Smart Lighting System

Milestone One Concept Memo

Team SightRPI

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IED Section: 3
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Introduction

The MetLife Mature Market Institute (MMI) has found that one in three older adults will experience a fall this year, and nearly half of older adults cannot get up on their own [11, 14]. In-home, wearable medical alert systems were first introduced in the 1970’s to combat this growing issue [16].

We have found that many of the products on the market are still using this technology that has been implemented for nearly the last 50 years [16]. Our team is going to address the issue of protecting older adults from falls while not disrupting their independence and lifestyle. This report details our progress thus far, covering the many aspects from our problem statement, customer requirements, and benchmarking/research to our proposed solution and project plan.

Problem Statement

According to the American Association of Retired Persons (AARP), 90% of Americans wish to stay in their homes as they grow older [1]. While this trend, also known as “aging in place”, has been found to be very popular, it still does not eliminate the need for personal care. Both Consumer Reports and the National Safety Council have found that most falls and medical emergencies occur in the home [2, 13].

As one grows older, one experiences changes in vision, hearing, reflexes, and much more. These changes can make it more challenging to maintain the independent lifestyle that many covet during aging. Both the National Safety Council and the MMI reported that falls are the primary cause of death in adults older than 65 [11, 13]. According to aarp.com, 79% of seniors identified a “personal system that allows for one to call for help in emergencies” as a housing feature that is important to them [1].

Older adults will even go as far as to make modifications to their homes to make it more feasible to live there alone [1]. While caregivers and nursing homes are effective ways of keeping older adults safe, these two methods do not allow for the independence factor.

Some older adults utilize wearable medical devices. However, these devices require monthly fees and are not always equipped with the ability to automatically detect a fall [6]. Additionally, one of the requirements for these devices to work is for the user to be wearing it at the time of the emergency; this is not always the case. We are proposing a solution that will provide the comfort of having someone there to help, but without the constant supervision.

Customer Requirements

The target customer for our system would be older adults who are seeking ways to make aging at home more feasible. While this product may be appealing to caregivers and adult children of older adults, our target customer is going to be simply older adults for the scope of the proof of concept. Additionally, a residential setting is an ideal model due to the fact that the area of the room is generally smaller and there are not many people in one common space at one time. Furthermore, most falls occur in the home [2, 13].

While many older adults are at risk for various health issues, falls are the most common cause of accidental death in this age group [13]. This is a statistic that is important and why we have chosen to focus on fall detection and getting help for those who may experience a fall.

It was reported that AARP (American Association of Retired Persons) found that 70% of older adults made modifications to their home due to safety concerns. Additionally, AARP is reporting that a significant amount of older adults (60%) made those modifications to their home to increase the chances that they will be able to live there independently [1]. These findings demonstrate that safety is something that is a priority to our customers. This is something that we took into consideration while developing the methods for fall detection in our device.

On top of that, the Center for Disease Control (CDC) speculates that 2.8 million older adults are treated for fall-related injuries in emergency rooms each year. Of these injuries, 1 out of 5 are considered serious [3]. Furthermore, according to aarp.com, 79% of seniors identified a “personal system that allows for one to call for help in emergencies” as a housing feature that is important to them [1]. This demonstrates that our device should be able to get medical attention for someone in the event of a fall since some falls do result in injury.

Table 1 Customer Needs and Corresponding Technical Specifications

Customer Needs	**Technical Specification**	
	Metric	**Target Value / Range of Values**
User Comfort	Brightness	100-200 lux/m^2
Can I control the light from long distance?	Remote control (Phone Application)	0-600 feet
Can it cover all the working area?	Effective area	8 cm^2/sensor (in demo room)
Can detect a child?	Age	3-10 years old
Timely notification	Communication between phone application and device	1-2 second
Location of emergency	Color change	Normal light to red light
Hands-free	Automatic fall detection	No wearable device needed
Low amount of false positives	Confirmation system	1 speaker and 1 microphone to detect the reply from the user
No need to charge	Connected to house’s power directly	Input: 100-240 v

Table 2 Prioritized Customer Requirements

Need	Importance (1 being the most)
Automatic fall detection (hands-free)	1
Timely notification to caregiver	2
Reliable/low false positives	3
Cost	4
Energy consumption	5
Entertainment use (e.g. color-change)	6
Aesthetic	7

Concepts and Benchmarking

Products on the market

In addition to having a caregiver or moving to a nursing home, some safety devices are also offered on the market. We researched these existing products to gain an understanding of some of the customer requirements we needed to consider. Consumer Reports published a comparison chart for many different medical alert devices. This chart is shown in Figure 1 [6].

Facts to consider	Life Alert	LifeStation	Medical Alert	MobileHelp	Philips Lifeline	Rescue Alert
Monthly service cost						
Landline/Cellular	$50/$60	$26/$33	$30/$35	NA/$35	$30/$42	$29/$43
Features						
Mobile 911 phone	Yes	Yes	Yes	No	No	Yes
Automatic fall detection	No	No	Yes	Yes	Yes	No
Fees						
Minimum obligation	36 months	30 days	90 days	None	None	None
Activation	$95	None	None	None	$0 to $50	None
Cancellation fee	Remainder of contract	None	None	None	None	$0 to $25

Figure 1 Comparison of many emergency alert devices

All the devices that they discuss are wearable devices that require a monthly service fee. In addition to that, nearly all of these devices included some sort of minimum obligation, activation, and cancellation fee [6]. Consumer Reports also pointed out that these devices are assuming that the user is wearing them, they are charged, and they are functioning properly [2].

Three of these devices (Life Alert, LifeStation, and Rescue Alert) do not have automatic fall detection. Instead, the device has a button that the user must press to signal that there is an emergency [2]. This means that the user must be conscious and alert enough to press the button on their device.

On top of that, it was mentioned previously that for each of these devices to work, the user must be wearing it. We did not want to pursue this design since we want to provide a system that is hands-free and does not require lifestyle changes (e.g. having to remember to wear a device every day). Furthermore, the device must be charged. Finally, the monthly service fee must be paid in order to have the device work correctly.

From the initial benchmarking of other products on the market, we were able to conclude that we did not want to pursue creating a wearable device since there are so many, and they have their downfalls. We also decided that we wanted our device to be hands-free. Furthermore, we also decided that we wanted our device to not require any user learning prior to use (lifestyle changes, such as requiring the user to lay on the floor during an emergency so the system can detect it).

From our customer research, we noticed that users would be willing to make modifications to their home in order to implement a safety system [1]. We decided that a system that may require home modifications (such as adding sensors in entryways and replacing light fixtures) would be something that customers would not be opposed to.

We looked into Philips LifeLine, the market leader with 750,000 customers [16]. Philips offers a model of their LifeLine product that includes automatic fall detection [14]. The system is shown in Figure 2 [15].

Figure 2 Philips LineLife System

The LifeLine system is connected to a landline phone and is how operators communicate with the user in an emergency. Once the fall has been detected, an operator communicates with the user through the LifeLine system. The model of LifeLine that does not include automatic fall detection still includes the confirmation system. Specific directions to be used in the event that the user does not respond to the operator can be specified [14]. We decided that our system should have a confirmation system in addition to automatic fall detection to decrease false positives.

We were able to conclude that we wanted to design a system that could automatically detect falls and have an automatic notification method. Additionally, we decided that communication between the device and user should be wireless since nearly all other products on the market have wireless technology.

Fall detection

Our problem requires a solution that includes a system that can accurately detect falls. To consider all of our options, the team created a map (shown in Figure 3). The different options that we found would be practical for our device were the use of a camera, a proximity sensor, a Microsoft Kinect sensor, or a robot.

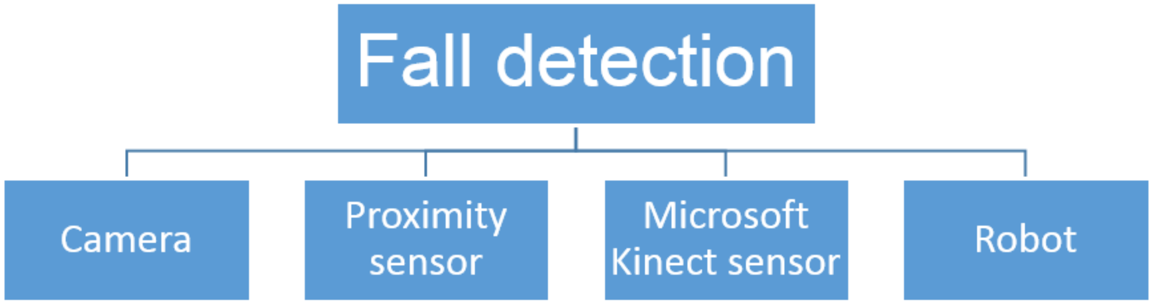


Figure 3 Fall detection map

Choosing which of the options in Figure 3 fit best into our system was done by using a concept selection matrix (Figure 4). The criteria that we included in our concept selection matrix was based on customer requirements, research, and engineering decisions. These criteria included reliability, accuracy, cost, privacy to user, energy efficiency, aesthetics, ease of usage, and knowledge base of engineer.

FALL DETECTION

	Kinect sensor	Proximity sensor	Camera	Robot
Reliable	1	1	0	-1
Accuracy	0	-1	0	0
Cost	0	1	-1	-1
Privacy	-1	1	-1	0
Energy efficient	1	1	0	0
Asthetics	1	-1	0	0
Easy to use	1	1	1	-1
Knowledge base	-1	1	-1	0
Sum of +1's	4	6	1	0
Sum of 0's	0	0	0	0
Sum of -1's	-2	-2	-3	-3
Net Score	2	4	-2	-3

Figure 4 Fall Detection Concept Selection Matrix

The team was able to determine that the method of using a robot would not be an ideal choice. A robot, designed to check in with the user periodically, scored the lowest in our matrix. The team felt that the idea of a robot did not align with our solution of a system that is as hands-free as possible to the user. The team found that using a camera also did not align with the goals of our proposed solution. Additionally, a camera may make some users feel uncomfortable and may deter them from using this system.

The team also considered using a Microsoft Kinect sensor to detect falls. The Kinect sensor was found to be reliable, energy efficient, aesthetic, and easy to use. However, the Kinect sensor has a camera and this may also make users uncomfortable. On top of that, the team concluded that we did not have the proper knowledge base to program a Kinect sensor to accurately detect falls.

With all above considered, the team selected the method of using a proximity sensor for fall detection. The proximity sensor is reliable and is not very costly. Additionally, the proximity sensor does not use a camera to collect data. This fact will allow the user to feel more independent and like they are not being constantly watched. Furthermore, the proximity sensor is energy efficient, easy to use, and the team has a strong knowledge base in this subject. The proximity sensor also had the highest net score.

Motion detection

To be able to detect falls, our system must also know when there a human in the room. There are many ways that this can be done, and they are outlined in Figure 5.

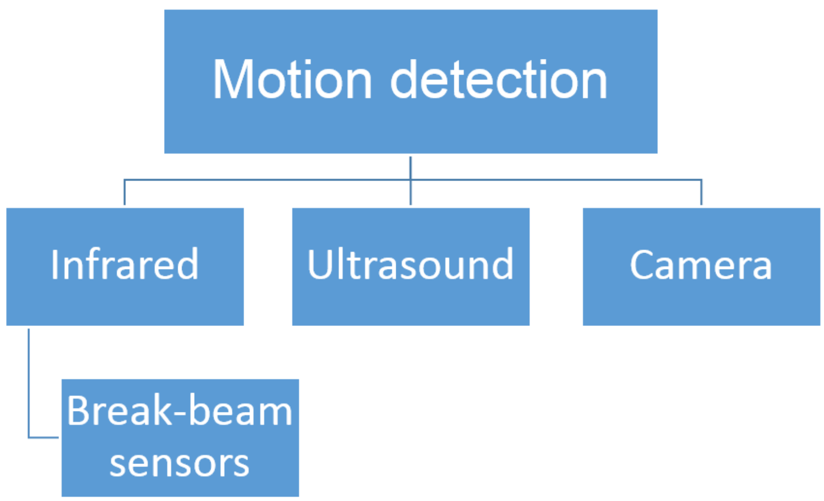


Figure 5 Motion detection map

The team created another concept selection matrix to determine which method of motion detection would be best. The matrix is shown in Figure 6.

The criteria listed was again based on customer requirements, research, and engineering decisions. These criteria included reliability, accuracy, cost, privacy to user, energy efficiency, aesthetics, ease of use, and safety to user.

MOTION DETECTION

	Infrared	Ultrasound	Camera
Reliable	1	1	0
Accuracy	1	0	1
Cost	1	1	-1
Privacy	1	1	-1
Energy efficient	1	1	0
Asthetics	-1	-1	0
Easy to use	1	1	1
Safety	0	0	1
Sum of +1's	5	6	3
Sum of 0's	0	0	0
Sum of -1's	-1	-2	-3
Net Score	4	4	0

Figure 6 Motion Detection Concept Selection Matrix

The camera was again found to be the lowest scoring choice. As stated previously, the camera may make users feel uncomfortable and like they are being watched.

While ultrasound and infrared scored the same, the team felt that the infrared method would be the best choice. Ultrasound motion detection would not be able to detect the difference between a user's pet and the user. We want to make our system accurate and give as many false positives as possible, and ultrasound would not be the correct choice in this case. Infrared motion detection will be implemented since it is more accurate and will be able to detect humans only.

Notification method

Our research showed that older adults prefer a system that can detect a medical emergency. We decided that our system must have a way to notify emergency contacts or emergency services. We created a map (shown in Figure 7) to demonstrate all of the options for notification method.

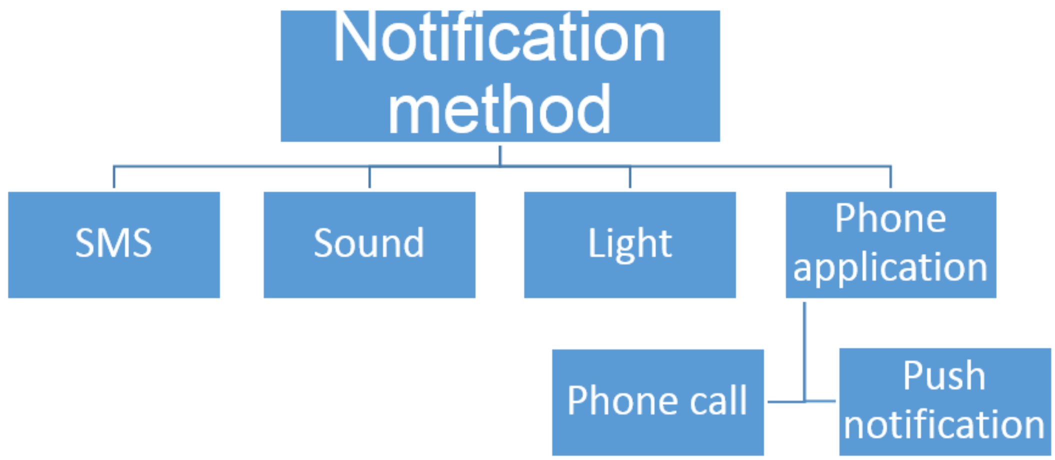


Figure 7 Notification method map

Deciding which of the options in Figure 7 would be the best fit for our system was done by using a concept selection matrix, shown in Figure 8. Our criteria were again based on customer requirements, research, and engineering decisions. These criteria include reliability, latency, cost, privacy to user, energy efficiency, aesthetics, ease of use, and comfort to user.

NOTIFICATION METHOD

	SMS	Sound	Light	Phone App
Reliable	0	1	0	-1
Latency	0	0	0	1
Cost	-1	1	1	1
Privacy	-1	1	1	-1
Energy efficient	1	0	0	1
Asthetics	0	0	0	0
Easy to use	1	1	1	-1
Comfort	1	-1	0	1
Sum of +1's	3	4	1	4
Sum of 0's	0	0	0	0
Sum of -1's	-2	-1	-3	-3
Net Score	1	3	-2	1

Figure 8 Notification Method Concept Selection Matrix

While sound had the highest net score of any of the other methods, we felt that this method was not exactly what we were looking for. Sound may cause discomfort to the user and is not the best notification method since it has a range for which it can be heard.

Light had the lowest net score of any of the other methods. We feel that this is not the best method since it does not provide any of the benefits that we are looking for, based on customer requirements. Light cannot provide a timely notification if the emergency contact or emergency services cannot see it.

We have chosen to use a smartphone application as our notification method. This method can give users the timeliest notification method of an emergency, which is one of the most important customer requirements. However, this method is not the most private since users will have to create an account to use it. (Creating an account requires giving out personal information.)

We did not choose to use SMS as our notification method since implementing it accurately into our system would not be feasible for the restricted time period we have for the proof of concept prototype. This is something that we are looking into for future iterations of this prototype.

To further support our decision to use a smartphone application instead of sound (the highest scoring in the selection matrix), we did more research to show why this is the direction we want to go in.

It was found in 2016 that 77% of American adults and 92% of American young adults owned a smartphone. Figure 9 shows the trend of the increase in smartphone usage since 2000 [18].

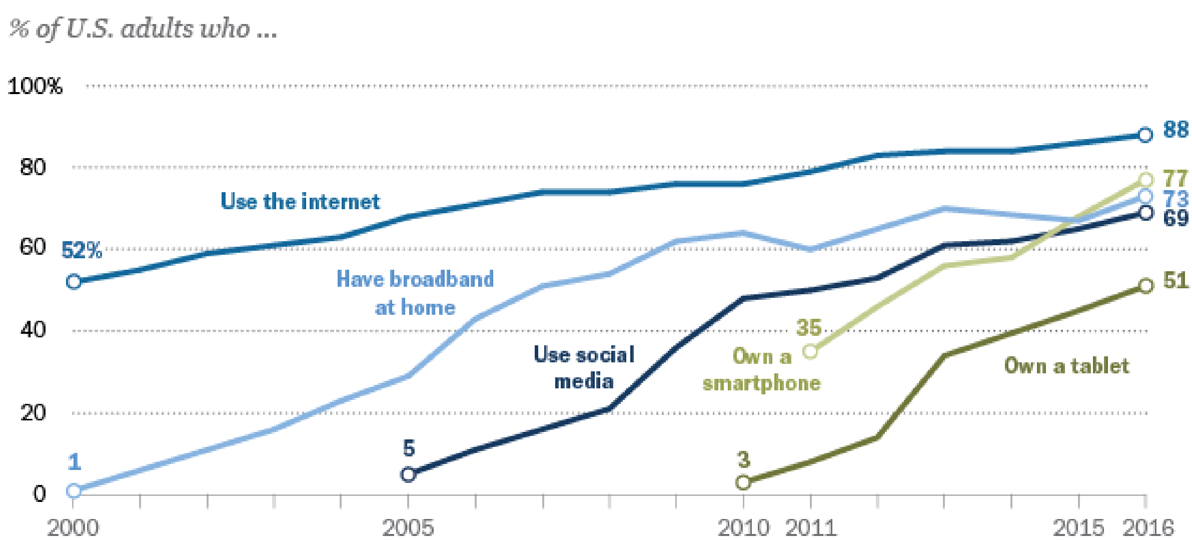


Figure 9 Technology usage in American Adults (2000-2016)

Furthermore, almost two-thirds (63.66%) of the population have Android as their operating system. However, for our prototype, we will use the second most prevalent (33.03%) system: iOS system because we don't have any experience with Android development [12].

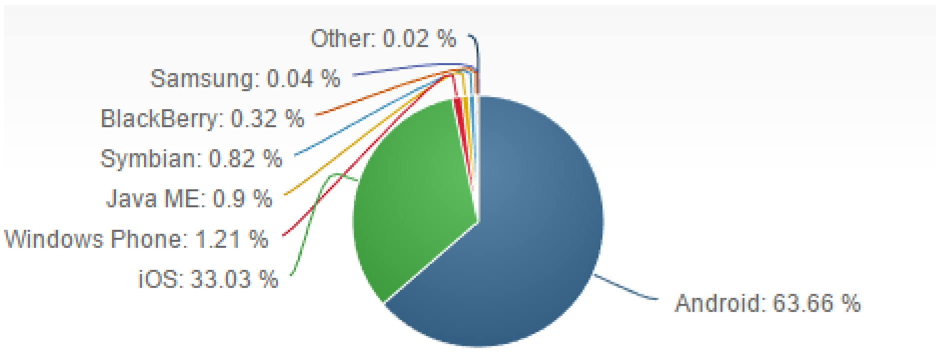


Figure 10 Smartphone operating systems [12]

Our application will have following features:

- On/Off switch: Turn on or off the light manually
- Color Palette: Change the color of the light
- Brightness Adjuster: Change the brightness of the light
- Pop-up Emergency Notification: Show push notifications on lock screen
- Emergency Conformation: Need emergency contact to clear the emergency signal or report an emergency to 911. (For several emergency contacts, we will give the full control to the one who opens the application first.)

Wireless Module

For our prototype, we will implement low-energy Bluetooth (i.e. BLE, Bluetooth 4.0). We chose this method considering time-limit, budget-limit and easiness of setup. Because Bluetooth is a built-in function on the Arduino Chip, we do not need to purchase more hardware. We are also assuming that the user’s emergency contact(s) has a smartphone that has Bluetooth capabilities.

For the ideal module (future iterations), we will use VPS (virtual private server) to provide free a communication service for customers. This requires each house to install our system to have at least a Wi-Fi connection. As mentioned previously, in 2016 73% of American adults had Internet access in their home. Additionally, 77% of American adults owned a smartphone as of 2016 [18]. In 2012, 61% of American households had a Wi-Fi connection [19] and in 2014 over 90% had three or more devices connecting to the Internet in their home [9]. These numbers increased in 2016 when it was found that 73% of American adults have Wi-Fi in their home [18]. Based on these facts, we feel comfortable using this method. This enables our ideal module that Arduino will communicate with our server on cloud through the user's Wi-Fi. Considering the rest small amount of houses who do not have Wi-Fi implementation, we could contact carriers in future iterations to enable SMS text message communication and cellular network.

Considering the budget for a VPS or a self-built server, the long-lasting maintenance fee and running fee can both be neglected. Because the server should only record every system installed and each user as well as his/her emergency contact(s), the required data storage is not as large as other technology companies need. The only investment for our system that needs to be taken into account is the initial establishment fee when we choose to build our own server. We would need thousands of dollars to build our server. However, because we can make good profit from our product when we compare our input price with that of benchmarking products, the fixed cost can be neglected in long run. The other way to use VPS is to rent a server from a large server-service provider, such as Amazon and GoDaddy. There is no establishment fee for a VPS and the cost would be approximately $32 per month to have 240GB storage, 8GB memory and unmetered bandwidth. [10]

Demo Room

We decided that designing a demo room would be the best way to showcase our prototype due to time constraints and budget constraints. Additionally, a demo room would be the best way to test some of the extreme cases such as a pet or baby being in the room instead of an adult.

In order to maintain an accurate reading from our proximity sensors, the material of the demo room must be opaque so that no waves from the sensor will be disrupted. Additionally, the demo room should not contain any metal since this can also disrupt the readings from the proximity sensor [citation needed]. Professor Connor from the RPI Light Center told us that Light Center students and faculty use a Styrofoam demo room to test their designs [5]. We have decided that foam board will be the best option since it is easy to work with and inexpensive. It also will be easy to create additional demo rooms for further iterations of our prototype.

We have decided as a team that the area of over demo room will be 12 inches by 12 inches, 1 square foot. We made this decision based on the fact that we are demonstrating our prototype to an audience and we would like them to be able to see what is going on. We plan to add enough proximity sensors to cover this area. Additionally, the additional dimensions (such as door dimensions, ceiling height, and others) will be dependent on the International Building Code. Our demo room will feature a door for our IR sensors (as discussed in Project Plan) and props to demonstrate a realistic test case. We are also planning on using a human model that is to scale with the rest of the demo room.

Proposed Solution

Our system is lighting based and has sound implementation. We decided to implement the *IR beam sensor* to detect person coming into or leaving the room. Afterwards, the *range sensor* installed on the ceiling will start measuring height and fit the results into different ranges shown in the working flowchart (Figure 11). If the height measured by *range sensor* shows the person is lying on the ground, the *confirmation system* will be automatically triggered (read *Task 1* of *Project Plan* for more details) and provide instantaneous emergency service if needed. To provide instantaneous emergency detection and notification, we decided to design a graphical user interface (GUI) on a smartphone application which needs the user's emergency contact(s) to download and setup for first use. Ideally, a server will be established on a cloud to provide free service for information transmission if the person has purchased our product. However, considering limited time for our project building, we will simplify the wireless module by using Bluetooth instead (read *Task 1* for more details).

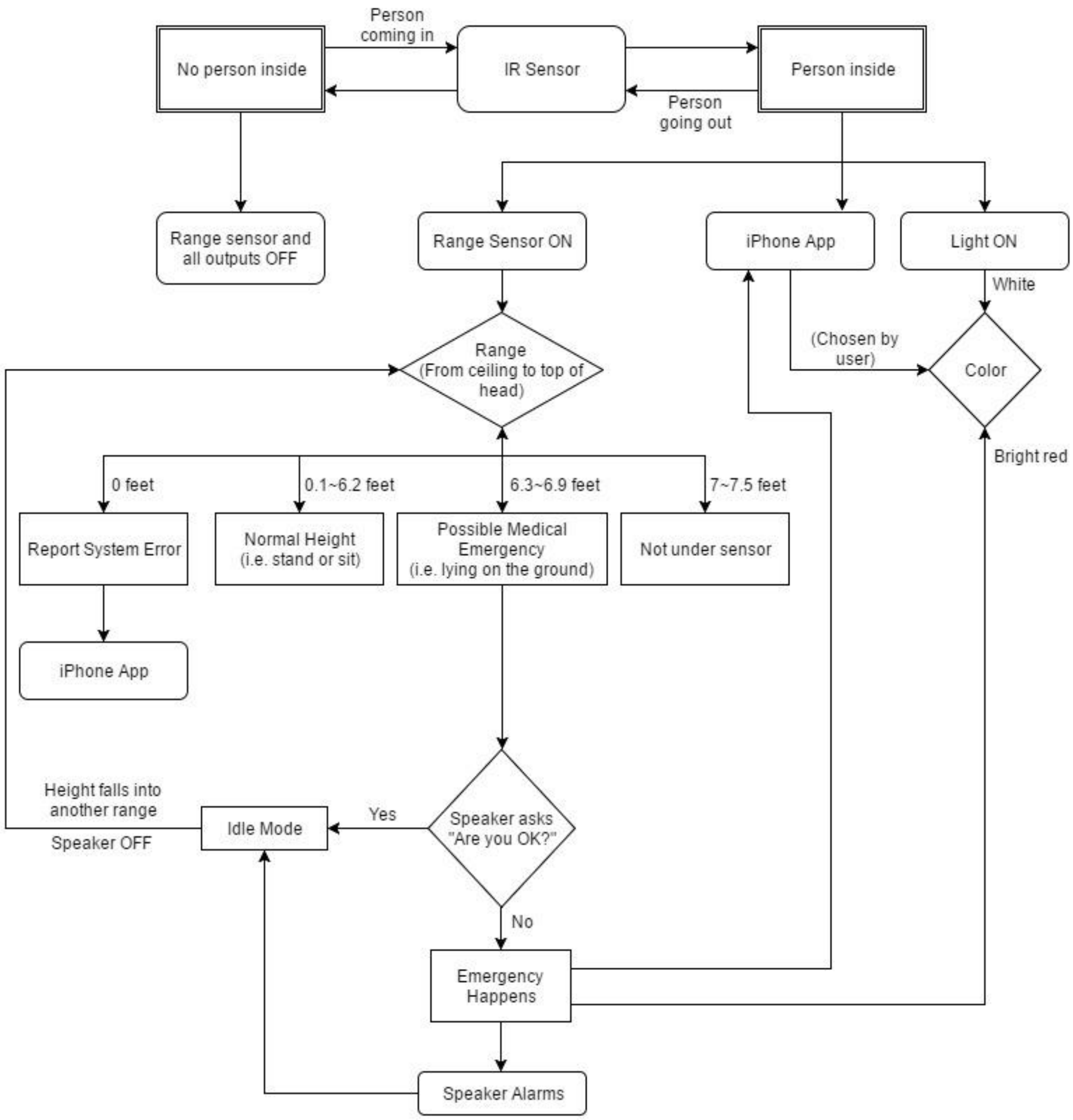
The flowchart of system working (Figure 11, with reference numbers consistent with reference list at the end of Memo) and subsystems distribution (Figure 12) is drawn to demonstrate each step and person responsible for construction of that part.

System Working Flowchart

Assumptions

1) Room ceiling height: 7.5 feet [7]

2) Person height: standing [4] (5.6 feet), sitting [8] (4.7 feet above ground), lying (0.82~0.98 feet)



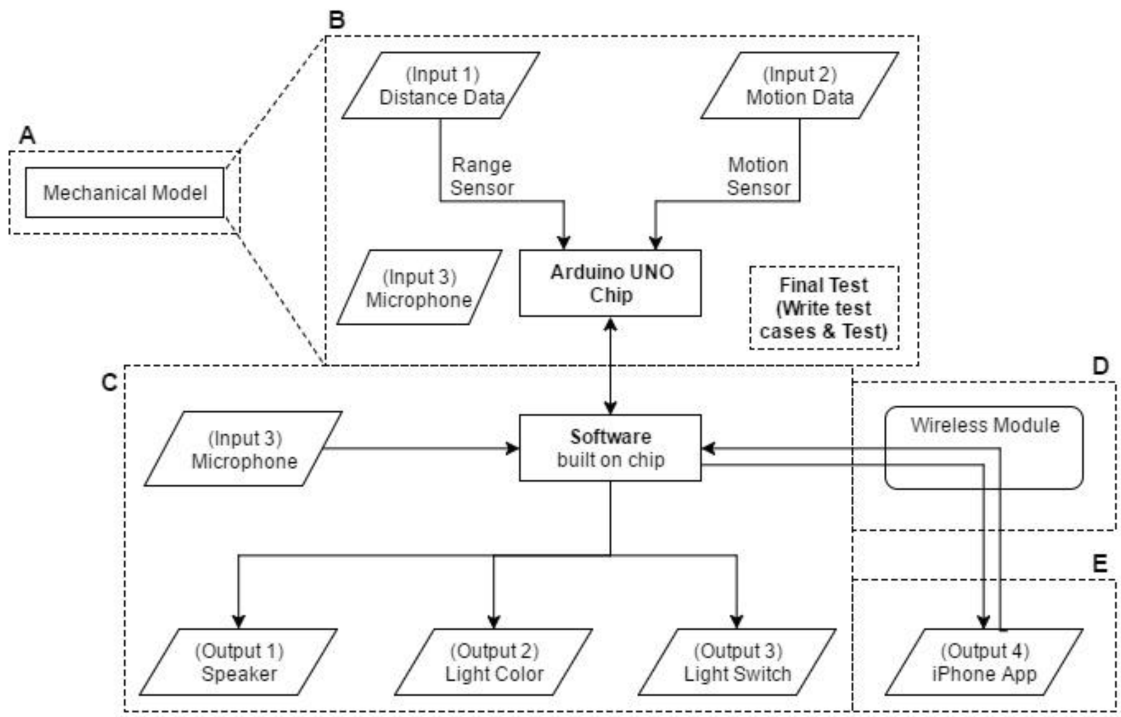
References
[7] Ceiling Height: https://up.codes/viewer/general/int_building_code_2012/chapter/12#12
[4] Standing height: https://www.cdc.gov/nchs/fastats/body-measurements.htm
[8] Sitting height: http://www.firstinarchitecture.co.uk/average-heights-dimensions-of-person-sitting

Figure 11 System Working Flowchart

Below in Figure 12 is the chart that details the subsystem assignments. The cutline and more comments are at the bottom of the flowchart.

Chart & Assignments for Subsystems

Every subsystem is circled by a dash rectangle.



Subsystems Assignment

A) Alex
B) Zhen
C) Ding
D) Cornelius
E) Ziyi

<u>To clarify software part of Section B & C</u>
For section B, after the engineer builds circuits, he also should write code to obtain every piece of data to ensure the hardware is fully debugged.
For section C, the engineer writes all rest codes. (At this step, any bug cannot/should not be with hardware.)

<u>Further comments</u>
Microphone (Input 3) will be replaced by pushbutton for demo, because voice recognition cannot be implemented in our project now.

Figure 12 Subsystems Assignment

Table 3 below features the subsystem descriptions as well as who is responsible for each.

Table 3 Subsystem Descriptions

Subsystem	Owner	Description
Wireless Module	Hanyuan (Cornelius) Xiao	• Enable communication between smartphone (e.g. iPhone) and Arduino (i.e. system) • Enable “clear” and “call 9-1-1” via smartphone
Confirmation system	Junjie Ding	• Handles input from all our sensors • Translate the data into action • Design the coding logic for the project
Demo room	Alexandra Fearn	• Design a scale demo room • Create testing environment for system • Create test cases
Design the circuits and test case	Zhen Chen	• Design and wire the circuits • Test subsystem robustness and safety • Make sure all components work properly • Create test cases
Smartphone Application	Ziyi Lu	• Create mobile application for iOS • Design the user surface

		• Include emergency notification and user preference controls in application

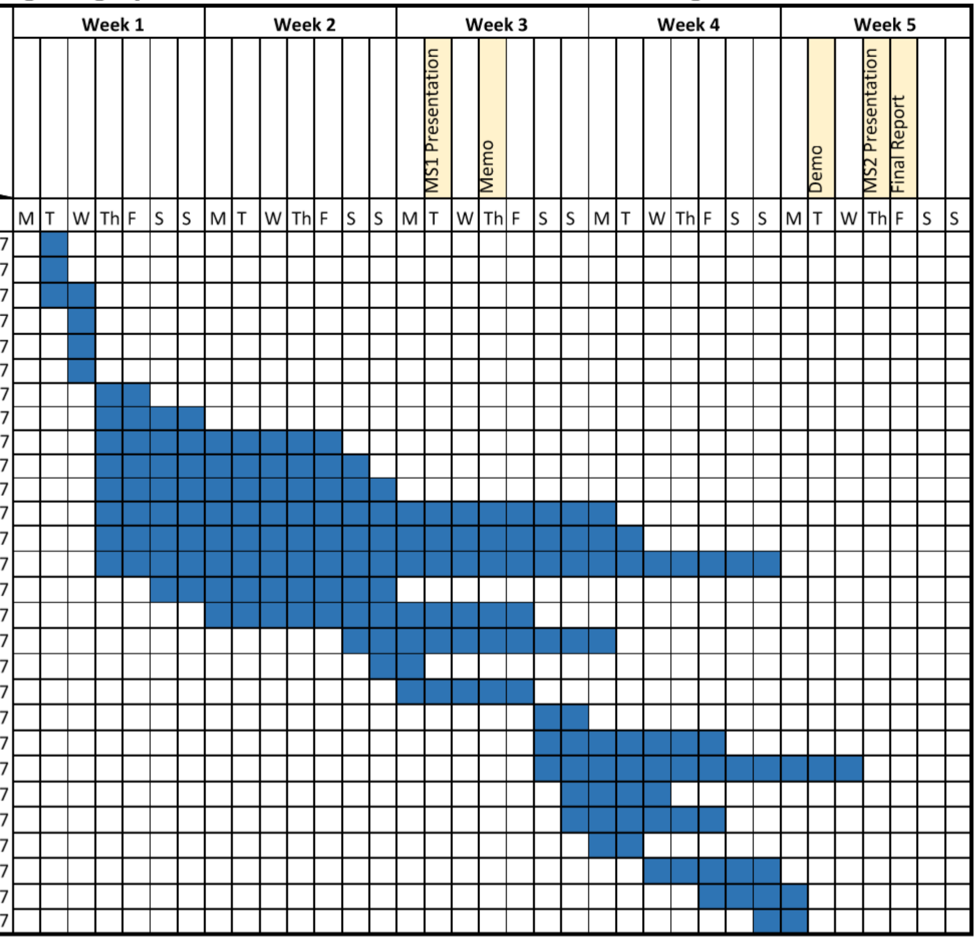
Project Plan

The Gantt Chart (Table 4) shown on the next page outlines every task and person responsible for the task. The status in Gantt Chart is the percentage of finish up to June 13th, 2017. Cutline for name abbreviations is under the table. The starting week is the second week of summer session due to group members' determination. The Gantt Chart is classified by topics, such as hardware, software and general concept decision. Important dates have been marked into yellow under the week row. Note that this is the chart for task distribution rather than subsystem distribution. For information about system and subsystems, please refer to the Proposed Solution part.

Table 4 Project Gantt Chart

IED - ENGR 2050 **Project - Smart Lighting System** **Team - SightRPI**

Task #	Task	Status	Owner(s)	Start	End
1	Interview with Professor Connor	100%	A,C	5/30/17	5/30/17
2	Research emergencies in homes	100%	A,C	5/30/17	5/30/17
3	Benchmark other products on the market	100%	Z1,A	5/30/17	5/31/17
4	Decide between camera or smart lighting method	100%	ALL	5/31/17	5/31/17
5	Determine main functions of device	100%	ALL	5/31/17	5/31/17
6	Assign subsystems to group members	100%	ALL	5/31/17	5/31/17
7	Borrow & Purchase necessary hardware	100%	Z2	6/1/17	6/2/17
8	Determine tech specifications	100%	A	6/1/17	6/4/17
9	Write network communication module	50%	C	6/1/17	6/9/17
10	Write memo	100%	ALL	6/1/17	6/10/17
11	Slides for presentation 1	100%	ALL	6/1/17	6/11/17
12	Write iPhone App	50%	Z1	6/1/17	6/19/17
13	Write functional programs	40%	D	6/1/17	6/20/17
14	Slides for presentation 2	0%	ALL	6/1/17	6/25/17
15	Build circuits	70%	Z2	6/3/17	6/11/17
16	Build model (for presentation 2)	40%	A,Z2	6/5/17	6/16/17
17	Write iPhone communication module	20%	C	6/10/17	6/19/17
18	Practice presentation 1	100%	ALL	6/11/17	6/12/17
19	Build data Structure	80%	D	6/12/17	6/16/17
20	Install circuits and model	80%	A,Z2	6/17/17	6/18/17
21	Collect data	50%	Z2,D	6/17/17	6/23/17
22	Write final report	30%	ALL	6/17/17	6/28/17
23	Test wireless module	0%	C	6/18/17	6/21/17
24	iPhone App Test	0%	Z1	6/18/17	6/23/17
25	Test Hardware	0%	A,Z2	6/19/17	6/20/17
26	Test functional programs	0%	D	6/21/17	6/25/17
27	Test final model	0%	ALL	6/23/17	6/26/17
28	Practice presentation 2	0%	ALL	6/25/17	6/26/17



Alex	A
Cornelius	C
Ding	D
Ziyi	Z1
Zhen	Z2
Everyone	ALL

Here is the description of all main tasks. These tasks are listed chronologically, as triggering IR beam sensor will turn the whole system on, and then range sensor will start measuring distance, and last

Task 1: Occupancy Detection

Considering that system should not be on if there is no person in the room, minimizing energy consumption becomes a significant issue for *Smart Lighting project*. In order to fulfill this goal, we use *Infrared (IR) break-beam sensors* to detect whether someone enters the room or leaves the room. This can be seen in Figure 13.

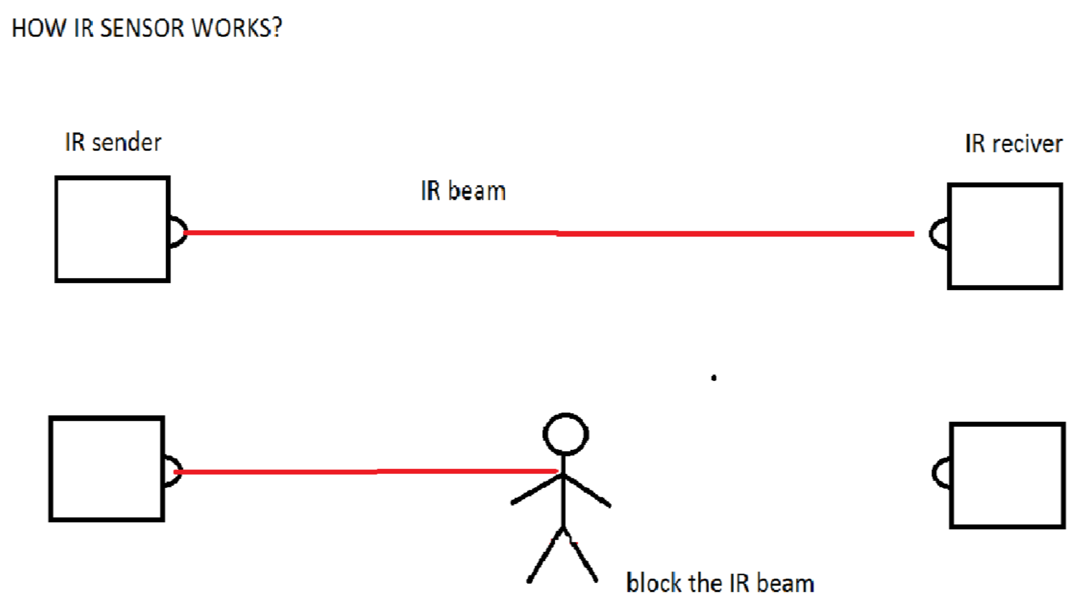


Figure 13 IR sensor beam logic (top view)

We prepare two *IR sensors* to distinguish between entering or leaving the house. Figure 14, on the next page, demonstrates this idea.

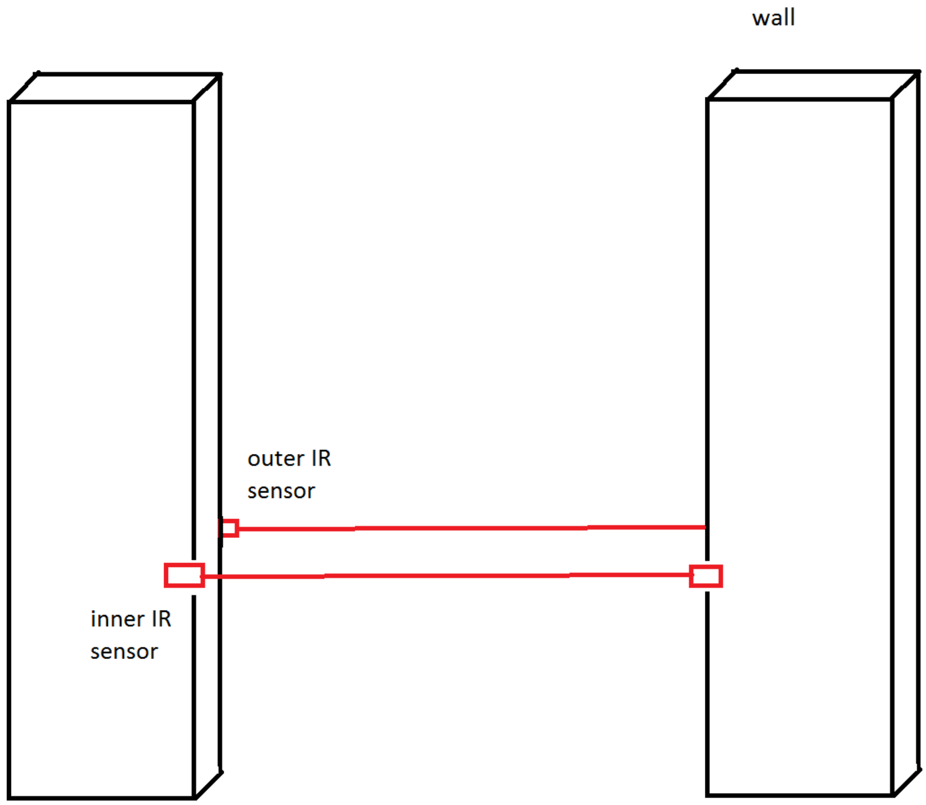


Figure 14 IR sensor beam logic (side view)

Note that this *IR sensor system* should be installed at the place that can cut user's belly. Considering variation among users' body size and body shape, we will consult users and make appropriate adjustment to the location during system installation.

This system should not be fixed too low so that it can be triggered by pets or babies. However, this system should not be fixed too high so that no one can trigger it.

This system is designed to account for the following two situations:

- If the outer IR sensor detects one object crossing the IR beam first, it is the case that a person is entering the room.
    - The light will be turned on.
    - All range sensors will start working.
- If the inner IR sensor detects one object crossing the IR beam first, it is the case that a person is leaving the room.

    - The light will be turned off.
    - All range sensors will cease working.

Task 2: Medical Emergency (automatic fall detection)

The core task for *Smart Lighting project* is to deal with medical emergencies of elderly who live alone in their homes. The system will be turned on when the proper *IR sensor* is triggered described in *Task 1* on Page 22. In order to handle this task, we use *range sensor* (lux and laser) to measure the distance between ceiling and obstacle. Note that there is a negligible angle of signal, so the only returned distance is in vertical direction. The obstacle is

- the top of user's head when he/she is standing under the sensor,
- or the front side of body when he/she lies on the ground,

Note that if the *range sensor* reads the value zero (0), system will report error to user to ask for fixation. For any reason during normal conditions, the range sensor should not be blocked, so we assume a reading value zero (0) means the occurrence of system error or misuse of users. When the person falls over, the distance measured is within some range (6.8~7.4 feet, data from flowchart and calculation). The *confirmation system* will implement a speaker to ask user if he/she is okay or not (i.e. "Are you OK?").

- If the answer from user is "Yes", the system will be in idle mode until the distance changes into another range.
- If the answer is "No", the system will
    - turn the color of light into bright red to signal to other people outside (if any) to help him/her,
    - turn on the alarm speaker,
    - and send notification via smartphone (iPhone for the purposes of our prototype).

Note that, in order to have the user's emergency contact(s) receive notification, his/her contact(s) should also download the smartphone application on his/her phone and enable push notifications. In our ideal plan, we will build a server on cloud which allows hardware to send and user to receive notifications as long as there is a network connection. This service will be free for users who have purchased our system. However, for our prototype, we use Bluetooth connection (low-power Bluetooth) to reduce difficulty and save budget and time.

Alarm sound and constant bright red light can be turned off when the person under emergency is removed from the place or the user turns off the alarm on his/her own phone (considering cases when the person should not be moved, e.g. serious injury).

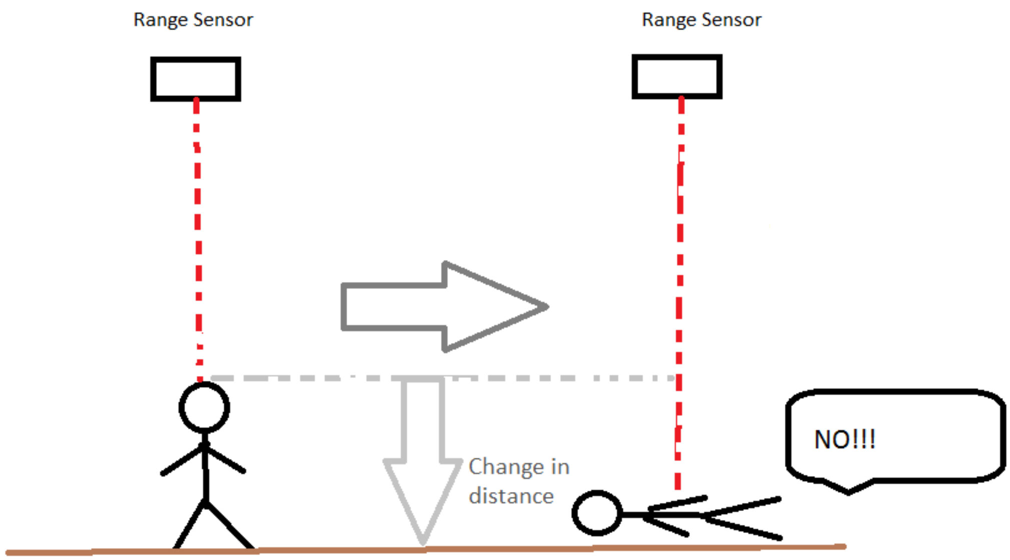


Figure 15 Range sensor logic

Task 3: Auto-switch of Light

Auto-switch will be implemented with *IR sensor* described in *Task 1*. Only when the system detects a person coming into the room, the light will be switched on, and similar for the case that a person going out of room will turn off the light automatically. The light switch will also be built on the wall physically. We will implement a virtual switch on the smartphone application as well to allow users/emergency contact(s) control the switch as well as the color of lights on phone for convenience. This will be fulfilled by a sliding bar on the application.

Task 4: Color Change

Color changing is considered the most efficient way to transfer info to human beings because around 70% of info obtained in our daily lives comes from vision [16]. As described before, the color of light can be changed in two ways:

- under emergency cases, color will be forced to be bright red to signal to the outside,

- or be controlled by the user via smartphone application when no emergency occurs.

Arduino has highest priority in color-change. On the smartphone application, we will build a GUI for the purpose of ease of use and visualization. Two modes are built in the app, which are *free mode* and *emergency mode*. When *emergency mode* is on (*free mode* is off), there is a large warning sign shown on the screen. Under *free mode* (*emergency mode* is off), the warning sign will be replaced by a rainbow circle and user can choose color by rotating the circle. Images (Figure 16 and Figure 17) shows the appearance of application in two modes. (Further cutline)

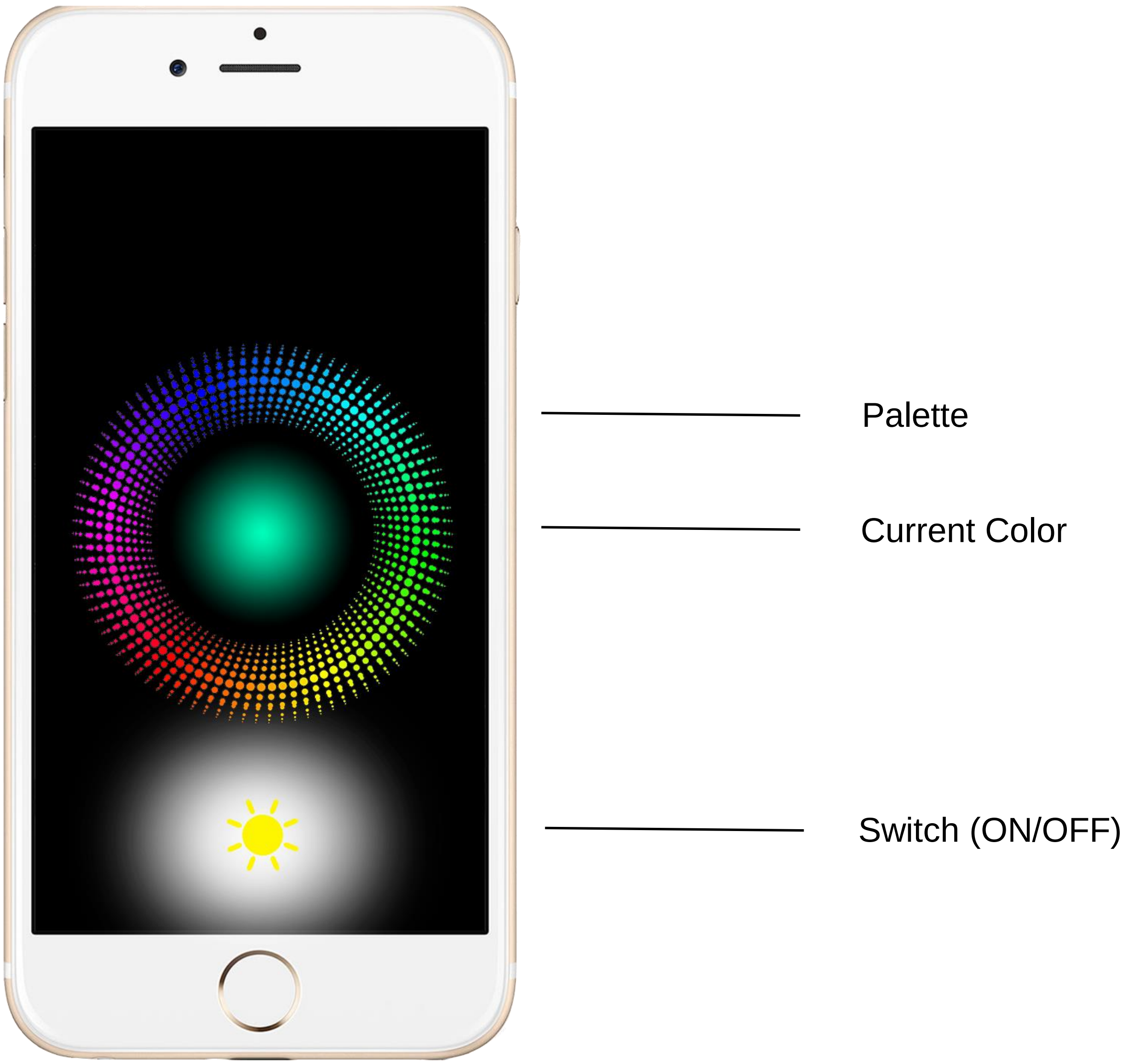


Figure 16 Smartphone Application (Free Mode)

Figure 17 Smartphone Application (Emergency Mode)

Materials

Table 5 lists the materials that we will be using to assemble our entire system proof of concept.

Table 5 Materials used for system assembly

Part	**Where to buy?**	**Price**
Arduino Kit	Amazon https://www.amazon.com/gp/product/B01D8K	$34.99

	OZF4/ref=oh_aui_detailpage_o00_s00?ie=UTF8&psc=1	
Lux Distance Sensor	Adafruit https://www.adafruit.com/product/3316	$13.49
IR break Beam Sensor	Adafruit https://www.adafruit.com/product/2349	$3.90
Speaker	Amazon	(Included in Arduino Kit)
LED	Amazon	(Included in Arduino Kit)
Foam board	Staples	$6.99
Total		**$59.37**

Conclusion

Nearly one in three older adults will fall in one year, with nearly two thirds falling again within 6 months [11]. On top of that, falls can result in injuries, ranging from minor to severe, and even death [3]. With aging in place becoming more popular among older adults, there is most certainly a need for medical alert systems that can provide quality assistance with minimal disruption to daily life.

We feel that our system can provide quality assistance through accurate proximity sensors and a built-in conformation system. Furthermore, our system can provide this service with minimal lifestyle changes or disruptions. The system does not require the user to wear it daily, charge it, and pay a monthly service fee. After benchmarking and researching other products on the market, we found that no other device can provide this kind of service while having the benefits of our system.

Success in this proof of concept and rapid prototyping can yield a system that would be competitive with some of the market’s most popular devices. This system also has the potential to be implemented in nursing homes, hospitals, offices, and schools. This could make emergency response much more efficient and timely, effectively making all of us safer.

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