Six-Minute-Walk Test iPhone Application

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1.0 Introduction

1.1 Background

Not surprisingly, the 6-Minute Walk Test (6MWT) is a walk test performed in a period of 6 minutes by patients with cardiopulmonary diseases. The primary measurement is the distance (6MWD) that the patient can walk as quickly as possible on a flat, hard surface. Currently the test should be monitored in a clinical setting of a 100-ft hallway (ATS, 2002). The 6MWD of each performance can be compared and analyzed with the standard data in order to indicate the health condition of the patient.

Following the 12-minute walk test in 1960s, the 12-minute walk test was altered to a period of 6 minutes instead of 12. This was done because the results of a 6-minute walk test remain accurate but the shorter period lowers the intensity of the course. Moreover, the 6MWT is easier to administer and better reflects activities of daily living than other walk tests (Enright, 2003). In preparation for the test, the patient should not have food intake, should be rested for 10 minutes preceding the test and should wear comfortable attire. During the test, the physicians must have easy access to any emergency agents such as an automated external defibrillator in case of emergency (ATS, 2002). Unlike other walk tests, the patients while performing the 6MWT can pace themselves under their own tolerance of the intensity, but the pause times should be recorded and taken into consideration after the test (Enright, 2003). Another important feature is the verbal encouragements. There is a set of standard phrasing of encouragement that the physicians will use at specific time intervals during the test to motivate the patients in their performance. Besides the measurement of 6MWD, patient's heart rate, dyspnea, fatigue, and SpO_2 (Pulse Oximeter Oxygen Saturation) will be looked at before and after the test to investigate the cardiopulmonary condition of the patient (ATS, 2002). In short, the results of the 6MWT imply the medical intervention in patients with various levels of cardiopulmonary diseases.

1.2 iPhone Functionality

Taking out the features and the benefits from the 6MWT, our objective is to create a similar test using an iPhone application that will generate 6MWT data in an at home setting. This data will be useful in assessing patient improvement by testing the patient before and after medical intervention. The standard iPhone has robust functionality to make this possible. Our application will utilize the multi-touch screen, accelerometer, 3G, audio and recording ability, data storage, and exportation to create a useful home test for functional exercise capacity.

1.2.1 Multi-Touch Screen

With the 3.5-inch (diagonal) widescreen multi-touch display, the users can softly touch the screen with their fingers rather than pushing the buttons. This technology enhances the ease of use when generating with the 6MWT since the patients can start/stop the test easier by tapping the screen than hitting a small button on regular mobile phone.

1.2.2 Accelerometer

The iPhone responds to motion using a built-in accelerometer. When rotating an iPhone from portrait to landscape, the accelerometer detects the movement and changes the orientation of the image on the screen accordingly (Wilson). Several existing applications have taken the advantages of the accelerometer in the iPhone and merged it with pedometers, video-playing, and game system. The accelerometer feature in the iPhone will be used in calculating the patient's walking distance. This is possible because the change in orientation of the device while walking will create an acceleration that can be picked up by the accelerometer, turned into a vector quantity, and therefore detect a step (preliminary acceleration graphs can be seen in appendix 8.3). Moreover, the option of rotating the screen will also give an additional option for patients to view the results in a wider screen display.

1.2.3 3G Network

3G technology gives the iPhone fast access to the Internet. With support for 7.2Mbps HSDPA, the latest iPhone 3GS allows the users to connect with the Internet while talking on the phone (Apple, 2009). This network will be required for the exportation of the data after performing the 6MWT, as well as being able to access to any other relevant information and being able to contact the doctors via email.

1.2.4 Audio Recording

The headphone jack and speaker can also be taken into account to the design. The verbal instructions of the test and the encouragements can be delivered through the headphone jack or speaker to the patients. Along with the headphone jack and speaker, the microphone attached can be used for any audio recording.

1.2.5 Power Efficiency

According to the technology specification published by the Apple, the built-in rechargeable lithium-ion battery performs at high power efficient. The standby time has been up to 300 hours. While using the 3G network, it is up to 5-hour of usage (Apple, 2009). With the length of the 6MWT being short compared to these values, the power provided by iPhone is sufficient for our application.

1.3 Motivation

Despite the fact that this is an extremely powerful and research-proven test, it still has several aspects that ultimately led to the creation of our solution. Firstly, the test requires a technician or doctor to be present while it is performed this led to its steep cost of up to two-hundred dollars. Although this was insurance reimbursable, it presents a significant financial burden for those without insurance who would greatly benefit from routine tracking.

Secondly, the test is time consuming for both the hospital and the patient. Appointments have to be made in advance, long traffic time both ways, and waiting times when the patient actually reaches the hospital can add up to many times the amount of the actual test which just takes six minutes.

These two factors made it logical to redesign the six-minute-walk-test (6MWT) to take advantage of the current available technology so that its benefits can be more widespread. Combining the test with the iPhone or iTouch allowed three crucial benefits to arise. Firstly, if the application was available on the iTunes store along with a short description, there would be greater awareness generated for the test and the major diseases of its main users (COPD). Awareness, for this project, gives the patients another option for gauging their health. Secondly, the test gives the patient the flexibility to perform it at his/her own time and setting. A significant portion of the "middle-man" time would be cut out as the patient could perform the test on his or her own schedule. Finally, because the application is on the highly-trafficked iTunes store, it would be available to millions of people regardless of their condition. As long as they have a cardio or pulmonary ailment, this test can provide meaningful information for both the patient and the doctor.

2.0 Design Specifications

Our client, David Van Sickle, suggested some important requirements for this project. He noted that it was necessary to record and organize the data from the test so that patients can see progress over time. This would allow patterns to be observed and could provide opportunities for preemptive action. Next, there would also be periodic GPS calibrations. This would occur in the background when the test is taking place in which the GPS also keeps track of the distance walked. Due to the fact that the GPS can only be used outside, it is not our primary source of distance tracking although it may be more accurate. When the test is complete, the GPS distance can be compared to the pedometer distance and then the program would automatically calibrate threshold values for detected steps so that each time the test is completed, the pedometer becomes more accurate. Finally, the original 6MWT contained periodic encouragements so that feature will be included in the application as well.

In addition to our client's recommendations, it was also necessary to set up some specifications ourselves. First, the program must not be resource intensive. The accelerometer measurements have to be precise enough so that steps are accurately recorded without using too much battery life. From initial testing, a frequency of ten hertz appears to accurately catalog the steps while being power-friendly at the same time.

Another issue that arose was the availability and organization of the collected data. It was necessary to provide a method of cataloging the data into a central online database such as in a Google Health account. This way, general statistics about patients with specific diseases can be collected and compared as well as the fact that it provides the option for doctors to quickly and easily look up data on their patients.

A few safety concerns arose including the idea of distracting visuals on the screen while the test is in progress. Because the primary audience for the test is older individuals, having distracting visuals on the test screen can easily lead to distraction and possible injuries. If injury were to occur, it would be extremely helpful to have some method to contact others for assistance. This is why a large, easily accessible button to call the patient's emergency contact was implemented on our test screen, so that assistance for injury or other problems can be quickly addressed.

For the test itself, it required measurement accuracy to within five meters. This is because the distance measured is the primary statistic that is looked at when analyzing the 6MWT data. So, a large variability in the pedometer can lead to misleading results. In addition to accurate distances, the application must also be able to accommodate varying elevations that are traversed during the test. If a user were to walk up an inclined slope, the accelerometer should be able to account for this and adjust the threshold values for steps accordingly.

Finally, one of the most important aspects of the 6MWT is that the program must be easy to use for the patient. With an older and less technology-savvy audience in mind, the interface had to have an intuitive page flow as well as large, easily accessible buttons. Both Fitts' and Hick's laws were applied to our three designs and influenced the final decision of pursuing the "hybrid design".

3.0 Design Options

The three design ideas portray differences in the user interface (UI). Because the design must accurately measure the 6MWD and send data to a physician, these aspects must be consistent across all design proposals. Furthermore, focusing on the usability of the user interface is important for prototype success because most 6MWT patients have little to no experience with a smart phone. The three designs of our UI are wizard, branched, and hybrid. All of these designs contain the functional components, such as taking the test, viewing previous data, etc.

3.1 Design 1: Wizard

This design is similar to the wizard program that helps user's install software on their computers. This design is straightforward to use, and it is the most intuitive design. The user proceeds through the options in a predetermined order on a linear path, without the option to jump to other screens without going through several intermediates.

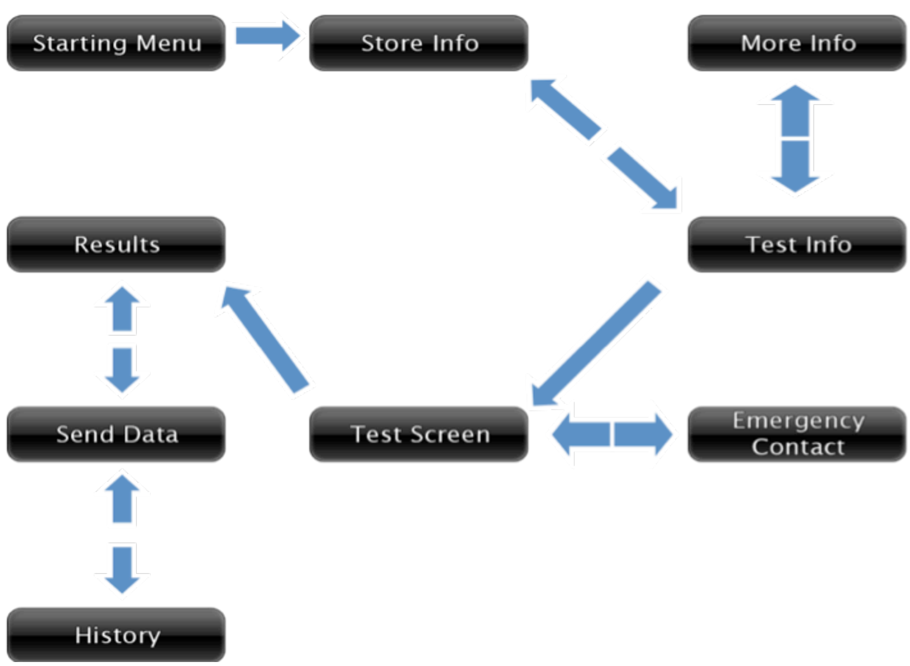

Figure 1: The Wizard Design

As you can see in figure 1, the wizard design also lets the user go back to change any information they may later determine to be incorrect. The "more info" and "emergency contact" options are the only options do not adhere to the linearity principle. In all designs, these two options cannot be part of the standard walk test. The "emergency contact" option should only be executed in the event of an emergency. While the user should already have an understanding of the 6MWT, the "more info" option is accessible for precautionary reasons.

This design received the highest speed rating from all of our sample users. The application of Fitt's and Hick's law also favored this design. Hick's Law is upheld because the number of choices on any given screen is low. Because there were few buttons, we were able to make the buttons larger, allowing a more favorable Fitt's Law value. On the other hand, the questionnaire filled out by the sample users showed little support for this option. User comments indicated this is because they often had to go through too many screens to get to the one they wanted.

3.2 Design 2: Branched

Our second design increases the usability of the user interface. This is accomplished by adding a menu option to the UI. The menu will allow the user more freedom to move around, making options easier, and in some cases faster, to execute. This design has little linearity in its structure. The degree of connectivity is large, and this allows the user to access other options while going through the absolute minimum of intermediate screens.

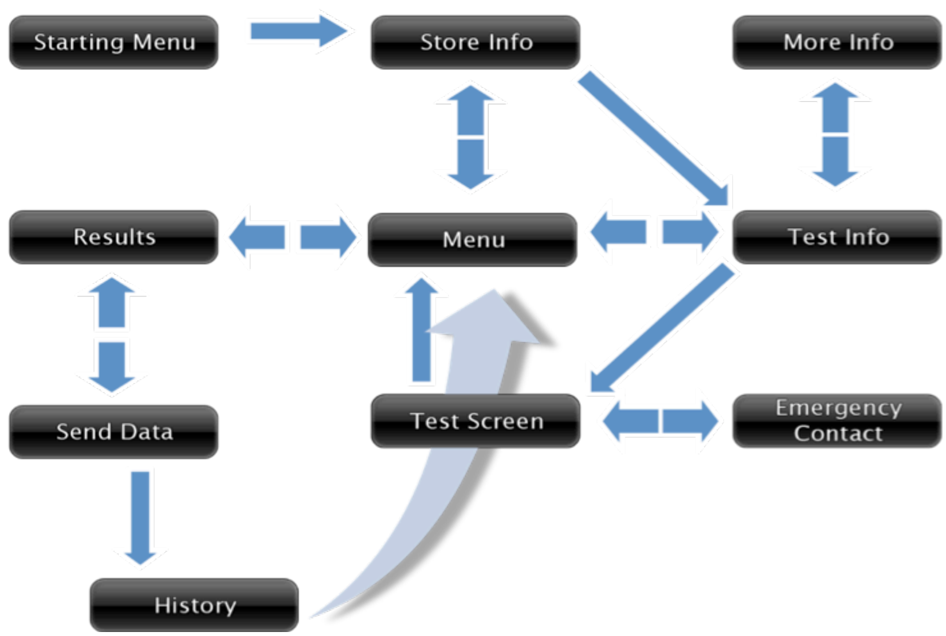

Figure 2: The Branched Design

The user is directed towards the "store info" options only with their initial use of the application. Subsequent uses will initialize directly at the menu screen. Five of the main options will be allowed to send the user back to the menu. The menu will allow the user to access three of the main options. The "more info" and "emergency contact" options have remained the same as in the wizard design. The only screens that must be viewed in sequence are the "test info" and "test screen" options. This is to re-emphasize the preparatory procedures the patient must perform for the test.

This design warranted the lowest score in the speed test among the sample users. This is likely because with so many options at each screen, the user had to take a longer time to decide which button to press to get to the indicated screen. Similarly, this large amount of choices led a lower Hick's Law value than the wizard. These added options also mean less room to expand buttons, which makes them smaller and more difficult to press. This is represented in a low Fitt's Law value. The branched design earned a mediocre score from the user questionnaire. User comments indicated that this design seemed similar to user interfaces they were used to, but had too many options to work smoothly.

3.3 Design 3: Hybrid

Our third design is a combination of the first two. The best design is one that would incorporate some of the user freedom of the branched option, while still guiding the user to their most likely desired screen. For the average user, an experience would resemble opening the app, taking the test, viewing results compared to previous attempts, and possibly sending this data to their physician.

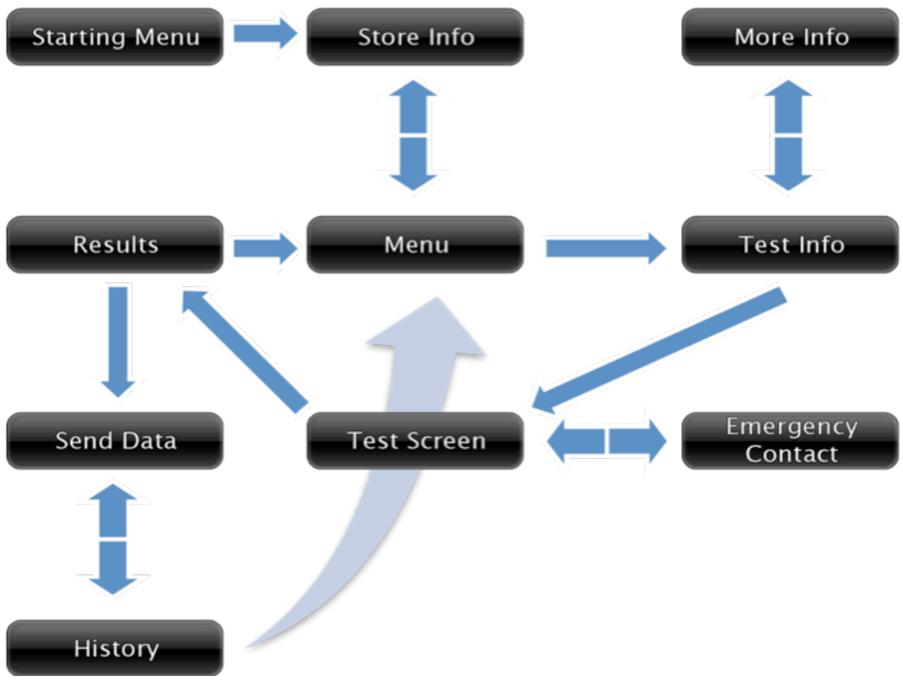

Figure 3: The Hybrid Design

Similarly to the first two designs, the user is asked to store their personal information upon initial use of the application. The menu option from the branched design was kept. This provides a "home base" where the user will be sent upon completion of the most common components of the application. Much of the user choice has been removed. This helps remove clutter from screens that had too many choices. This also helps direct the user to their most likely destination (the test screen).

Removal of user option warranted a much higher speed score than the branched design. The users found their way to the desired screen much more quickly and efficiently. As a consequence, the limited amount of buttons per screen achieved a higher Fitt's Law values than the branched design.

This design was the overwhelming favorite among our sample users. User comments indicated that this is because it is was similar to what they are familiar with, either in other iPhone apps, or other software user interfaces in general.

4.0 Design Matrix

Our design matrix focused on four main categories: Ease of Navigation, User Rating, Hick's Law Rating, and Fitts' Law Rating.

Table 1: Design Matrix

Category	Wizard	Branched	Hybrid
Ease of Navigation (40)	35	15	30
User Rating (40)	16	24	35
Fitt's Law Coefficient (10)	10	5	6
Hick's Law Coefficient (10)	10	8	7
Total (100)	71	52	78

4.1 Ease of Navigation

Our sample users directly determined the "Ease of Navigation" categories values. The test users were given a list of five of the most important aspects of the designs and asked to get to that option in the user interface. The users were then timed for each option. The average of all times for all users was then correlated to a value out of forty and inserted into the matrix.

4.2 User Rating

The sample users also determined the user rating category values. After they were done sampling the user interfaces, they were given a questionnaire. The questionnaire asked for a rating (1 – 10) of each user interface and to indicate a reason for the rating you gave. This rating was then adjusted to be out of forty and inserted into the matrix.

4.3 Fitts' and Hick's Law

In order to help decide between the three different interfaces, two tests were conducted to look at the ergonomics of these interfaces. The first of these tests was Fitts' Law, which was created in 1954, by Paul Fitts. This law models the ease of movement in human-computer interactions and assigns a number to the index of difficulty of a task. The equation of Fitts' Law is T = a + b(ID) but for our purposes we only used the index of difficulty (ID) portion of the law. The equation for the index of difficulty is $ID = \log_2\left(\frac{D}{W}+1\right)$ with ID being the index of difficulty, D the distance from the starting position to the button, and W the width of the button on the axis of movement (Beggs et al., 1972). To make the test as accurate and realistic as possible, the starting position was on the right side half way up the phone and remained constant for every screen on all three interfaces.

The other test performed was Hick's Law, which was created in 1952, by William Hick. This law was used to quantify the time it would take the average person to make a decision between the buttons on the screen. The equation for Hick's Law is $T = \log_2 (n+1)$ where T is the decision or reaction time and n is the number of buttons on the screen (Kirkby, 1974).

Both of these tests resulted in numerical values with the smaller numbers meaning the screen and interface were more user friendly. In order to use these values in our design matrix we needed to make the smaller values worth more. This was done by looking at the numbers relative to each other and then assigning each a value of one to ten.

Fitts' Law assigned the Wizard interface a value of 2.128, the Branched interface a 2.184, and the Hybrid interface a 2.173 (see appendix 8.2). These values resulted in the Wizard getting a 10, the Branched a 5, and the Hybrid a 6 in our design matrix. Hick's Law assigned the Wizard interface a value of 1.416, the Branched interface a 1.618, and the Hybrid a 1.737 (see appendix 8.2). These values resulted in the Wizard getting a 10, Branched an 8, and the Hybrid a 7.

4.4 Category Weights

Because the first two categories involved user input, they are rated significantly higher than the Hick's and Fitts' Law categories. The "Ease of Navigation" and "User Rating" categories were each given a weight of 40%, while the Hick's and Fitts' Law categories were given a weight of 10% each. The difference is so drastic because in the end we want to make this program user friendly. This is much more accurately determined through the use of experimentation than through analytical equations.

5.0 Final Design

The final design incorporates the automation of the 'wizard' and the choice of the 'branched'. Testing provided substantial feedback that lead the team to the final design. The sequence of screens of the final user interface is shown below in figure 4.

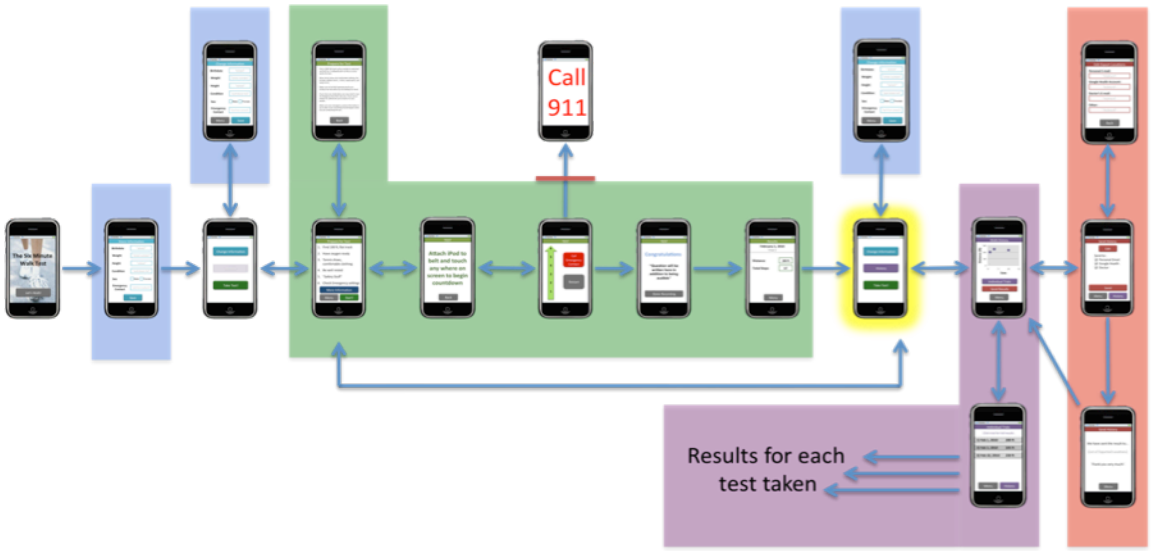

Figure 4: Flow of anticipated programming in page-by-page sequence. Blue sections refer to data entry, green to taking the test, purple to viewing history, and red to exporting data.

5.1 First use and main menus

Upon first opening of the application, the program will prompt the user to enter personal information pertinent to determined stride length and differentiating user from other patients in use of the program. After saving data, user will be taken to a menu page with options to either take the test or change their information. This menu (shown in figure 4 as un-highlighted menu screen) will be the default page upon opening the application until the user has completed at least one test. After the taking the test once the user will then be directed to a similarly designed page (shown in figure 4 as yellow highlighted menu screen) with the expectation that the 'history' button is activated.

5.2 'Change Information' button – blue section

The blue button on the menu page allows the user to change and save their personal information at any time.

5.3 'Take Test' button – green section

Once the user presses the 'Take Test' button, they are taken to the important preparation information page and are given the option to see more detailed instructions if needed. Following the 'go' button, the user will be prompted to attach their iPhone to their belt and then touch the screen to begin the test. During the test the user will be given audio encouragement at minute intervals and will be warned 15 seconds before the end of the test and be given instructions pertinent to the audio recording that will proceed (see appendix 8.4 for audio). When the test ends, the phone will vibrate and say, “STOP.” The next page will ask for audio input. When done recording user will be taken to a results page and have an option to proceed to the main menu.

5.4 ‘History’ button – purple (data) and red (export) section

Upon pressing the user will see a graph with data points that display their absolute distance traveled from each test over time. The user can flip the phone to see a larger graph and obtain more information by touching each data point. From the initial page (un-flipped) the user can either see the full results from each trial or export their data. The export page has an option to check box of locations that data will be sent to and the option to edit these locations. Upon sending data, the user will be given a list of exported locations and prompted back to the main menu.

6.0 Future work

Currently, the team has finalized the sequencing of the user interface and design sans minor apple preset related to button characteristics. The team will now focus on the programming of the interface and linking the program to additional iPhone functionalities.

One such functionality that our application will utilize is the iPhone’s built in accelerometer. We will use the accelerometer to derive the number of steps the user has walked within the six minute time period. From initial testing of the accelerometer (see appendix 8.3), the most efficient place to “mount” the iPhone in order to obtain independent readings from each step is on the belt. Further testing against a mechanical pedometer will be done to determine accuracy of these readings.

Additional research will be preformed to determine the most efficient method for doctor-patient communication and how to incorporate these methods into our application. Automatic emails sent to a 3rd party server, such as Google Health accounts, look promising. These servers have the ability to provide a patient with an individual account to log their data online, which would provide a better user interface than the iPhone, and also accumulate the data from the population of users for individual comparisons and research purposes.

The most vital work ahead is the coding of the program. The iPhone Developer’s Program’s Software Development Kit (SDK) will allow us to code specifically for the iPhone. We will use its drag-and-drop features to create the pages of our user interface and its coding section Xcode to link the pages and incorporate such other programs as the accelerometer. This work will require the majority of the team’s time spent working on the project.

Once the coding is complete, testing on a large population will begin. A more efficient and complete evaluation form will need to be created for these tests. Additionally, a separate test for only those who would actually benefit from the six minute walk test will be preformed to further pinpoint flaws in our design and make the test more accessible to this specific population.

7.0 References

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8.0 Appendix

8.1 Select testing evaluation forms

Design Interface Simulation Evaluation
Test Subject: Lindsey Meyer

Enter time at which task was completed

	1 (original)	**2** (H/S combo)	**3** (wizard)
Save Personal Information		.05	.20
Run Test		.30	all in
Send Data		.05	one
See Specific Trial History		.05	
Change Emergency Contact		.10	
Total Time	.30	.41	1.39

Enter 1(hard) – 10 (easy)

Ease of Use	6.3	8.5	5

no option to move home

Design Interface Simulation Evaluation
Test Subject: Grace Pitera

Enter time at which task was completed

	1 (original)	**2** (H/S combo)	**3** (wizard)
Save Personal Information	.04	clear	
Run Test			
Send Data	.04		
See Specific Trial History	.13	.09	
Change Emergency Contact	.03		
Total Time	1.02	.29	.40

Enter 1(hard) – 10 (easy)

Ease of Use	5.5	7	4

need more options after test

not clear that use history to exit

back to prep button confusing

very confusing

Design Interface Simulation Evaluation
Test Subject: Lauren Hudlitedt

Enter time at which task was completed

	1 (original)	**2** (H/S combo)	**3** (wizard)
Save Personal Information			
Run Test			
Send Data			
See Specific Trial History			
Change Emergency Contact			
Total Time	.40	.34	.31

Enter 1(hard) – 10 (easy)

Ease of Use	4	6	6

hated

ok

no control

8.2 Fitt's and Hick's Law analysis

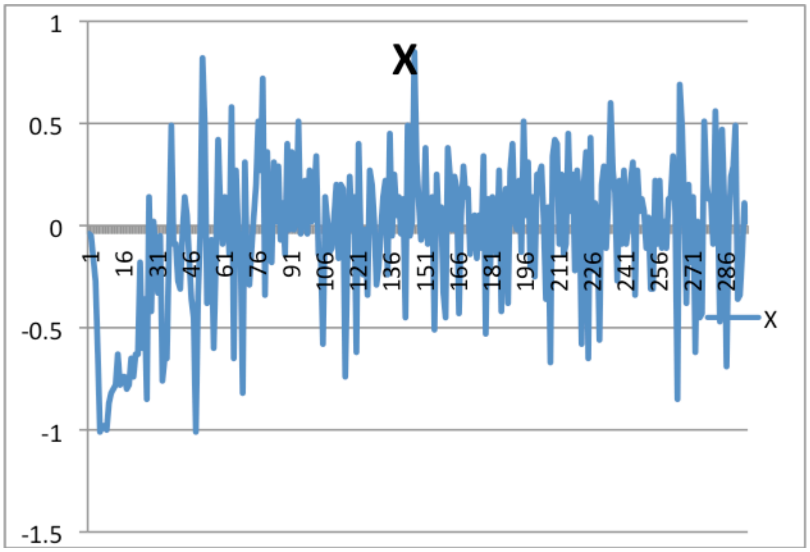
Hick's Law										
Hybrid				Wizard				Options		
Slide #	n	T		Slide #	n	T		Slide #	n	T
2	1	1		3	1	1		3	1	1
3	2	1.584963		4	7	3		4	1	1
4	3	2		5	2	1.584963		5	2	1.584963
5	8	3.169925		6	4	2.321928		6	4	2.321928
6	9	3.321928		7	3	2		7	7	3
8	3	2		8	2	1.584963		8	8	3.169925
9	5	2.584963		9	2	1.584963		9	2	1.584963
10	3	2		10	2	1.584963		10	5	2.584963
14	3	2		11	1	1		11	3	2
15	2	1.584963		12	1	1		12	7	3
16	2	1.584963		13	1	1		13	3	2
17	1	1		14	1	1		14	2	1.584963
18	1	1		15	1	1		15	1	1
19	4	2.321928		16	1	1		16	3	2
20	5	2.584963		17	1	1		17	3	2
21	1	1		18	1	1		18	1	1
22	1	1				1.416361		19	1	1
23	1	1						20	1	1
24	1	1						21	1	1
25	1	1						22	1	1
		1.73693						23	1	1
								24	1	1
								25	1	1
								26	1	1
										1.617988

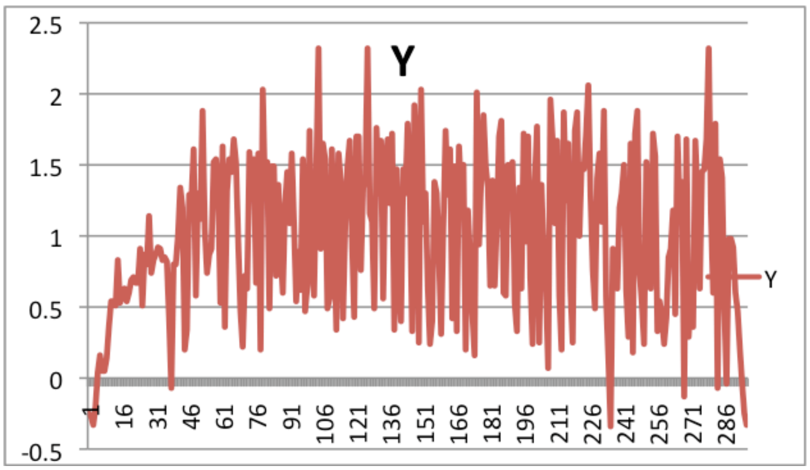
Fitts Law	From side position					
		d	w	ID		
Hybrid						
2	Let's Walk	4.3	1.4	2.025535		Slide
				2.025535		Average
3	change info	3.9	1.6	1.78136		**2.173405**
	Take test	3.8	1.5	1.82103		
				1.801195		
4	change info	3.9	1.6	1.78136		
	history	3.1	4	0.827819		
	take test	3.8	1.5	1.82103		
				1.476736		
5	save	4.8	1	2.536053		
	bday	2.5	0.9	1.917538		
	weight	2.2	1.1	1.584963		
	height	2	2	1		
	condition	2.1	2	1.035624		
	sex male	3.3	0.5	2.925999		
	sex female	2.4	0.4	2.807355		
	ec	3.3	0.7	2.514573		
				2.040263		
6	menu	5.6	1	2.722466		
	save	4.3	0.9	2.530515		
	bday	2.5	0.9	1.917538		
	weight	2.2	1.1	1.584963		
	height	2	2	1		
	condison	2.1	2	1.035624		
	sex male	3.3	0.5	2.925999		
	sex female	2.4	0.4	2.807355		
	EC	3.3	0.7	2.514573		
				2.115448		
7	menu	5.6	1	2.722466		
	save	4.3	0.9	2.530515		
	bday	2.5	0.9	1.917538		
	weight	2.2	1.1	1.584963		
	height	2	2	1		
	condison	2.1	2	1.035624		
	sex male	3.3	0.5	2.925999		
	sex female	2.4	0.4	2.807355		
	EC	3.3	0.7	2.514573		
				2.115448		
8	Individual	3.5	1.2	1.969626		
	Send	3.9	1	2.292782		
	Menue	3.5	1.1	2.06413		
				2.108846		
9	trial 1	3.4	1.7	1.584963		
	trial 2	3.2	2	1.378512		
	trial 3	3	4	0.807355		
	menu	5.4	1.2	2.459432		
	History	4	0.9	2.444785		
				1.735009		
10	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
11	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
12	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
13	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
14	More info	4.2	1.1	2.268489		
	menu	5.6	1.2	2.5025		
	start	4	1	2.321928		
				2.364306		
15	back	4.8	1.1	2.423211		
	begin	2.5	5	0.584963		
				1.504087		
16	Restart	2.7	2.7	1		
	Call EC	2.1	2.5	0.879706		
				0.939853		
17	Done Recording	4.6	1	2.485427		
				2.485427		
18	menu	4.8	1.1	2.423211		
				2.423211		
19	edit	3.8	0.9	2.384664		
	send	4.2	1	2.378512		
	menu	5.7	1.1	2.628031		
	history	3.9	0.9	2.415037		
				2.451561		
20	back	4.8	1.1	2.423211		
				2.423211		
21	menu	4.8	1.1	2.423211		
				2.423211		
22	back	4.8	1.1	2.423211		
				2.423211		
23	back	4.8	1.1	2.423211		
				2.423211		
24	back	4.8	1.1	2.423211		
				2.423211		

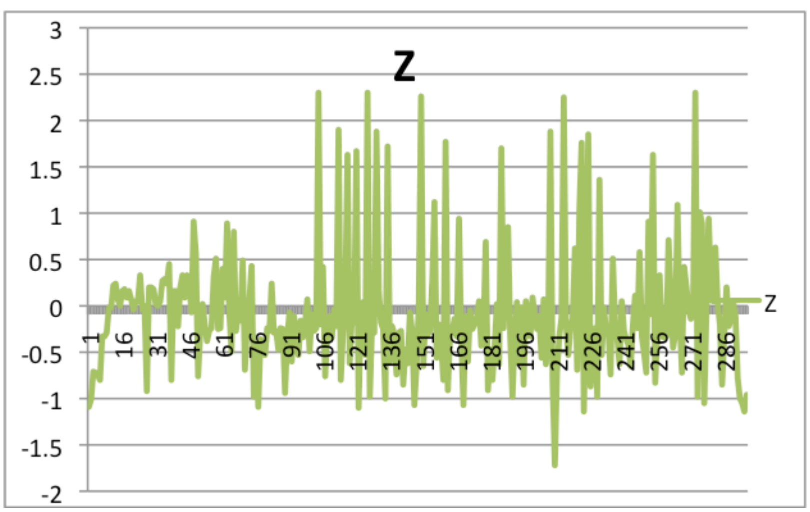
		d	w	ID		
Branched						
3	Let's Walk	4.3	1.4	2.025535		Slide
				2.025535		Average
4	Store Info	4.1	1.5	1.900464		**2.183802**
				1.900464		
5	Change Info	4.1	1.5	1.900464		
	Take Test	4.4	1.3	2.13245		
				2.016457		
6	Change info	4.1	1.5	1.900464		
	History	3.1	2.9	1.04891		
	Send	3.4	2.8	1.146841		
	Take Test	4.4	1.3	2.13245		
				1.557166		
7	Birthdate	2.5	0.9	1.917538		
	weight	2.2	1.1	1.584963		
	height	2	2	1		
	condition	2.1	2	1.035624		
	Stride	2.5	1.2	1.624491		
	Econtact	3.3	0.7	2.514573		
	Save	4.8	1.1	2.423211		
				1.728629		
8	Birthdate	2.5	0.9	1.917538		
	weight	2.2	1.1	1.584963		
	height	2	2	1		
	condition	2.1	2	1.035624		
	Stride	2.5	1.2	1.624491		
	Econtact	3.3	0.7	2.514573		
	Save	4.2	0.9	2.5025		
	menu	5.9	1.1	2.669851		
				1.856193		
9	Individual Trials	3.5	1.2	1.969626		
	menu	4.8	1.1	2.423211		
				2.196419		
10	trial 1	3.4	1.7	1.584963		
	trial 2	3.2	2	1.378512		
	trial 3	3	4	0.807355		
	menu	5.4	1.2	2.459432		
	back	4	0.9	2.444785		
				1.735009		
11	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
12	menu	5.6	1.2	2.5025		
	start	4	1	2.321928		
	i1	2.6	0.8	2.087463		
	i2	1.4	0.8	1.459432		
	i3	0.4	0.8	0.584963		
	i4	1.7	0.8	1.643856		
	i5	2.5	0.8	2.044394		
				1.806362		
13	menu	5.7	1.1	2.628031		
	back	3.9	0.9	2.415037		
	start	2.5	5	0.584963		
				1.87601		
14	restart	2.7	2.7	1		
	call contact	2.1	2.5	0.879706		
				0.939853		
15	done record	4.6	1	2.485427		
				2.485427		
16	send	4	1.3	2.027481		
	menu	5.7	1.1	2.628031		
	history	3.9	0.9	2.415037		
				2.35685		
17	send	4	1.3	2.027481		
	menu	5.7	1.1	2.628031		
	history	3.9	0.9	2.415037		
				2.35685		
18	menu	4.8	1.1	2.423211		
				2.423211		
19	back	4.8	1.1	2.423211		
				2.423211		
20	back	4.8	1.1	2.423211		
				2.423211		
21	back	4.8	1.1	2.423211		
				2.423211		
22	back	4.8	1.1	2.423211		
				2.423211		
23	back	4.8	1.1	2.423211		
				2.423211		
24	back	4.8	1.1	2.423211		
				2.423211		
25	back	4.8	1.1	2.423211		
				2.423211		
26	back	4.8	1.1	2.423211		
				2.423211		

		d	w	ID		
Wizard						
3	Let's Walk	4.3	1.4	2.025535		Slide
				2.025535		Average
4	Save	4.1	1.5	1.900464		**2.127739**
				1.900464		
5	Individual Trial	3.7	1.3	1.943416		
	Send	4.6	0.9	2.611435		
				2.277426		
6	trail 1	3.4	1.7	1.584963		
	trial 2	3.2	2	1.378512		
	trial 3	3	4	0.807355		
	back	4.8	1.1	2.423211		
				1.54851		
7	dot 1	8	0.5	4.087463		
	dot 2	7.2	0.5	3.944858		
	dot 3	4.3	0.5	3.263034		
				3.765119		
8	More info	4.4	1	2.432959		
	Start	4.8	1.1	2.423211		
				2.428085		
9	back	4.8	1.1	2.423211		
	begin	2.5	5	0.584963		
				1.504087		
10	restart	2.7	2.7	1		
	call ec	2.1	2.5	0.879706		
				0.939853		
11	done recording	3	4.5	0.736966		
				0.736966		
12	history	4.8	1.1	2.423211		
				2.423211		
13	send	4.2	1	2.378512		
				2.378512		
14	exit	4.8	1.1	2.423211		
				2.423211		
15	back	4.8	1.1	2.423211		
				2.423211		
16	back	4.8	1.1	2.423211		
				2.423211		
17	back	4.8	1.1	2.423211		
				2.423211		
18	back	4.8	1.1	2.423211		
				2.423211		

8.3 Accelerometer Data







8.4 Audio Recordings

1 minute – “You are doing well. You have 5 minutes to go.”

2 minutes – “Keep up the good work. You have 4 minutes to go.”

3 minutes – “You are doing well. You are halfway done.”

4 minutes – “Keep up the good work. You have only 2 minutes left.”

5 minutes – “You are doing well. You only have 1 minute left.”

5:45 minutes – “In a moment I’m going to tell you to stop. When I do, just stop right there and I will ask you a question. Press the finish recording button when you have fully answered.

8.5 Project Design Specifications (PDS)

Walk Test Product Design Specifications

March 9th, 2010

John Renfrew, Kenneth O. Xu, Sarah Sandock, Wan-Ting Kou, Josh Kolz

Problem Statement:

There is a clinically-approved cardiopulmonary health test called the 6-minute-walk-test (6WMT) that accurately gauges cardiopulmonary health through a simple technician-guided walk procedure. Our objective is to create a similar test using an iPhone application that will generate 6MWT data at the comfort of the patient's home or any other setting of the patient's choice. This data will be useful in assessing patient improvement by testing the patient before and after medical intervention.

Client requirements:

- Must work on iPhone.
- Ability to store and organize test and clearly display data
- Consider an internet based application alternative.
- Look into expansion of audience to healthy individuals for early diagnosis of mild Chronic Obstructive Pulmonary Disease (COPD).
- Consider performing statistical tests showing that the application gets reliable data through supplementary GPS comparisons.
- Integrate audio encouragements and verbal instructions to assist in 6MWT.
- Show it is as accurate as the current 6MWT by testing.

Novel Test Data

- Record a spoken statement for evaluation.
- Capture heart rate
- Structured report of any problems at the end of the test.
- Free text comments about test results.

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*: Device must be energy efficient. It should be able to upload to central database for interpersonal comparison and analysis from third party. Compare current 6MWT data and compare with previous attempts and/or general population data.

b. *Safety*: Must not cause detrimental visual effects and deter from distract patient while he/she is performing test. Possible safety button in case of medical emergency during 6MWT.

c. *Accuracy and Reliability*: Must be able to track distance walked to around +-5 meters. Must be able to match or exceed performance of clinical 6MWT; must account for varying courses shapes, conditions, and distances.

d. *Life in Service*: N/A

e. *Shelf Life*: N/A

f. *Operating Environment*: In home use or outside

g. *Ergonomics*: Acquire good Fitts' Law and Hick's Law values
h. *Size*: Under 50 megabytes
i. *Weight*: N/A
j. *Materials*: iPhone, iTouch, iPhone Standard Developer Kit (SDK)
k. *Aesthetics*, *Appearance, and Finish*: Large, clear buttons, clean interface, easy to understand voice instructions

2. Production Characteristics

a. *Quantity*: Available for download when finished
b. *Target Product Cost*: To be determined

3. Miscellaneous

a. *Standards and Specifications*: N/A
b. *Customer*: Patients with COPD and others looking for a health test.
c. *Patient-related concerns*: Ability to call for help easily through the program
d. *Competition*: Clinic-run 6MWT, Mechanical Pedometers, iPhone pedometers