ANDROID PHOTO DIET LOGGER

Natasha Benkovich, Kaitlin Brendel, Aaron Freis, Matt Hoffman, Vincent Mi

Client: Professor Wally Block

Advisor: Professor Mitch Tyler

December 8, 2009

Table of Contents

ABSTRACT

This project proposes a different approach to promote healthy eating. Possible methods of accomplishing this are discussed along with the final design, a photo diet log implemented as a Smartphone application. The diet log works by having the user take pictures of their food and distinguish the different categories of food present in a given meal. Overall it is not about counting calories but rather focuses on portion size and relative amount of food categories consumed.

PROBLEM STATEMENT

Obesity is the fastest growing expense in the Unites States healthcare system. It manifests itself in serious problems in nearly every organ system in the body. Often individuals are advised to keep a log of their diet to better appreciate what and how much they are eating or as part of a nutritional study. However, self-administered logs are notoriously inaccurate and hard to maintain even over a short interval. Written logs are also especially cumbersome for younger individuals.

BACKGROUND

Approximately 60 million Americans are obese, and the number continues to climb despite growing awareness on the issue (AOA, 2005). The magnitude of the epidemic is shown in Figure 1, which shows the obesity percentages of individual states. Obesity has become a leading cause of cardiovascular disease, diabetes, and cancer.

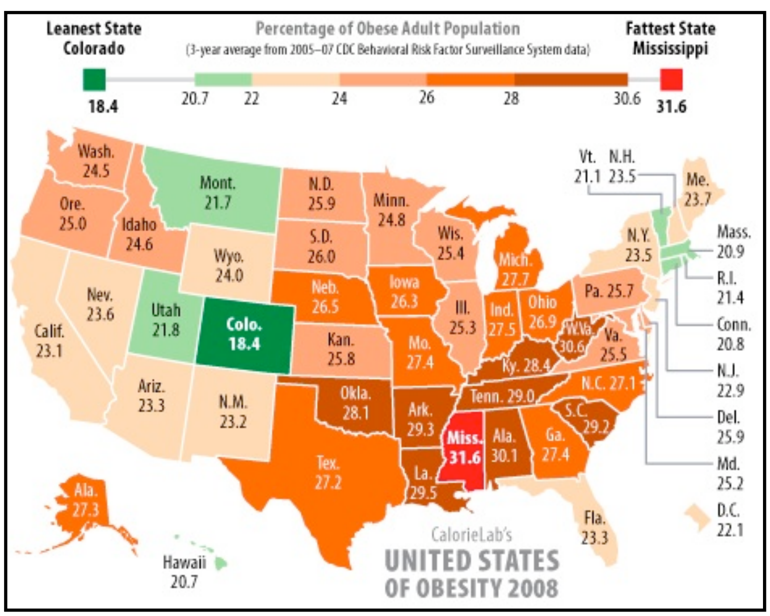

Figure 1: Percentage of Obese Adult Population (Alter, 2008).

According to the American Heart Association, obesity causes hypertension, which greatly increases the risk of cardiovascular disease (AHA, 1998). Obesity is directly linked to 75% of hypertension, which accounts for 92% of cardiovascular disease (AHA, 2009).

Obesity also puts pressure on the body's ability to properly control blood sugar (via insulin) and increases the chances of developing type 2 diabetes. Approximately 90% of people with type 2 diabetes are obese (Obesity Society, 2009). In 2001, experts concluded that cancers of the colon, breast, uterus, kidney, and esophagus are all associated with obesity (NCI, 2004). It appears to be caused by the added adipose cells release of hormones that promote uncontrolled growth of cells—which can lead to tumor growth (WellcomeTrust, 2004).

It should then come as no surprise that dieting programs and diet logs have become a $40 billion per year industry in the United States (Reisner, 2008). Dieting programs range from Weight Watchers to Atkins, while diet logs range from a simple pen-and-paper technique to electronic calorie counters. Dieting programs are highly controversial and very different, all claiming to assist the user in losing weight. The diet logging devices range from simplistic techniques to advanced programs that attempt to provide the user with complete nutritional information—albeit at the expense of the user's time and dedication to the device.

Numerous competitors already exist in the diet-logging market, from online websites to traditional written journals. Often times the user is required to know the exact type, amount, and preparation method of each food they ate which is tedious and difficult to do accurately. Some are free and others require a paid subscription. Examples of diet logging websites include: www.fitday.com, www.my-calorie-counter.com, www.caloriecount.about.com, and www.calorieking.com. Programs that are not web based that can be used on small electronics such as Smartphones also exist.

Despite the heavy competition in the diet logging and dieting market, we see a recurrent problem that needs to be addressed. The tediousness of the electronic diet loggers—and manual ones, for that matter—leads to low compliance with such devices. In today's fast-paced society, users cannot be expected to take the time to record every gram of food they ate, or how many ounces of juice they drank.

Recognizing the problem with current diet logs, the National Institutes of Health (NIH) has stepped in to offer a grant to whoever can come up with a solution. This grant has been posted since 2005, but is still available. In addition to the NIH, there are many other governmental organizations backing the grant, including the National Cancer Institute (NCI), the National Institute of Child Health and Human Development (NICHD), and the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The purpose of the grant is to improve upon the current diet and physical activity logs that are assessed for clinical research purposes. The current self-reporting instruments used are "cognitively difficult for respondents, and are prone to considerable measurement errors" (NIH, 2009).

SPECIFICATIONS

Our client's idea of an ideal diet-logging program will allow the user to make their own judgments on their health. It avoids the strict rules and guidelines that current dieting programs elicit, in an effort to increase compliance. While the product would not provide inherent recommendations on food consumption, the log could be part of a research study. The research study would allow outside assistance with dieting habits. In order for the design to be used in a research study it must exhibit the ability to allow an outside researcher to customize the product for their intended use. These goals are in line with Michael Pollan's book, In Defense of Food (Eat food. Not too much. Mostly plants.), which is where our client devised the original idea.

Using these guidelines, the product should focus more on qualitative categories rather than quantitative values—that is to say that food groups (such as vegetables, fruit, meat, etc.) are more important to achieving the product's goal than calories. In addition, the initial focus will be on college-aged young adults (ages 18-25). College is a crucial time for beginning to eat right since it is the first time that a person is forced to make their own choices about food. Therefore this product must be made easily accessible to the college-aged demographic.

Using these client requirements as our baseline, we created our own set of design requirements (Appendix – Product Design Specifications). A brief summary of such requirements follows: the application will be accessible on a Smartphone capable of taking pictures with a touchscreen interface, due to its popularity with the demographic. Since the application is being built as a research tool, its accuracy, reliability, life in service, and other production characteristics are ultimately limited by the size and length of the research study. The user population is restricted to users with basic computer/Smartphone literacy—which can be inferred from the demographic. However, the application will aim to be intuitive, keeping in line with our main goal of making a simpler diet log.

DISCUSSION OF ALTERNATE DESIGNS

The progression of our design development was somewhat different from the standard design curriculum. Instead of developing an initial number of designs and comparing them all at once, we continuously built upon initial ideas to achieve various end products. While in the end there were three distinct designs, two of the three were determined unfit for our client's specifications, or for our team's ability. The progression of the development of the two rejected designs is outlined in the following two sections.

Design 1 – Website

The website idea originated through the (relative) simplicity of using HTML code and building a website, as opposed to other electronic platforms. This initial appeal became more attractive as we sculpted the design into various forms, intended to alter the types of foods people eat. While diet logging was the initial cornerstone of the project, the more research completed into current diet logging methods revealed how difficult it would be to improve the compliance problems. This was coupled by the fact that the Nutritional Sciences Department at the University of Wisconsin—Madison did not support the claims we had hoped for in our product, or Michael Pollan's beliefs from *In Defense of Food*. The design of the website thus transformed into a whole new product.

The first part of the website, and realistically the bulk of the home page, would be a blog-based element. The blog section would provide interesting articles and suggest new habits toward eating healthy and/or losing weight. An example article would be "Does drinking ice water help you lose weight?" These articles would have to be found and updated by our team, and could perhaps be paraphrased on our site to highlight the most interesting points of the corresponding article.

The second part would be specific to the University of Wisconsin—Madison campus, although it could be expanded to larger audiences in the future. In this section, the user of the site could access a restaurant and grocery database that would provide healthy options for eating out, dining in, and buying groceries. It would incorporate calories, food type, location, ratings, and user comments into the mix. In essence, a user could ask where they could find the healthiest pizza in town, and the site would direct them to it.

While encouraging and innovative, this first design has several pitfalls. Number one, it involves questionable biomedical engineering. Writing HTML code, creating databases, and searching/paraphrasing articles is a difficult task, but not a suitable biomedical engineering design project. Second, the website would require high upkeep with articles and restaurant/grocery maintenance, and with graduation looming, would be difficult to maintain the website in the future. Finally, and most importantly, nutrition and health guidance is a huge industry in America today, and there is a lot of controversy surrounding the subject. Therefore, it is not in our best interest to decide for our user population what constitutes a healthy pizza, for instance. Is it the ingredients? Calories? Fat? Sodium? We are not versed well enough in nutrition to enter the health argument at this juncture.

Design 2 – Food Probe

After the failings of the first design, alternatives needed to be created. A unique and attractive idea was that of a food probe. The probe could be incorporated into essentially anything—from tooth fillings to eating utensils—and would classify the food as you ate it. This was more consistent with our design specifications, because it would log the food into qualitative categories. The classifications/categories would be developed based on a difference in the voltage potential of different foods.

The details of the plan would be to send a small signal into the food at one terminal of a small circuit within the probe, and receive the output signal at the other terminal. This signal would then be amplified and processed to develop a voltage reading corresponding to a category. The theory behind the device is that various foods will conduct electricity in different ways. One would expect a piece of steak to offer a different impedance than a stalk of broccoli. The impedance (and therefore voltage output) could be used to classify foods into groups. This is a similar technique to impedance plethysmography, although incorporated on the scale of a meat thermometer (or smaller).

While an attractive futuristic endeavor, this design also had several shortcomings. First, while the device would be highly qualitative, it would lack any opportunity to be quantitative. This poses a problem. While it would be capable of logging various food groups eaten, this is essentially irrelevant if the quantity of that food is unknown. Second, there is no known impedance-food group correlation curve available for use. This means that for our device to work, we would need to do extensive testing to determine this relationship. Furthermore, presuming we could experimentally develop a relationship between impedance and food groups, this relationship could easily be overruled by something as simple as a splash of water on the food, or differences in the time the food is cooked. It is no small task to account for the conductivity that something like soup would exhibit. Because of these reasons, it is clear that the feasibility of the food probe design is very low.

FINAL DESIGN – ANDROID PICTURE-BASED DIET LOGGER

As determined in the proceeding sections, our original designs did not fit the scope of our project well. Therefore, we developed a third design, which incorporated ideas from both. We used the electronic interface from the website design, built into a Smartphone application instead of a website, and used the categorization determination from the food probe design, with more qualitative ability to the design.

Android Platform

The third design uses the Android platform, a rival to Apple's iPhone applications, as its basis. Android is an attractive platform because of its low developer cost (in relation to Apple) and because of its wide-ranging capabilities in the near future. Verizon wireless, the second largest cell phone company in the United States, just launched Droid—a phone that threatens to rival the iPhone by improving on its predecessor's shortcomings. Albeit the AT&T/Cingular network is still the largest in the United States, the iPhone's use is limited to this carrier. Android, on the other hand, currently has over 20 different phones on the market, 12 of which are available through different cell phone companies (androphones.com, 2009).

Camera Screen

If the user opens the application and touches the 'Take Picture' button, the camera view screen opens. When the select button is clicked, the picture is taken and is then saved to the phone's SD card. The drawing screen is overlaid onto the photo as shown in Figure 3. The user can then draw on the picture using their finger to draw shapes around each different type of food in the meal. Once a shape is completed, the user can then select the category of food from the drop-down menu at the top of the screen. Since the picture is taken and saved, it does not require immediate categorization, which is an attractive feature for the busy lives of young adults.

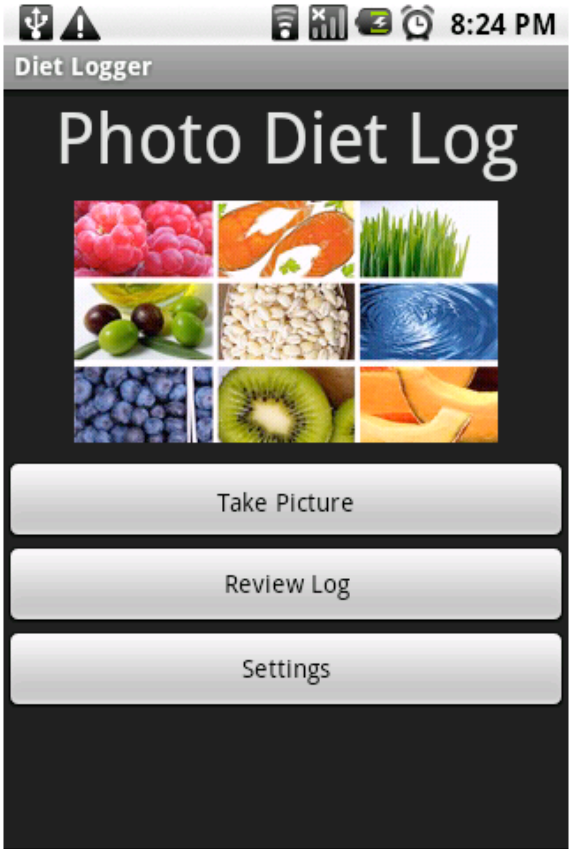

Figure 2: Main menu of application

Review Log

At the main menu screen, if the user selects ‘Review Log’ a slideshow of all of the photos taken and saved by the diet logger application will be displayed. From this screen, the user can press the ‘Menu’ button on the phone to have the option to edit the picture currently being viewed. If the user selects this edit option, the drawing layout will be displayed on the photo as shown in Figure 3, as it was on the camera view screen. The user will then be able to edit the picture as if they had just taken the photo.

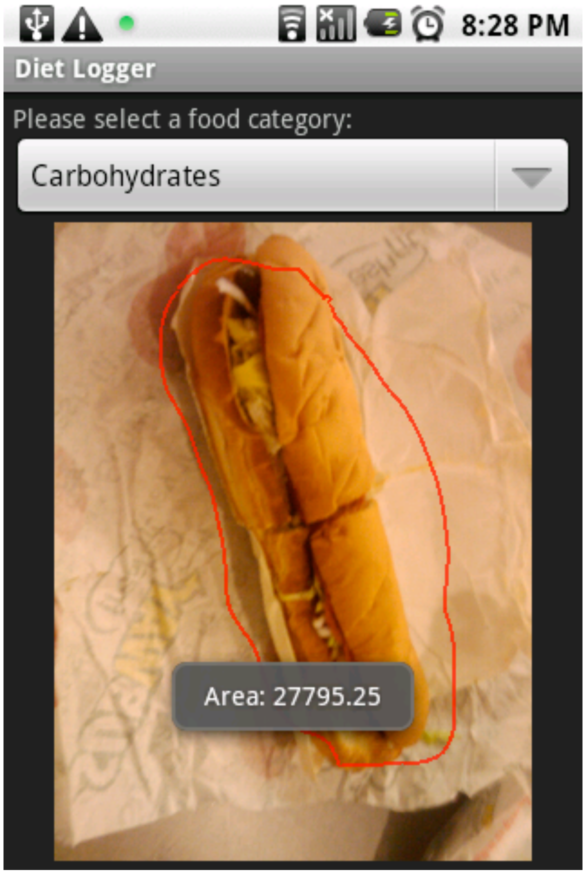

Figure 3: Drawing layout

Area Calculation

Following the trace of food categories in a meal, and the selection of a food group category, the corresponding area displays as a pop-up message. The area is calculated using a polygon approximation formula. The program stores all of the vertices from the trace into an array and enters them into Equation 1 to compute the approximate area (Beyer, 1987). To ensure accuracy, and because the program is designed to be used as a research tool, the pictures can be reviewed by an outside researcher. The researcher will determine if the categorizations and tracings look correct.

$$A = \tfrac{1}{2}\,(x_n\, y_n - x_2\, y_1 + x_2\, y_3 - x_3\, y_2 + \ldots + x_n\text{-}1\; y_n - x_n\, y_n\text{-}1 + x_n\, y_n - x_n\, y_n) \qquad \text{(Eq. 1)}$$

Settings

Currently the ‘Settings’ button opens a mock settings menu which includes options to change the food categories as well as a ‘review options’ button which will eventually allow the user to change the viewing options of the weekly review.

FUTURE WORK

There are several aspects to the Smartphone application that we would like to improve upon. These include developing user-customizable categories, a weekly summary, a database for log storage, and compensation for varying meal size.

A better user interface will incorporate certain developments. One such development is to implement user-customizable categories. Default category settings for our program utilize the government's food pyramid, but it is prudent to allow the user to modify these categories (USDA, 2009). For instance, if the user would like to distinguish between simple grains and whole grains, the custom categorization would allow them to do so. Customizable categories are ideal because then our program can be tailored to a research study or an individual.

The next user interface component to be developed is the Review Log. Our program will offer an end-of-week, end-of-month, and end-of-year summary in the Review Log. Currently, our application cannot offer practical assistance to the user because they cannot easily determine the relative amounts of food groups they have eaten in the past. Therefore, implementing a feature such as this would make the application astronomically better for marketability and research purposes. The Review Log will consist of a slideshow to allow the user to see what they have eaten in a certain time period. Following the slideshow, a pie chart or some other form of graphical display will show the user how much of each food group they have eaten, according for the time period chosen.

Along with the user modifiable aspects we need to develop the background processes of the program. In order to store the photo diet log with the correct food categorizations and areas a database will need to be created. The photos in the database will be accessed for the slideshow gallery as well as the review summary. Area values will be used for calculations of the relative frequencies of food eaten.

Another background aspect is compensation for varying meal sizes. There are several possible ways in which to accomplish this. One method involves user selected sizes of meals. This method allows the user to select a meal size: small, medium or large. A potential concern associated with the selection of meal size is maintaining consistent meal sizes among users. However, one would assume that a user would remain consistent throughout their individual definitions. This is sufficient for our purposes because ratios are solely compared for one person's diet. The researcher has access to the user's database of photos and area information and could suggest changes if desired.

In order to calculate how often a category of food is eaten the method of user selected size will be used. The various sizes would provide standard values for the sum of corresponding areas (small = 1, medium = 2, large = 3). The percentage of food category for each meal is determined by dividing the category pixel area by the total enclosed pixel area; this accounts for variation in photo distance. This percentage is then multiplied by the value of the meal size. The total weighted area of the category over time is then divided by the total weighted areas of all categories. An overall percent of the food category in relation to all food eaten is obtained. Percentages are calculated as follows:

PA_{food} = Pixel area of selected category of food

PA_{total} = Total pixel area of drawn shapes on picture

V = Value for meal compensation ($V_{small} = 1, V_{medium} = 2, V_{large} = 3$)

$$\%_{category\ per\ week} = \frac{A_{category\ total\ per\ week}}{A_{total\ \ for\ all\ categories\ per\ week}}$$

and

$$A_{category\ total\ per\ week} = \sum \left(\frac{PA_{category}}{PA_{total}} \right) V$$

where

$\frac{PA_{category}}{PA_{total}} * V$ is weighted area of one category in one meal

Overall:

$$\%_{category\ per\ week} = \frac{\Sigma \left(\frac{PA_{category}}{PA_{total}} \right) V}{A_{total\ for\ all\ categories}}$$

ETHICAL CONCERNS/USABILITY

Since our application leaves much of the recommending up to the user, there is not much to worry about as far as ethical concerns. In addition, provided the application is used in a research environment, the user would be expected to understand that all of their data is at full disclosure to the researcher. It would be important, however, to ensure that individual food logs are not distributed to anyone other than the user and researcher involved, for privacy reasons.

As described in the product design specifications, the user must have basic Smartphone knowledge to use the device. This should not be a problem for the average college-aged young adult. More importantly, the user must be relatively educated in nutrition and food groups, since much of the categorization and tracking is on their own. This is a bit of a hurdle, since the structure of the standard food pyramid has changed some since the college-aged population was taught on it in the 1990s. Therefore, it may be important to provide a short tutorial on how to categorize the more difficult foods. In addition, compound foods such as pizza or soup have many categories to them, and the user would be expected to make accurate judgments on the relatively quantities (i.e. relative tracings) involved. This could be implemented in the tutorial as well, to give “average” values of various food groups for common college foods.

Another big usability concern involves the researcher(s) in question. Since the application is based on user customization and alternative dieting, the researcher(s) would need to be open to alternative eating styles. In other words, they cannot be strict nutritional scientists that live or die by the food pyramid. Finding researchers that fit this description may prove to be the most challenging portion of our project. It may be difficult to find someone well-enough versed in nutrition, but still open-minded enough to accept a lack of calorie-counting in their analysis.

CONCLUSIONS

What began initially as a loose framework centered around Michael Pollan's ideals from *In Defense of Food* has become a well-developed prototype. The current product works as an application for Google's Android mobile operating system, an ideal platform for college-aged students with Smartphones. The application utilizes the phone's camera capabilities to create a snapshot recording of what the user eats, to eliminate the guesswork that inevitably occurs with creating diet logs from memory. This snapshot can then be accessed later, where the user traces around individual food groups to categorize what he/she has eaten. The tracing is recorded as *x-y* coordinates, which are used in matrix form to calculate the areas of each food. With the extension of some more functions in the near future—such as weekly reviews—this product provides a great alternative to conventional diet loggers for the fast-paced young American.

REFERENCES

1. Alter, L. (2008, July 10). *You are where you eat: Obesity maps of North America*. Retrieved from Treehugger website: http://www.treehugger.com/files/2008/07/you-are-where-you-eat.php
2. American Heart Association (AHA). (2009, November 16). *Cardiovascular Disease Statistics*. Retrieved from http://www.americanheart.org/presenter.jhtml?identifier=4478
3. American Obesity Association (AOA). (2005, May 2). Obesity in the U.S. [Fact sheet]. Retrieved from http://obesity1.tempdomainname.com/subs/fastfacts/obesity_US.shtml
4. Beyer, W. H. (Ed.). CRC Standard Mathematical Tables, 28th ed. Boca Raton, FL: CRC Press, pp. 123-124, 1987.
5. National Cancer Institute (NCI). (2004, March 16). What have scientists learned about the relationship between obesity and cancer? Obesity and Cancer: Questions and Answers [Fact sheet]. Retrieved from http://www.cancer.gov/cancertopics/factsheet/Risk/obesity#ques4
6. National Institutes of Health (NIH). (2009, July 9). Improving Diet and Physical Activity Assessment (R01) [Program announcement]. Retrieved December 1, 2009, from http://grants.nih.gov/grants/guide/pa-files/PAR-07-259.html
7. The Obesity Society. (2009). Your Weight and Diabetes. Retrieved from http://www.obesity.org/information/diabetes_obesity.asp
8. Reisner, R., & Thompson, D. (2008, January). The Diet Industry: A Big Fat Lie. Business Week. Retrieved from http://www.businessweek.com/debateroom/archives/2008/01/the_diet_indust.html
9. United States Food and Drug Administration (USDA). (2009). MyPyramid.gov. Retrieved from http://www.mypyramid.gov/
10. WellcomeTrust. (2004). How does obesity cause ill-health? Retrieved from http://www.wellcome.ac.uk/Education-resources/Teaching-and-education/Big-Picture/All-issues/Obesity/Articles/WTX023503.htm

Appendix

Project Design Specifications

I. Problem Statement

Obesity is the fastest growing expense in the United States healthcare system. The condition can cause problems in nearly every organ system in the body. Often individuals are advised to keep a log of their diet as part of a nutritional study or to better appreciate what and how much they are eating. But self-administered logs, particularly written logs, are notoriously inaccurate, cumbersome, and difficult to maintain for a significant period of time. The inadequacy of current diet logging methods can be seen in the amount of dieters who fail to reach their weight loss goals. In this project we will design a system for use by a younger audience, ages 18-25 that will make diet logging fast and easy, as well as focus less on the exact amount of food eaten and more on diet trends.

II. Client Requirements

- a. Develop a diet-logging program, different from what is available, that helps people to see what they are eating and make their own judgments, rather than force them to subscribe to a dieting program.
    - i. Push toward smaller portions
    - ii. Less processed food and more plants
- b. Focus on relative amounts of categorized food groups, rather than quantitative amounts.
- c. Focus on college-aged young adults—ages 18-25.
- d. Make it easily accessible to the demographic, method such as:
    - i. Smartphone application
    - ii. Web-based program
    - iii. Computer software program

III. Design Requirements

- a. Physical and Operation Characteristics:
    - i. Performance Requirements
        1. Minimum System Requirements
            - a. Smartphone with camera and touchscreen
            - b. Phone runs with Google Android operating system
            - c. Minimum screen resolution must be 240x320, smaller resolutions may work but may not be supported
        2. Accessibility

a. Application intended for research, further accessibility concerns will be addressed if application goes commercial
b. Basic computer/smartphone literacy of user expected

ii. Security
1. Software safe from viruses and hacks.
2. Privacy policy will be provided by researchers

iii. Accuracy and Reliability
1. Software code must be tested to ensure that it accurately tracks the selected areas
2. Software will be tested to prevent crashes and bugs
3. Quantity estimation and categorization can be corrected by researcher upon review

iv. Life in Service
1. Limited to client/user use
2. Ultimate lifetime limited by hardware

v. Aesthetics
1. Product must be visually appealing (appropriate use of color and layout)
2. Interface will be easy to learn and use

b. Production Characteristics

i. Quantity
1. Limited by size of research study
2. Ultimately limited by distribution method and hardware distribution

ii. Target Production Cost
1. Development and design time
2. $25 developer registration fee
3. $400 phone for use by development team in testing

iii. Testing Procedure
1. Goal is to test the product on the developer team
2. IRB approval will be required to test the product on other college students at the university.