determine what feedback to provide. The Kinect most likely has the best live-feedback system on the market at the moment due to its special camera and computer vision technology. Unlike past technology that used color and texture differences for background subtraction, the Kinect camera generates a 3D-image that gives depth information by transmitting infrared-light and using measurements of how the light is reflected off objects. The Kinect is then able to recognize the human body in the image through machine-learning. After, it makes sense of the motions detected through its sensor in terms of the game that the user is currently playing [3]. Because the Kinect uses a special sensor to provide accurate feedback, the cost of a Kinect system is understandably high. In order to actually play fitness games and receive feedback, a user also needs to purchase an Xbox system in addition to a Kinect sensor. Altogether, a Kinect sensor and Xbox system bundle costs $399 [19], a hefty price for the convenience of an at-home workout and the effectiveness of an in-person fitness class.

The most similar product overall, however, is a smartphone app called FitNet. While the user works out to one of FitNet's prerecorded workout videos, FitNet uses the smartphone's camera to analyze the user's performance during a workout and provide live feedback in the form of a numeric score calculated from a scoring system [2]. ***Figure 1*** demonstrates FitNet's user interface. The user can be seen working out in the upper-left corner and the orange dots and score are indicators of his performance.

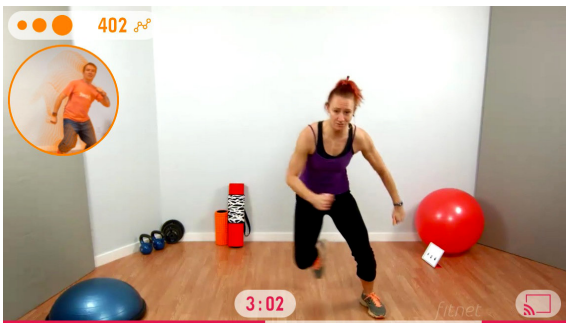


Figure 1: This snapshot of FitNet shows how the user receives feedback as a score while following along to the pre-recorded workout video. [2]

The main goal of FitNet, however, is to allow fitness trainers to stay in contact with their clients. Fitness trainers have access to their clients' workout scores and can communicate feedback through the app [15]. In the future, it aims to move away from camera analytics and rather will send data to the trainer who will provide live feedback [2]. The app is free to download, but costs about $0.99 to $1.99 to participate in fitness challenges on the app. Currently, the app is compatible with the iPhone, iPad, and Android smartphones [5].

2.2 Poze vs. Competitors

Although many of Poze's competitors in the market aim to address the same problem of maintaining a healthy and fit lifestyle with limited budget and time, Poze carves a niche for itself in the fitness market by specifically targeting the consumer group of young women who workout to yoga and Pilates videos on Youtube. Unlike fitness clubs and gyms that require one to actually be physically present at a location, Poze allows users to have the freedom to exercise whenever and wherever they choose. Also, users can save time by cutting out the commute to a physical location. Although workout DVDs and video games on the Kinect and Wii also allow flexibility with workouts, Poze still has several advantages over these competitors. Workout DVDs are unable to provide the user with personal feedback during the workout, but Poze, on the other hand, aims to increase the effectiveness of at-home workouts by providing motivational and

form-correctional feedback. The Kinect can provide accurate feedback during workouts with its special camera, but its price-tag makes the product out of reach for some users. Poze, however, uses technology already available to the majority of the market. Almost everyone has a laptop with a webcam and access to the Internet. In addition, Poze is offered at a much cheaper price. Overall, Poze is much more accessible product, especially for young women in college who may lack consistent access to technology such as the Kinect.

Poze's main competitor, FitNet, is definitely a developed product in the market that cannot be ignored, but Poze aims to distinguish itself by focusing on specifically providing qualitative live feedback rather than a numeric score. A score does not provide sufficient information on how to improve one's form and workout performance, so Poze hopes that by providing descriptive feedback, users will actually understand how to exercise more effectively. In addition, instead of restricting the user's choice of workouts to only those made by trainers who use the app, Poze allows the user to receive feedback from workouts they had already been doing from videos on Youtube. For the millions of subscribers who are already following these videos from fitness trainers on Youtube, transitioning to Poze is intuitive whereas switching to an app that contains its own pre-recorded workout videos risks alienating users who may not like the app's workouts. Essentially, Poze has two advantages over FitNet: it provides more specific and detailed live feedback that helps users maintain or improve the effectiveness of their workouts and it has a better chance of attracting and retaining users as it allows users to exercise to a wider range of workout videos that they are already familiar with.

In summary, Poze has the potential for success in the fitness industry because it targets a very specific niche of young women who work out to Youtube Pilates and yoga videos and because it is more affordable, more convenient, and more efficient than its competitors.

3. Approach

3.1 Key Idea behind the Product

The initial key idea behind our product, Poze, is a website that provides an affordable tool for young women to get real-time feedback as they follow along to free yoga and Pilates videos on Youtube. By using the webcam from the user's laptop and computer vision techniques, Poze can track the user's movements while the user exercises to a Youtube workout video. It can detect, for example, when the user begins to slow down and will respond with the appropriate feedback immediately to ensure that the user is maximizing the efficiency of the workout. To use the features of Poze, a user must first make an account on the website. When the user wants to exercise, she selects from our selection of Youtube workout videos. After starting the video, the user will workout along to the video while verbal feedback is generated by Poze based on the data captured from the webcam of the laptop.

3.2 Business Model and Marketing Plan

Although we firmly believe that Poze has the potential to succeed in the fitness industry due to its unique features and target market, we understand that simply creating a high-quality product will not ensure the success of our business. As a result, we created a business model and marketing plan for Poze in order to ensure its commercial success. Before creating the model and plan, we first examined our target market to understand the size of the market as well as who our "perfect" user would be. ***Figure 2*** depicts the global health club industry revenue from 2009-2014 in billions of US Dollars:

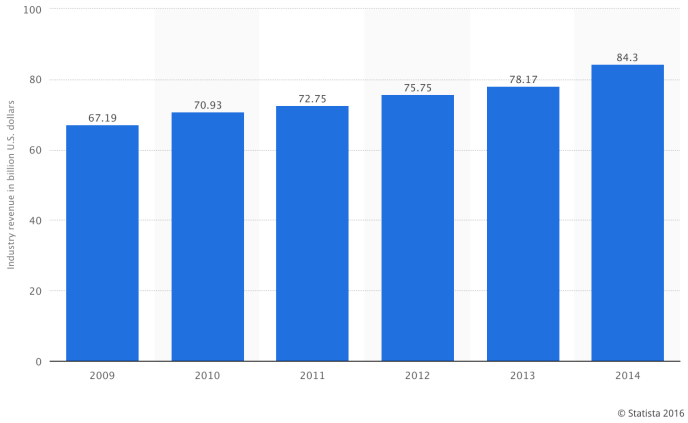


Figure 2: Global Health Club Industry Revenue (2009-2014) in billions of dollars [8]

From the graph, we can see that there is a clear upward trend in revenue that is already in the billions. Most recently, in 2014, the global health club industry revenue was 84.3 billion dollars [8]. The International Health, Racquet, and Sportsclub Association estimates that, locally, in the United States, the total industry revenue (gained from memberships and fees of physical locations such gyms, fitness centers, and studios) grew by 7.4% to $24.2 billion in 2014 [9]. IBISWorld estimates the annual revenue from fitness DVDs to be about $297 million [10]. Based on these estimates, we can conclude that Poze has the chance to make a significant profit by entering into the fitness industry.

Poze, however, does not intend to capture the entire fitness industry, but rather, hopes to carve out its own section in the billion-dollar industry. We hope to focus initially on the Youtube subscriber community because we estimate that it has an untapped audience of around 10 million people as just one popular Youtube Pilates fitness guru can have upwards of 2.5 million subscribers. Blogilates, for example, one of the most popular fitness channels on Youtube, currently has 2,718,440 subscribers as of 1/1/16 [20]. As previously mentioned, the switch from working out to these videos on Youtube to working out to the same videos on Poze is easy and intuitive, and so, Poze will be an attractive option to these millions of subscribers.

Additionally, Poze hopes to attract the demographic of young women who currently have memberships at fitness centers or attend classes at studios. As ***Figure 3*** shows, 35% of the fitness market comprises consumers between the ages of 18 and 34. If 50% of those consumers are female, then the estimated market segmentation is 17.5%, around $4.5 billion [1].

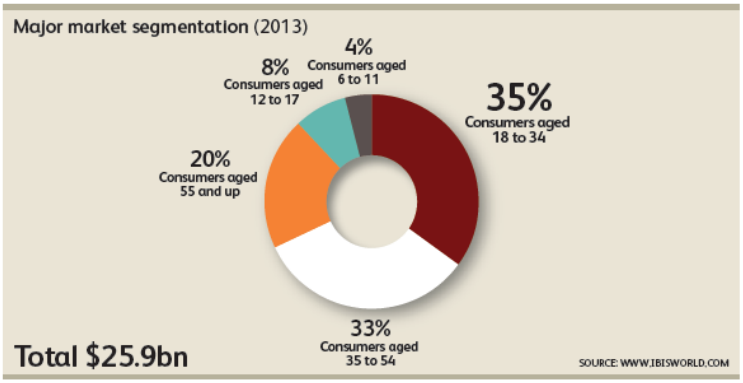


Figure 3: Market Segmentation of the Health/Fitness industry in 2013 [1]

Therefore, we can conclude that, by targeting the demographic of young women between 18-34 and current subscribers on Youtube, Poze is carving out a sizable market for itself.

Although statistics and data have definitely shown that Poze has the potential to attract a substantial user base and make significant profit, how exactly will Poze achieve this potential? Our business model for this product is to make Poze a subscription-based service. Users will pay a monthly or annual fee for access to Poze, but in order to initially attract users, Poze will offer a free trial subscription. In addition to charging users for access, Poze will also provide the option to Youtube fitness gurus to pay to be featured on the site. Youtube fitness gurus have the incentive to form this partnership with Poze because it will build up their client base. Users will be more likely to subscribe to their channels now that they can receive live feedback through Poze's camera analysis. By following this model, Poze will be able to generate revenue through two channels: the users and the fitness instructors.

Poze's marketing plan aims to attract the demographic of young women who want to maintain healthy and fit lifestyles, but struggle to do so due to limitations such as busy schedules, lack of easy access to facilities, or lack of money. A typical female college student, for example, would be Poze's perfect user. College students typically are loaded with work sand also have limited budgets. A lot of students who work out to Youtube videos in their dorm rooms, however, will often find themselves cheating workouts and losing motivation without a product like Poze to provide live feedback. Because college students are the perfect users for Poze, our marketing plan aims to first target this demographic, starting with Princeton University. Marketing the product on Princeton's campus will involve sending out emails to ListServs, posting in Facebook groups, as well as potentially working with Dillon Gym to advertise Poze. After establishing a strong foothold on Princeton's campus and proving that Poze has the ability succeed, we aim to spread to other college campuses through a Campus Ambassador program. Eventually, in order to expand to young women outside of colleges, we will use online marketing tools such as Google AdWords and social media to share Poze with a nationwide audience. With this marketing plan and business model, we are confident that Poze will have the ability to attract a large consumer base and carve its own niche in the health/fitness industry.

3.3 Pitch Deck: Attracting Investors

One of the key components to the success of Poze is a powerful pitch deck. The slides of our pitch deck can be found in the Appendix. In the first slide, our tagline, "A product that will change the way you workout at home" sets up the general direction of the pitch while also grabbing the attention of the audience. We first explain the problem that we hope to address with our product by using eye-catching images of familiar brands and numbers on slide 3 to convey the idea that maintaining a healthy and fit lifestyle is trendy but expensive. We then transition

into our discussion of the market size on slide 5 to demonstrate that, despite high costs, people are still willing to spend money on fitness. With its promise of a major profit, this slide helps us attract potential investors. In slide 6, in order to focus specifically on Poze's target audience, we narrow down to the Youtube community and provide an estimate of the size of that market. With this slide, we wanted to demonstrate that Poze does not intend to capture the entire fitness industry, but rather will focus on a smaller, but still significant portion of the market, which is much more feasible. Next, on slide 7, we present a high-level description of Poze that accurately summarizes all its features without delving into detailed specifics so as to avoid confusing or losing the attention of potential investors. Slide 8 presents a brief overview of competitors to give an accurate representation of the current market and what Poze must distinguish itself from. The pitch then transitions into a discussion of the business model and marketing plan in slides 10-12 to persuade investors that Poze has the ability to succeed as a business. We chose to describe our perfect user on slide 11 so as to provide a clear idea of the demographic we hope to target. In slide 13, we describe some metrics that we plan on using to measure the success of Poze as a business. Lastly, slide 14 presents some background on the team as an insurance to potential investors that we have the ability to build and execute this product and business. Altogether, the pitch deck presents the information and evidence necessary to convince investors and future consumers of Poze's potential for success.

4. Implementation

4.1 Stack

Poze's stack is composed of MEAN.JS and Python. The website itself was created using MEAN.JS, an open-source full-stack Javascript framework that uses MongoDB, Express, AngularJS, and Node.js. MongoDB is the database that stores information such as user accounts.

AngularJS, Express, and Node.js work in conjunction to run the web app. The data collection and analysis of the webcam recording, however, is a Python script that is run in a Python shell through Node.js. In the following sections, the paper will go into more depth about specific design choices and how these features were implemented.

4.2 Pose Estimation

The process of pose estimation and body tracking can be essentially summarized as data collection. The goal is to take input from the webcam, track the body within the frame, and output positions of points on the body. Because my partner was responsible for this section of the product, this paper will not go into great detail about pose estimation and instead will provide a general overview of the implementation process and final result. Initially, my partner used a combination of computer vision algorithms from the OpenCV library. In order to obtain the positions of points on the body that are moving, she used background subtraction to create a mask of the parts of the user that is moving in the video [12]. Then, she used key-point detection to find points within the mask that are good for tracking [4]. Finally, to track the movement of these points, she used Lucas-Kanade optical flow [14]. Through these algorithms from the OpenCV library, she was able to obtain x, y coordinates of the points within the frame, from which she calculated the velocity of these points to indicate how fast the user is moving at that moment. In addition to body tracking and speed calculation, she has also tested the use of the Pre-Trained Cascade Classifier to track certain body parts such as the head and feet [13].

4.3 Pose Analysis and Feedback System

After implementing pose estimation, we now had the coordinates and velocities of multiple points on the body in each frame of the video. While my partner was responsible for tracking the body from the webcam and obtaining data, I was responsible for implementing the

data analysis and feedback system. Originally, our goal had been to compare the user's form to the fitness instructor's form in the Youtube video and provide live critique so the user could adjust her form during the workout. Because we expected that being able to compare the forms of the user and the fitness instructor and provide accurate feedback would be very difficult, we also had a contingency plan in which we would focus on providing more motivational and less form-correctional live feedback. During the process of implementing pose estimation, we discovered few viable computer vision algorithms available that could accurately track a user's entire body from a webcam recording at a fast enough speed to provide real-time feedback. As a result, we had to adjust our plan for Poze and instead switched our feedback system to aim to provide motivational feedback based on the data from the points we could track in the video.

This data analysis was done through calls to a function from the main function that tracked the points in each frame. With every frame, a call to the changeInVelocity() function would be made and an array of velocities of the points in the current frame would be passed to the function. The function would then update an array that contained the running total of velocities for each point for the past fifteen frames. The function also updates an array that keeps track of the running total of velocities for the entire time that the points had been tracked. Once fifteen frames had been examined, the function would then calculate the percentage change between the average velocity of each point in the last fifteen frames and the average velocity of each point over the entire period of time it has been tracked. If the percentage change exceeded a threshold of 45%, the Python script sent back the message, "Don't slow down! You can do it!" and breaks out of the for loop examining each point to ensure that the same feedback is not given more than once for each frame. Then, the program updates the array of running total velocities with the total velocities from the last fifteen frames and returns back to the main function. Before

the voice recording was integrated into the feedback system, the message was simply printed from the Node.js server on the command-line. Additionally, the number of frames per comparison and the percentage change threshold were selected through experimenting with various combinations to determine what yielded the most accurate and timely feedback. The details and results of this experiment will be further discussed in section 5.

A major issue that had to be accounted for, however, was the possibility that the implemented OpenCV algorithms would lose track of the points. This unfortunately occurs regularly and so the camera must reprocess and find new points every time that the old points have been lost track of. In addition, the program will sometimes discover a new point to keep track of in addition to the old ones. As a result, to avoid comparing velocities of different points after new points have been discovered, if the camera reprocessed or if the length of the array containing velocities of current points differs from the length of the array containing the running total velocities of points, then the program will reset the velocity arrays and restart the calculation in velocity change. Before accounting for this possibility, the program would run into issues in which the new velocity array that was passed into the changeInVelocity() function was a different size than the array that kept track of the running total, resulting in an IndexError in which the list index was out of range and causing the program to crash.

4.4 Website

Although the final website is built on MEAN.JS, I first attempted to build the website using Meteor, a full-stack JavaScript App Platform, because of its ease of installation and initial set-up. Meteor, however, despite having a simplified “getting-started” process that made it easy to write a single page web app, resulted in complications later on when I attempted to use Meteor

in conjunction with AngularJS and when I tried to add multiple pages to the site. Integrating AngularJS, which I am familiar with, with Meteor was not intuitive.

As a result, I switched to the MEAN.JS stack. The MEAN.JS stack allows for the creation of websites that are more complex than a simple one-page web app since it organizes the numerous files necessary for creating a site built on MongoDB, Express, AngularJS, and Node.JS into an intuitive folder system. As a result, by setting up the integration of the four database/frameworks already in its basic source code, MEAN.JS makes it easy for the coder to start building the website and ensures that there are no issues in the foundation of the site later on when the site expands and the number of files increase. To set up Poze, I pulled the MEAN.JS source code from GitHub [22], which provided the files for a basic starting point, and using Bootstrap, built the following pages that are accessible without an account on Poze:

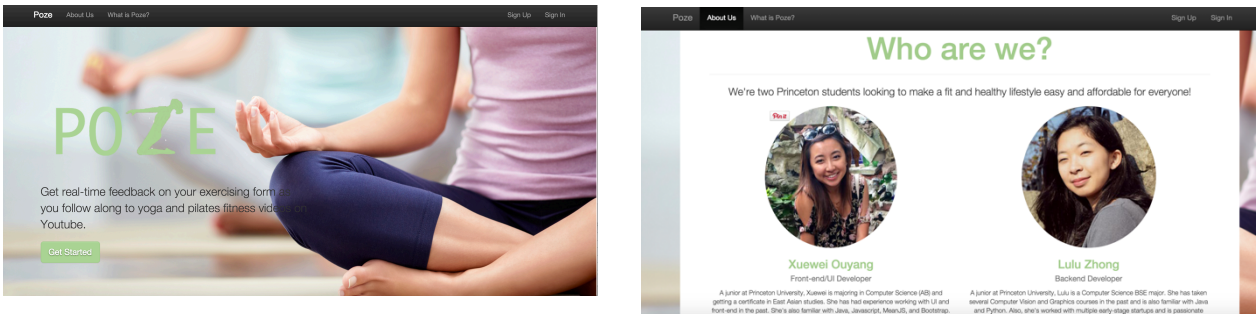


Figure 4: Home page, and About Us page (left to right)

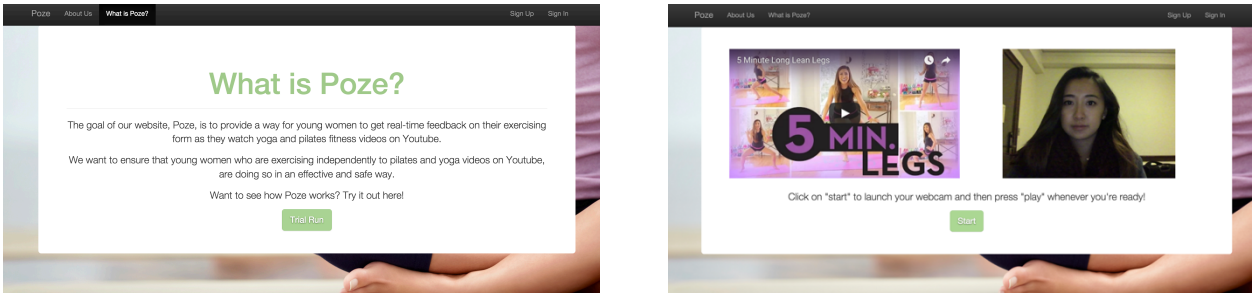


Figure 5: About Poze page and Workout-Feedback page (left to right)

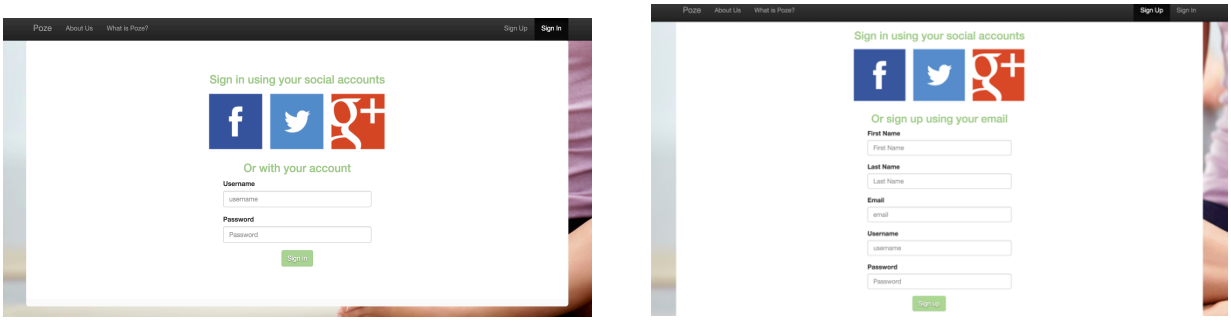


Figure 6: Sign In page and Sign Up (left to right)

Currently, the user account system is functional and users can create and login to their accounts on Poze, but no user-specific features or pages have been created yet. The Poze live-feedback system is currently only running on the trial page as depicted in ***Figure 6*** above. The user arrives at a page with the selected video, and presses play to launch the webcam and begin the workout feedback system and program.

Because the program for pose estimation and feedback is written in Python, I was able to integrate the program to the website by using a node package called python-shell which allows Python scripts to be run from Node.js [21]. When the user clicks the "Start" button on the website, it calls the front-end function in the Angular controller, which then makes an API call to the server function. In this server function, a PythonShell instance is created, which then runs the Python script for pose estimation and analysis. Whenever the Python script prints something, the server function receives it as a "message" event through the PythonShell and can then act accordingly. An issue that I ran into with this PythonShell method, however, was that the messages from the Python script would not be received in Node.js immediately and rather would all print out at once after a period of time. I discovered that this could be easily fixed by flushing StdOut in the Python script after every print message.

Once the server function receives the feedback prompt, it has to be able to play an audio feedback clip. We decided that the best method of feedback for Poze would be through audio so that the user can continue working out without any interruptions such as pop-up notifications. Originally, I attempted to play sound by having the server function send a text response to the API call from the front-end function and once the front-end function received this response, it would play the feedback audio. Because the Python script is a continuously running program, however, it sends more than one message back to the server function, which cannot repeatedly send responses to the same API call. Therefore, instead of playing audio through the front-end, I decided to play audio through the server function. After trying out several node audio packages that all turned out to be for front-end use, I found that the best way to play audio on the server-side is to decode the mp3 file into raw PCM data using a node package called node-lame [17]. Then, the program uses a node package called node-speaker [18] to pipe the raw PCM data into a "writable stream instance" that outputs the data to the speakers. Because the audio depends on the feedback from the Python script, when the node server receives a message from the Python script, the program checks to see if the message is feedback or an error. If the message is feedback, then the program does the conversion of the mp3, which plays "Don't slow down!", and creates a new Speaker() instance to play the raw PCM data.

5. Evaluation

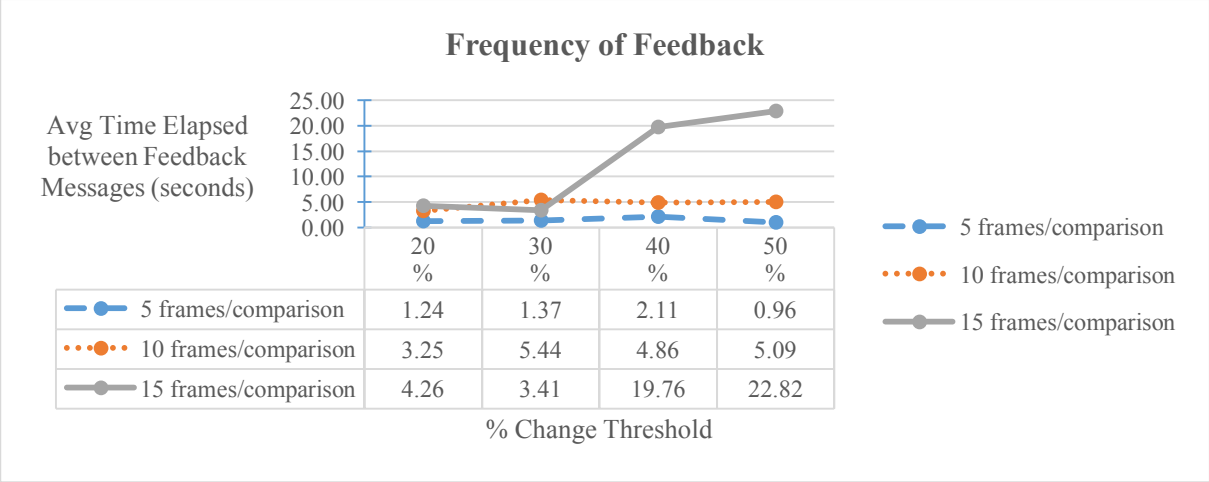
5.1 Testing design

In order to quantitatively test and evaluate our product Poze, I focused on the two main factors that had the largest impact on speed and accuracy of the feedback: the number of frames per comparison and the threshold for the percentage change in velocity. Although other factors from the pose estimation could have possibly affected the feedback, we cannot change the

algorithms themselves in the OpenCV library, and so the data analysis portion has the largest effect out of the factors we have control over. To test the data analysis, I ran the program multiple times while varying either the number of frames per comparison and or the percentage change threshold. In order to eliminate as many possible outside factors other than the frames/comparison and threshold, the program was run with the same exercise (plié squats) in the same location. I started the squats at the speed of the movements in the test Youtube fitness video, "5 Minute Long Lean Legs" by Blogilates (roughly one rep per second), but after forty seconds had elapsed, I slowed down to half speed and continued for another forty seconds. The program printed out the percentage change for every comparison made and the time elapsed between each feedback message sent. It also prints out the average percentage change and average time elapsed between feedback messages.

5.2 Testing results

The results of the testing are depicted in the following figures:



	20 %	30 %	40 %	50 %
5 frames/comparison	1.24	1.37	2.11	0.96
10 frames/comparison	3.25	5.44	4.86	5.09
15 frames/comparison	4.26	3.41	19.76	22.82

Figure 7: Average time elapsed between feedback for different thresholds & frames/comparison

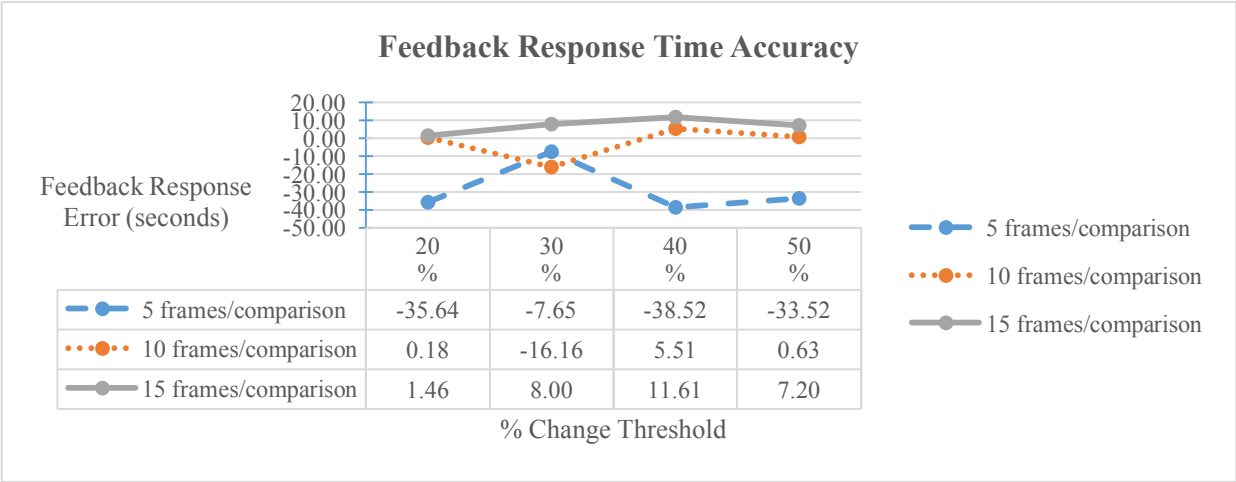


Figure 8: Error in response time of initial feedback for different thresholds & frames/comparison

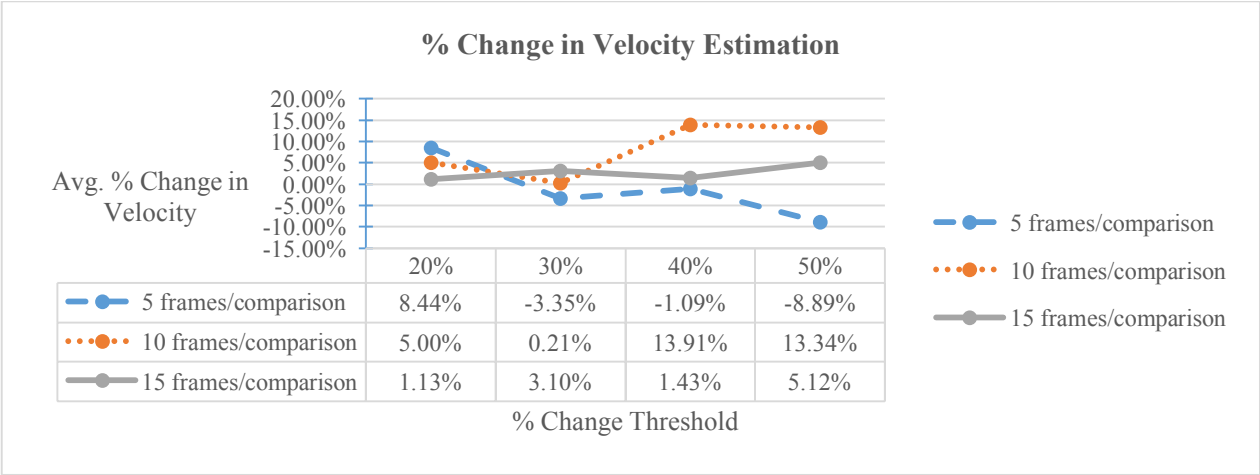


Figure 9: The accuracy of % change in velocity estimation for different thresholds & frames/comparison

Figure *7* shows how the frequency of feedback messages varies based on the percentage change in velocity threshold and the number of frames being compared each time. When either 5 or 10 frames are used in the comparison, regardless of the percentage change threshold, the average time between feedback is usually under five seconds. The average time between feedback messages for 15 frames, however, increases to 20 seconds and 22 seconds when the percentage change threshold increases to 40% and 50% respectively. The longer average time between feedback is better in this case as too frequent feedback can be more of a nuisance to the

user than an aid. Based on this measurement of feedback speed alone, the ideal threshold is 40-50% and the ideal frame comparison size is 15.

While **Figure *7*** evaluates the frequency of feedback messages, **Figure *8*** evaluates the accuracy in the feedback response time. During the testing, the squats were timed so as to slow down to half speed at the 40-second mark. The program printed out the elapsed time between the start of the program and the sending of the first feedback message. The data in the graph was obtained by finding the difference between the expected first feedback message time of 40 seconds and the actual first feedback message time. The 5 frames comparison size resulted in feedback messages very early on when the moves had not yet slowed down. This indicates that comparing 5 frames at a time gives an inaccurate prediction of when the user starts to slow down. The 10 and 15 frame comparison sizes, however, were better predictors of when the user actually begins to slow down.

Figure *9* shows the average percentage change in velocity of the entire workout for different combinations of thresholds and frame comparison sizes. This test was mean to evaluate the overall accuracy of the program in estimating the percentage change in velocity. The threshold should have had no effect on the average percentages because the averages were calculated with every comparison regardless of whether it resulted in a feedback message. From the data, we can see that the 5 frame comparison size is the least accurate as it calculated that the average change in velocity was negative, indicating that the user generally sped up during the video, which was not the case. The 10 frame comparison size and the 15 frame comparison size both had all positive percentage changes, and so correctly predicted that the user slowed down, but the 10 frame comparison size's average percentage change in velocity varied greatly ranging from 0.21% to 13.91% while the 15 frame comparison size remains relatively consistent in its

calculations. From this, the 15 frame comparison size provides a more consistent and accurate estimation of the change in velocity.

Based on these three evaluations, I concluded that the best frame comparison size is 15 frames and the best percentage change threshold is 45%.

5.3 Metrics

In addition to testing the quality of the product, we also wanted to measure the entrepreneurial success of Poze and so we decided to focus on four main business metrics: number of users, amount of user activity, customer feedback and profit. Tracking the number of users will give us an estimate of the popularity of Poze and whether it is widely known and used. The amount of user activity, however, provides more information about the quality of Poze. A large user base with little to no user activity clearly indicates that users do not find Poze useful in helping them with their fitness goals. Additionally, customer feedback from surveys can also give us a direct idea of the views of users toward the product. Lastly, because Poze is a for-profit business, the amount of profit is also important in determining how well Poze is performing in the market.

5.4 Survey Feedback

Because Poze has not actually been launched as a product in the market, the metrics described in the previous section can be considered as part of the potential business model. In order to evaluate Poze as a product, however, we created a survey to ask for feedback and commentary on the Poze's website user interface. The survey asked respondents to rate the appearance and ease of use of several website pages and provide written feedback about what could be improved. All respondents gave the appearance of the pages a rating of 3 or higher on scale of 1 to 5 with 5 as excellent. In addition, more than 60% of the respondents rated the ease

of use of the website at 1 or 2 in a scale of 1 to 5 with 1 being very easy and 5 being extremely difficult. Several respondents provided helpful suggestions and feedback on how to improve the site, however, including providing clearer instructions at the start of the workout on how the feedback system works, mirroring the webcam video on the page, and also changing the font on the home page. Overall, survey feedback indicated a general satisfaction with the simplicity and ease of use of the website, but pointed out some issues that would be great for future development.

5.5 Further results needed

Although the tests conducted on the program provided significant insight about the accuracy of the program as well as the user opinion of the product as a whole, there are definitely more tests that can be done to evaluate Poze. More extensive surveys with a greater sample group can give us a better understanding of areas to improve on in the user interface. As for evaluating the program itself, running the tests from section 5.1 on different exercises can be used to determine the types of body movements that Poze works best for. Also, testing the program on various body types and in different environments may also help us better understand Poze's limitations.

6. Conclusion

Poze was originally designed as a website that provides a way for young women to have the option of working out effectively in the comfort of their own homes to fitness videos on Youtube. By providing live feedback during workouts, it ensures that women can reap the same benefits as working out at an expensive gym or fitness class for a much cheaper price and at greater convenience. Although we had to adjust our original plan of creating a feedback system that could provide correctional feedback after comparing the user's form to the fitness

instructor's form, we were able to successfully deliver the minimum viable product, a website that uses the webcam to analyze a user's movements while she follows along to a Youtube video and provides motivational feedback. Poze's ability to detect a change in the user's speed of movement still allows it to provide valuable audio feedback to ensure that the user completes a workout at the appropriate speed, therefore maximizing the efficiency of the workout. The testing I conducted also confirms that the program works accurately enough to respond with feedback at appropriate times. All in all, Poze has the ability to successfully deliver the basic version of the feedback system it aims to provide to users.

Poze, however, still does face certain limitations in its current implementation. Because our program is dependent on the OpenCV library functions, its ability to estimate the pose and track the body of the user is limited by the quality of these algorithms. If the algorithms are unable to find good tracking points on the body and keep track of them in a setting with poor lighting, for example, Poze's feedback system, unfortunately, also cannot provide accurate feedback. In addition, while running the program, Poze occasionally runs into an error, "Camera dropped frame!", which is outputted by the OpenCV algorithms themselves. The error does not cause the program to crash, but causes the camera to reprocess, resulting in a delay in tracking the points. Besides the limitations resulting from the OpenCV algorithms, Poze also currently has limited feedback messages available. Since it can only detect when the user slows down, it only outputs one audio feedback stating "Don't slow down!" Lastly, the website itself runs locally using the node server, but has not been hosted on an actual site yet.

Despite its current limitations, however, I believe that Poze has the potential to succeed as a business with further development. Future research on improving pose estimation would include finding or developing better ways of tracking the body and estimating the user's form

than the current OpenCV library provides as well as leveraging pose estimation on pre-recorded videos so that the user's movements can be compared to those of the fitness instructor. Once we improve pose estimation, we can continue to pursue form-correctional feedback and determine how to best evaluate a user's technique during a workout. In addition to development of the back-end algorithms, we would also continue improve the UI of the website and add additional features, such as a search page to browse for videos. With these further improvements, Poze can definitely become a viable product in the market and revolutionize how women maintain fit lifestyles.

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8. Honor Code

This paper represents my own work in accordance with University regulations.

- Xuewei Ouyang

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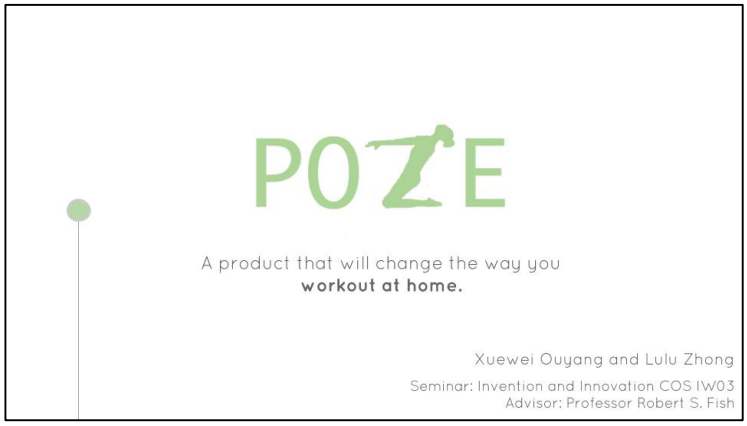
Appendix

Slide 1

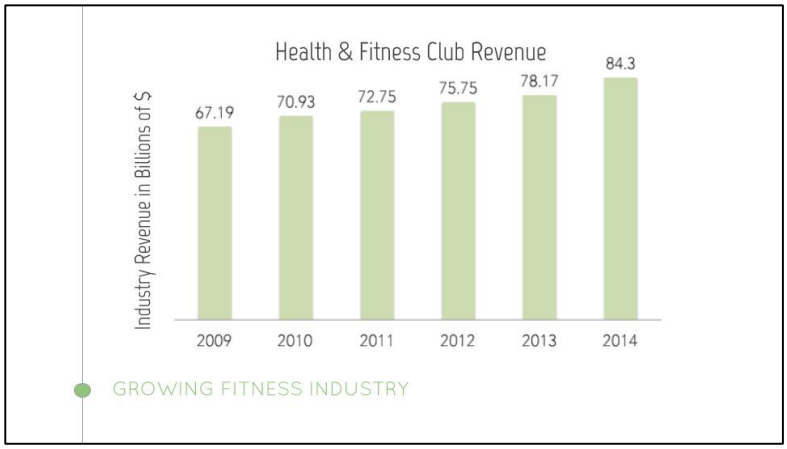


Slide 2

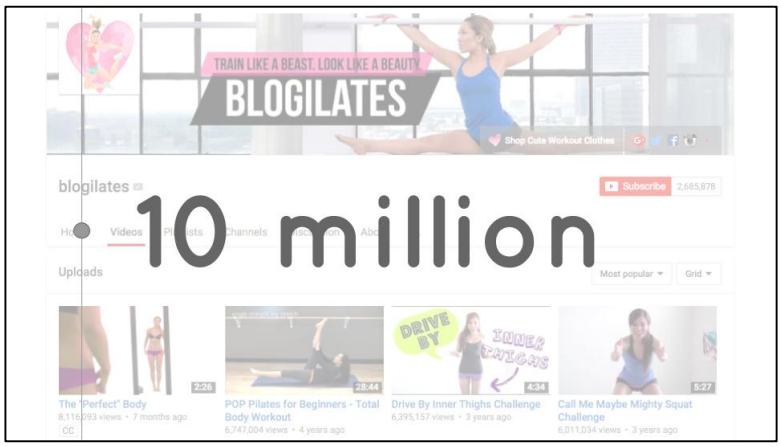
Slide 3

Slide 4

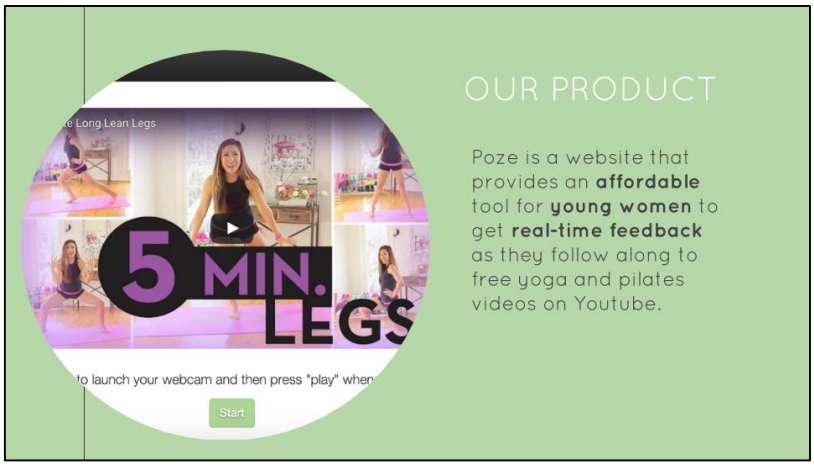
Slide 5



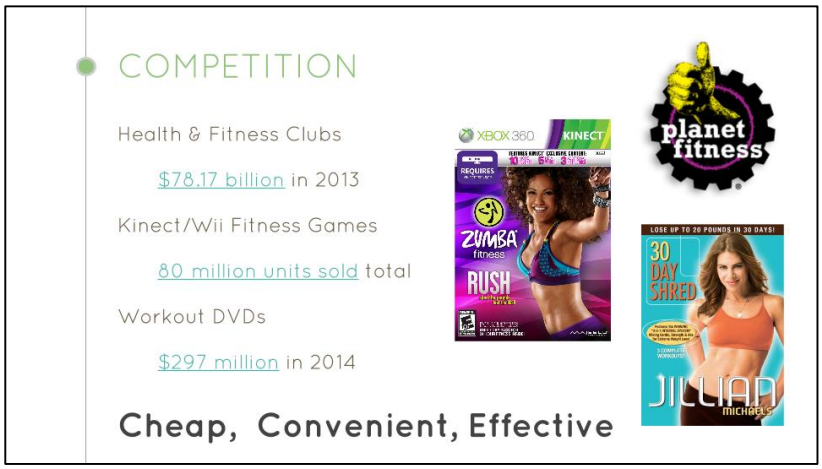
Slide 6



Slide 7



Slide 8



Slide 9

Slide 10

Poze is a **subscription based** service.

Users pay a monthly/annual fee for access to our product.

Youtube fitness instructors pay for their videos to be featured on our site.

To initially attract users, we will offer a free trial subscription (Spotify model).

BUSINESS MODEL

Slide 11

Meet Erika!

Junior at Princeton University

She tries to exercise everyday...

She curses Blogilates, but the workouts are too good!

However she finds herself cheating the workouts...

Slide 12

MARKETING/DISTRIBUTION

1 Start with Princeton campus

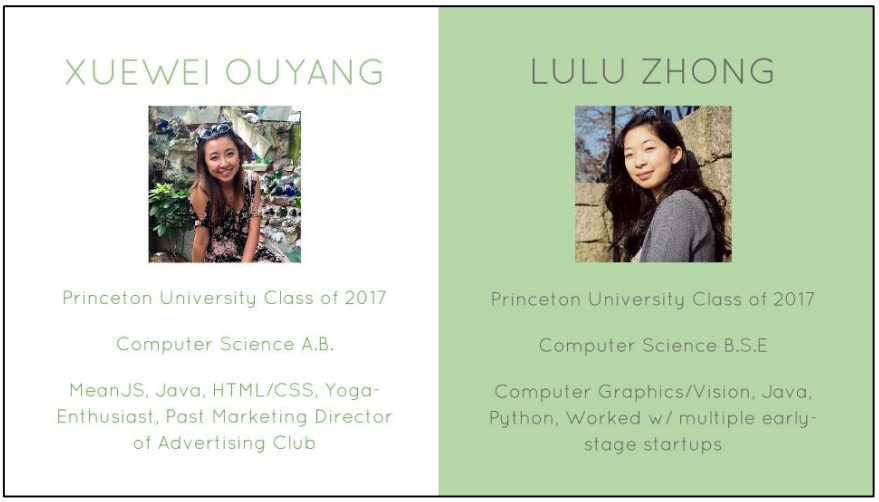
2 Reach out to Youtube Fitness Gurus

3 Spread to other campuses! (Campus Ambassador Program)

4 Google AdWords/Social Media

Slide 13

Slide 14



Slide 15