Indoor Navigation Deliverable 1

Indoor Navigation

Part 1 - Understanding the Problem

(Ratchapong Tangkijvorakul, Zeheng Chen, Joshua Lill, Anh Tuan Van)

Overview of the System

Purpose of Indoor Navigation

Our project is an indoor navigation system that helps individuals to find rooms in a building through their mobile phones. It is relatively easy to find a building because of GPS. However, indoor navigation can be quite a troublesome process to many people. When an individual is inside the building, indoor navigation will provide a set of directions to guide an individual to their destination.

Importance of Indoor Navigation

This system is needed because once an individual get inside the buildings, there is not an easy and straightforward way to find a room that he needs to go. Some buildings might have good signs that is easy to understand. But many other buildings has confusing signs and floor structures. Many individuals that visited the building for the first time will have trouble getting to the right destination. Even those who pay frequent visits to the building may find it confusing to navigate to certain room that they had not been before. Indoor navigation is needed to reduce time in navigating in the building to find a certain room.

Characteristics of the Users of the System

Potential Users

Users can generally be anyone who are trying to find ways to a room in the building. However, our system will choose to target these specific users who will find the system more beneficial and more impactful to their life:

- New students, faculty members and visitors that needs to find office rooms or classrooms in the campus building.
- Existing students and faculty members that needs to attend meeting often and meeting room are assigned to the locations unknown to them.
- People who need to find the room urgently and have no time to waste by finding the floor map or asking for help.

Characteristics of the Users

The users that will be able to use the system should have a smart device (phone, tablets etc.) that can access the system.

Physical Characteristics

- Age group: Teenagers, adults and elderly.
- Sex: There is no anticipated gender-bias among the user population

Perceptual Abilities

- Vision: Not important to this system. The interface can be used with impaired seeing ability. Hearing aid is given for directions.
- Hearing: Not important to this system. The interface can be used with impaired hearing ability. Visual aid is given for directions.
- Touch: The interface anticipate users to be able to operate smart device by applying pressure for the touch screen or buttons on the device.
- Smell: Not important to this system. The interface can be used with impaired smelling ability.

Cognitive Abilities

- Procedural Learning: Minimal learning is required to figure out how to operate the system.

Knowledge and Experience

- Education Level: Users represent all education levels
- Native Language: The majority of users' native language is expected to be English. Secondary language support should be incorporated, most likely Chinese.

IT and Computer Experience

- Computer Literacy: Users are expected to be familiar with the basic operation of smart device. This includes knowing how to press the button on the screen and typing in the locations using the device keyboard.

Task Analysis (Current Tasks)

Tasks Performed By Users

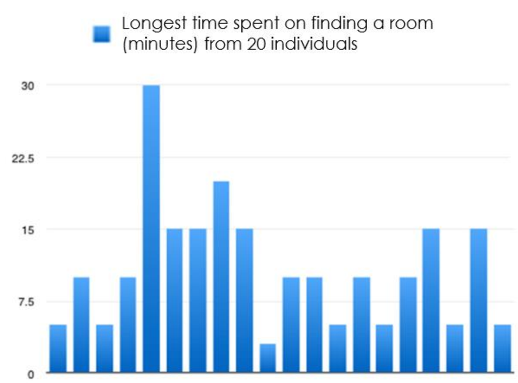
To perform a task analysis of the old system, we did this using three methods (Observation, Interviews and Ethnography).

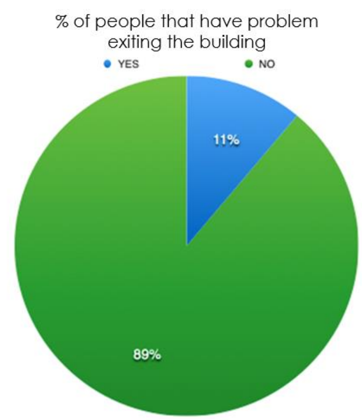
Observation of Current Tasks

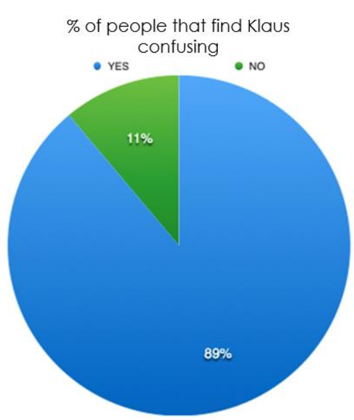
There are many observations made while gathering data on how users need to find a certain place in the building. In the context of campus, at the beginning of the semester, many students are lost and confused. Many students will come up and ask "Is this lecture 101?" A lot of students will look at the floor map once entered the building.

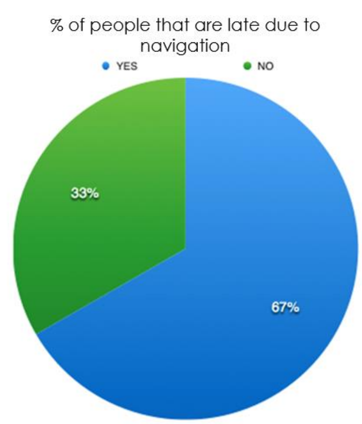
Interviews & Contextual Inquiry

We conducted 20 interviews with friends to gather data on how users need to find a certain place in the building. This interview is conducted with campus as a context. The results are the following.









Ethnography

As a student living among users we have similar problem locating the room. These are the situations that we normally adhere to.

Situation A

- Enter the building with a destination room/place in mind.
- Go to the floor logically implied by the room number.
- Look around for floor map (on the wall or on his phone).
- Proceed to the location with floor map in mind.

Situation B

- Enter the building with a destination room/place in mind.
- Look around for the receptionist and ask where the destination is located.
- Continue asking people/friends how to get to the destination.
- Proceed to the location.

Situation C

- Enter the building with a destination room/place in mind.
- Go to the floor logically implied by the room number.
- Look around for signs (Room 100 – 120 on the left etc.)
- Proceed to the location.

Tasks Environment

Environments are anywhere that located indoor. Potential environments include campus' building indoor and hospital's building indoor. Our system will choose to target these environment with the following characteristics:

Characteristics of Environment

- Indoor environment that has confusing structures (Klaus' circular structure etc.)
- Indoor environment that is new and unfamiliar to users.
- Indoor environment that has confusing floor plans.
- Indoor environment that does not have receptionist to aid in giving directions
- Indoor environment that has inconsistent or confusing signs as the guide to destination.

Simple Structured Tasks Analysis Outline

There are many ways to get to the destination in the building. We will outline one of the way user uses to get to the building.

Goal

Locating a professor's office in an unknown building.

Step 1. Find the building

1. Enter the building.
2. Locate floor, stairs/elevator/escalators.

Step 2. Go to the floor

1. Look for floor map nearby the gate.
2. Walk around the floor to locate the floor map.
3. Look around the wall, pillars to find the closest floor map.

Step 3. Study the floor map.

1. Locate the current location.
2. Figure out the orientation of the map.
3. Find the destination room in the floor plan.

Step 4. Locating the room

1. Attempt to walk to that direction.
    - i. Check the signs to see if you are in the right direction.
        - a. If you are, continue
        - b. If not reverse
    - ii. Follow the sign.
    - iii. Find the room.

Existing System

There are many existing system that users rely on these days in order to get them to a particular destination in the building. Most of the automated system are still in development and not yet deployed to the public. Mostly, users depend on the manual system to get them to the destination. In order to locate the correct room, users have to locate a floor plan or map of the buildings layout. This helps user to know where the room is, but of course there is always a chance that things could go wrong. Since maps are a top down view, the perspective users receive could not match up with how users view the building. If users wrongly view the map, then there is a chance that users could get lost and then users would have to trek back to the map or go back to the first method and just wander endlessly. The last option is to verbally ask someone for directions to the room that users are looking for. There are quite a few problems with this method. The person users ask could accidently give users the wrong directions or could confuse where it is that users need to go, and then he would end up sending users the wrong way. There are many technologies in place that allow users to easily locate the building that users need to get to, such as Google Maps, physical maps that are all across campus, and Georgia Tech even has an app that has a campus map on it. Unfortunately, there is not a Google maps feature that will pinpoint the exact location within a building that users need to go.

Manual System

- Asking people for directions
- Asking receptionist for directions
- Consulting floor plan
- Walk randomly until you find the location
- Follow signs
- Listen to friend's description ("It is next to the vending machine")

Strong Points

- To user - This manual system can be used at all time. There is no requirement that the users need to have a smart device.
- To developers - No extra costs in paying for extra devices to implement automatic indoor mapping.

Weak Points

- This system can impose delay in reaching the goal.
- User have to leave early to compensate for the expected delay in finding the destination.
- People guide in location can sometimes be confusing and misleading hence imposing uncertainty in reaching the goal.
- User can be late to meetings due to the time the manual system requires.
- In time of urgency, users will not be able to think clearly in using manual system.

Social Contexts and Technical Contexts

One social context would be navigating in campus. One of the hardest things that every student goes through each semester is trying to find an obscure classroom or office hidden in some back corner of an already complicated building on campus. Currently there are only a few ways to locate the room that you want to go to inside of a building. The first way to assume the general area and floor that the room would be at, and then physically wander around until you locate the room. This way is the most common method of located a room number, as usually there is always a general method of numbering rooms and by using the surrounding room numbers you receive either positive or negative feedback in whether or not your room is getting closer. However, there are flaws to this method. Since you are actively searching for the room there is always a chance that you might the longest possible route to get there, and this could cost the user valuable time. There is also the opportunity that the user could get lost or confused if the building happens to be oddly structured, has many hallways or paths, or even just numbered in a strange fashion. An example of this would be the Klaus building on campus, as the building is broken into two separate buildings and without general knowledge of the room numbers it could be a while before being able to make it into the right classroom.

A larger social context where our system intersect will be finding the room in the hospital. Way-finding in hospitals is a critical part of the healthcare experience. Large hospitals are inherently bewildering mazes of corridors and lobbies. Way-finding has a significant impact on satisfaction scores which contributes to health outcomes. Way-finding also affects the rate of missed or late appointments, which impacts operations and finance as well. Within these social context, there are some technical infrastructures (systems, devices and services) that the users have available.

Users' Intention In Using the New System

- Users' intention in using this system want to be more efficient in getting to where they need to be. Especially when they are facing in an unfamiliar place. It should reduce the time required to get to their destination.
- The only way to get to a new unfamiliar destination without being late is to leave earlier. Asking people has mixed results, and some people prefer not to interact with others.

People Who Are Involved When the System Is In Used

- Normally, users require cooperation of other people when they need to get to their destination. They either use a floor plan, ask other people or receptionists, or even walked around aimlessly until they find it.
- Despite the presence of directional signage and volunteer assistance, these environments continue to be a challenge for visitors.

Common Behaviors Associated With the Users When They Need to Use the System

- Users that need this system are often lost, confused, and frustrated when they cannot find their destination quickly and efficiently. If they are under a tight schedule, then this can induce a lot of stress.
- Patients and families often experience fear and anxiety amid uncertain health outcomes and these factors can make navigating a hospital even more challenging.

Current support

- Smart phones present an almost universal solution to this problem. Most people are familiar with smart-phone-based navigation for getting from point A to point B using maps and routing instructions. The system goal is to extend this same experience to indoor environments.
- Besides these underdeveloped existing technologies that can help. Other supports include floor plans which requires time to actually look for one. Receptionists exists but they may be off duty. Asking people has mixed results with no guarantee that they know or will give an explanation that the users will be able to adopt.

List of Usability Criteria/Principles

These are the list that will determine our system's success. The following list will reveal whether the system is successful in providing benefit and satisfaction to users.

Learnability and Memorability

When users return to the design after a period of not using it, how easily can they re-establish proficiency? Will the new system be easy to learn?

- The user should be able to use the system with little overhead.
- If the user knows the destination, he simply needs to input that location and the system should guide him without any confusion.
- Users should not require excessive steps in getting the system installed and ready to use.

Efficiency

Will the system be more efficient than the old system?

- There should be apparent result that this system performed successfully by allowing the user to reduce time spent in getting to a certain destination.

Will it reduce frequency of being late?

- Users should not be late due to time spent in navigation.

Satisfaction

Will it increase users' satisfaction?

- Users should not have to leave the origin earlier in order to compensate for the time to navigate the unfamiliar building.

Errors

How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

- Users should be able to undo their actions. In the case that the system crash, there should be back up recovery that can continue to guide the users to the destination when he re-access the system.

Measurement of Success

There are a variety of usability evaluation methods. Some methods use data from users. Our system will choose a method while considering cost, time constraints, and appropriateness.

Cognitive Modeling Methods

To evaluate the system learnability, efficiency we can use cognitive modeling method. We can use cognitive modeling to estimate how long it takes people to perform a given task. One modeling method example is GOMS.

- GOMS stands for goals, operator, methods, and selection rules. It is a family of techniques that analyzes the user complexity of interactive systems. The goal is to reach the destination in the building. An operator is an action performed in pursuit of a goal which involves accessing the system and input the destination location. A method is a sequence of operators that accomplish a goal. For example, the user first access the system followed by entering the location and after that follow the guide suggested by the system. Selection rules specify which method satisfies a given goal, based on context. This involves choosing the system language, assistance in disability etc.

A/B Testing

To evaluate the system efficiency, A/B testing can be used. A/B testing represents randomized experiment with two groups, A and B. A represents the controlled group, in this case the group using the old system and B represents the group that is in evaluation. This test will compare the time taken for each group to perform the same task. This helps to evaluate whether the new system use lesser or more time to find reach their destination in the building.

Questionnaires/Surveys

To evaluate satisfaction, errors and frequency of being late, we can use surveys to let the users provide feedback about our system. Surveys have the advantages of being inexpensive, require no testing equipment, and results reflect the users' opinions.

Data Gathering and Justification

This information was gathered by through the methods of ethnography and surveys. For ethnographical method, we evaluate ourselves as the users. We often need to find new room every semester and we experiences many problems in doing so. For the survey, we created a campus context and questioned 20 college friends. We keep the number of questions to be as few as possible so that it will not bore the participant. This prevents the data from being inaccurate due to participant just wanting to finish the survey as fast as they could. The formats we have chosen is multiple choice. The form that were sent to participants is shown below.

Evaluation Questionnaire

Please complete the following questionnaire. Your responses will be kept confidential and will be used only for implement the new indoor navigation system.

How many times do you need to go to a new building in one semester?

[Time(s)]

Do you have any problem exiting the building once you are inside?

☐ Yes
☐ No

Do you find building with complicated structure such as Klaus confusing?

☐ Yes
☐ No

How long do you usually spend when you are trying to navigate to your destination?

☐ Less than 5 minutes
☐ Approximately 5 minutes
☐ Approximately 10 minutes
☐ Approximately 15 minutes
☐ Approximately 20 minutes
☐ Approximately 25 minutes
☐ Approximately 30 minutes
☐ More than 30 minutes

Have you ever been late to class/meeting or other appointment because of the time spent on navigating?

☐ Yes
☐ No

Do you usually leave the origin point (dormitory, house etc.) earlier in order to compensate for the time needed to navigate?

☐ Yes
☐ No

Design Implications Discussion

Disability and Age

When noting down the characteristics of the users of the system, we have learnt that our design can greatly be influenced based on whether we want to accommodate the users with disability. This makes us think about whether we should design two separating systems in order to accommodate users with disability. If the users have impaired vision, it should not be a problem because our system will have voice guide (like a GPS) to tell the users to turn left or right. However, if the user is color blind then our system should have color blind mode. If the users have impaired hearing then they can use the visual aid that tell them to turn left or right. All these problems make the system really "heavy" because of so many features. We might plan to target the primary users first then focus on branching to other features. The same apply to the age range of users that use our system. To accommodate elderly, we think we should include large font size option and larger button for elderly. Kids, adults and teens should find the system easy to use provided that they are technical savvy.

Language

English is the main language of the system. Although language of the text can be easily change and mapped, voice command need some work and resources. We have to decide on how many language we should

Task Analysis

While performing an ethnographical task analysis. Our group member tried to locate a room using only floor map. We learnt that the floor map placement are not consistent. For example, in the library the first floor map is located near the toilet. The second part of the floor map has to be searched and is located near the elevator. We learnt that finding the floor map alone can be troublesome.

While gathering data by the mean of surveys, we learnt that many participants might be giving an inaccurate answer. This stems from the fact that they are afraid to present a negative image of themselves. After doing the survey, it shows that many people are confuse while trying to locate a room. This verify that there are room for improvements to be made so that people are less confused.

Social and Technical Context

Initially, we aimed to target the college students who need to find their classroom in campus. However, we learnt that it is not that impactful to campus students. After the first week many will stop relying on our design because they will be familiar with their new environment. Hence the primary potential users are not college students. We learnt that there are larger social context that our design will be more impactful and beneficial. This larger social context is hospital navigating system. The navigating system is a critical part of the healthcare experience. Large hospitals can be very challenging to navigate through due to it being unfamiliar and having so many corridors. Getting lost or successfully finding your way in a hospital can mean the difference between being present for the birth of a child or supporting a loved one as he or she is taken to surgery.

We learn that the existing automated system is very underdeveloped. Several indoor positioning methods have been tested using Wi-Fi, Bluetooth beacons, LED lighting, magnetic and sensor fusion. All of these systems have drawbacks, whether technical, practical or financial. In addition, there are concerns around effective deployment and user adoption. Wi-Fi technology will have the problem of coverage. Due to disparity in intensity of the signal, it is hard to pinpoint the exact location of the user. For iBeacon, the deployment will need many iBeacon devices (up to thousands) to cover the whole building.

Indoor Navigation

Part 2 - Design Alternatives

(Ratchapong Tangkijvorakul, Zeheng Chen, Joshua Lill, Anh Tuan Van)

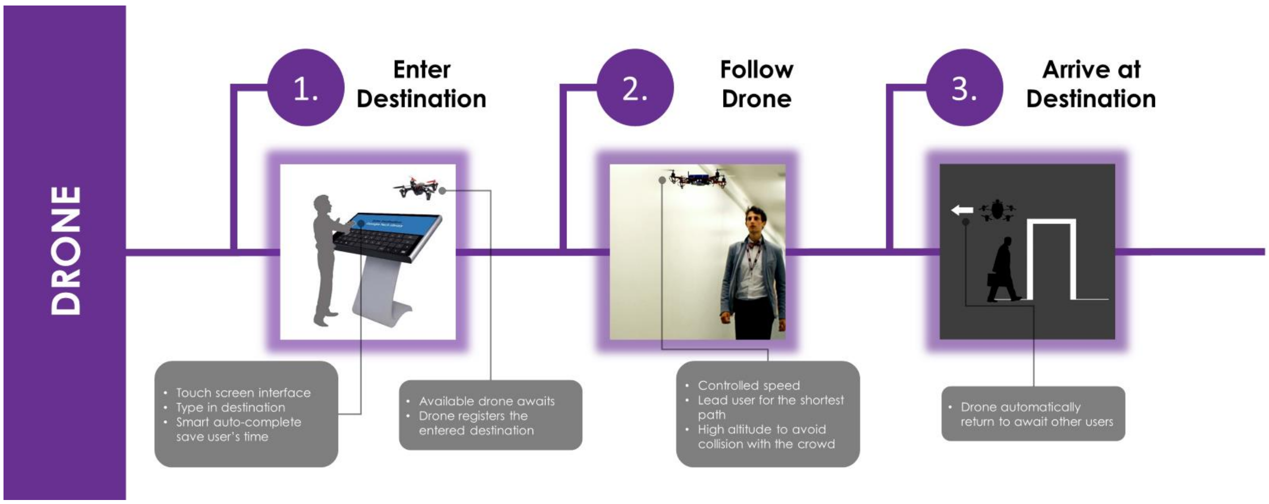
Project Description

Navigation is essential to most people's daily life these days. People can get to places much easier by using smartphones as a GPS device through Google Maps/Apple Maps. But GPS doesn't work indoors. In order to go to a certain room/place, a floor map is needed with clear numbering of the room. However, most of the times, people get lost and wasted a lot of time navigating through the building when the floor map is confusing and not well documented. Hence, finding places indoor can be very challenging and time consuming. There are many attempts to solve this problem by using various technologies such as wifi pining(Google's), active RFID, computer vision and bluetooth(Apple's iBeacon and Nokia's Here). None of them are good enough that get mass adoptions yet. Therefore, instead of focusing on one technology, we plan to experiment with various technologies(GPS,bluetooth,wifi,RFID) to come up with a more hybrid solution that is easier for buildings/venues to deploy and a more seamless integration with current major navigation provider such as Google and Apple's Map.

Our project is an indoor navigation system that helps individuals to find rooms in a building through their mobile phones. It is relatively easy to find a building because of GPS. However, indoor navigation can be quite a troublesome process to many people.When an individual is inside the building, indoor navigation will provide a set of directions to guide an individual to their destination.

This system is needed because once an individual get inside the buildings, there is not an easy and straightforward way to find a room that he needs to go. Some buildings might have good signs that is easy to understand. But many other buildings has confusing signs and floor structures. Many individuals that visited the building for the first time will have trouble getting to the right destination. Even those who pay frequent visits to the building may find it confusing to navigate to certain room that they had not been before. Indoor navigation is needed to reduce time in navigating in the building to find a certain room.

Design 1 Description – Drone



Narrative Walk-Through

The idea behind the drone design involves using an automated machine, the drone, that will lead user to his destination.

Entering Destination

At each important location in the building such as entrance or major intersections, there exists a touchscreen panel (similar to Kiosk desk) where user can enter his destination. Touchscreen mode is the hybrid of resistive digitizer (sensing pressure) and capacitive digitizer (sensing skin contact). User can enter destination from the on-screen keyboard and touchscreen will provide a smart completion for user. If there is an available drone, the drone stationed there will lead him to his destination, if not, a timer will appear on the screen to notify user of the wait time of the next available drone.

Follow the Drone

Once the user entered the destination, the available drone will register the commands and start guiding the user. The drone will fly with a specific attitude to avoid being an obstruction to the moving crowds. The drone will fly at the speed it seems fit based on the speed the user walks.

When user need to change floor, the current drone will end its navigation and will pass the command to the drone on the next floor to help user to continue his navigation. The original drone will then be ready to accept new orders from another user at that respective floor.

Arrive at Destination

The drone will ends it navigation if the user arrive at his destination or when the user change floor. Once this happens, the drone will return to its initial position to await another user command.

Justifications

This system have many features. These features are explained below,

- **Touchscreen Location Placement** - Touchscreen will be placed at important location like entrance, stair and elevators so that user can logically locate it.
- **Touchscreen Hardware Technology** - Resistive digitizer (sensing pressure) is for user who is not convenient to provide skin contact such as user who were gloves. Capacitive digitizer (sensing skin contact) are for the traditional touchscreen users. The hybrid of the two appeal to larger user group.
- **Smart Auto-Completion** - Help to assist user who cannot remember the spelling of the destination. This saves user time as well.
- **Display of Timer** - A timer gives the next person in line knowledge of when to expect their drone to arrive. This way they know whether or not it is worth it to wait or go and find an alternative way to find the room.
- **One Drone Per Floor** - From a cost perspective, having more than one drone per floor would at least double the cost, if not more. Also it prevents drones from crashing into each other, and any user confusion of which drone to follow.
- **Flying at Calculated Attitude** - A set height gives the drone its own space, it would be high enough that average and even above average human 's height would not have to worry about hitting it.
- **Flying at Calculated Speed** - A set speed would ensure safety and that the user has enough time to follow it. It cannot be too fast that the user cannotcatch up, or too slow that the user gets frustrated with it. If an elderly were to use the drone, the drone should allow her to follow it with ease at her own pace.

- **Return of the Drone** - By having a set return place, it has a place to charge, and pick up its next user.

Relative Strengths and Weaknesses

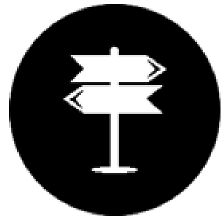
Strength

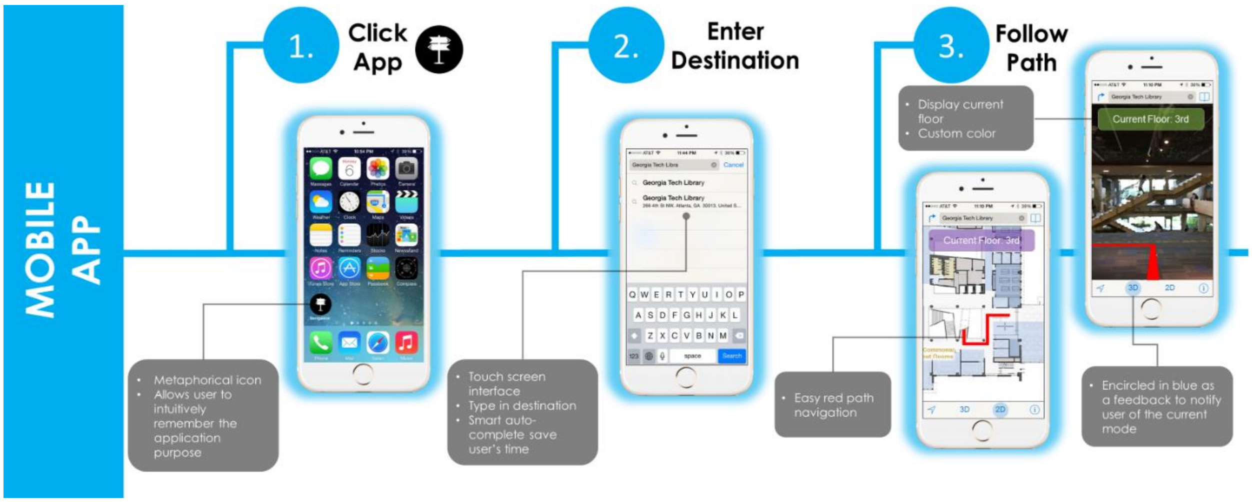
- Drone never gets lost, and neither does the user. As long as the user is properly following the drone, they are guaranteed to meet their destination.
- Creative idea, new to the world.
- Intuitive to use.

Weakness

- Limited drone per floor.
- Only one user on the floor can only user the system.
- Drone consumes energy, need charging.
- Overhead cost very high.

Design 2 Description - Mobile Application





Narrative Walk-Through

The main feature of this mobile application implementing indoor navigation is that it has a two dimensional map, as well as a three dimensional map. The two dimensional map would just be a simple floor plan of the building with a red line leading to the room that user is trying to get to, as well as an indicator of user's current location. However, the three dimensional design is more complex, and gives user a physical 3D look of the building, so that user is able to look at the hallways and rooms in an intuitive manner.

Click App

User simply click the icon that have an implied meaning of “navigation”.

Enter Destination

User then enter the destination into touch screen. Touch screen will assist user with smart auto-completion. Touch screen also match user conceptual model of navigation application such as Google Maps.

Follow path

A display and a red path will intuitively show user the correct way to his destination. User will also be informed of the current floor he is on by looking at the box at the top of the screen. This box color can be customized by user. User can choose between 2D or 3D mode for navigation. An blue circlie will act as a feedback to user of the current mode he selects.

Justifications

- **Choice of Icon** - Icon has to be easily identifiable so that it does not get lost in user's pages of applications. The application icon has a metaphorical and logical reasoning behind it.
- **Design of the Input Screen** - The design is similar to input screen of Google Maps. This maintain the conceptual model of many users and reduce the learnability curve.
- **Smart Auto-Completion** - Help to assist user who cannot remember the spelling of the destination. This saves user time as well.
- **Red Color for Path** - Design make use of selective attention, we chose red because it will grab the users attention and also it is easy to follow.
- **Current Floor Display -** Conveniently remind user of the current floor. User does not have to look for sign or try to count the floor by looking down. Custom color allow user to choose the color that he feels the most comfortable about.
- **3D Mode** - Shows the user exactly what he is looking at, and overlays a navigational arrow on top of it. It is easy to follow and hard to get lost.
- **2D Mode** - Provides the 'traditional' method of mobile navigation. It also provides the user the whole map and allows them to look ahead.

Relative Strengths and Weaknesses

Strength

- One of the strengths of this design is the three dimensional modeling of the buildings itself. This creates something visual that the users can utilize and makes the directions clear and concise, for there is no way to confuse directions when you can physically see the path.
- The system is design so each user have his own system. Just by owning a smartphone.

Weakness

- Modelling the building. Building 3D structure has to be hard-coded. This would be both a time consuming and expensive part of the project.
- Another weakness is that currently user just search for the building he wants, whereas it would be better if he could interact with the map.
- User likely to only use the application once for one destination. Design need to be able to let first time user know what to do.
- No consideration of elevator. Need to think about edge case if there is a fire.

Design 3 Description - SmartWatch

Narrative Walk-Through

The idea of the SmartWatch exists behind providing feedback to the user about the direction that they should go. The core concept behind this idea is to allow the user to easily move without being worried where they currently are location. While the watch initially starts with a voice system along with the vibration system, the voice system can be turned off to allow the user to simply rely on vibration pattern. The watch form of feedback can be customized by the user. For example, how early or how late the watch delivers the movement instruction.

Entering Destination

The user inputs their destination into the SmartWatch, by either typing or issuing a voice command.

Await Instructions

After the destination has been registered. A watch will try to calibrate its orientation. After calibration of orientation is done, a feedback sound and display will notify the user.

Follow Instructions

After the calibration process , the SmartWatch a voice mode that moves the user through the building, directing them whenever they have to turn. For example, it'll say 'Turn left' when you need to turn left. Additionally, the watch itself buzzes and vibrates in a specific way whenever these directions are given, these vibration pattern can be customized by the user. After arriving at its destination, a feedback sound and display will notify the user.

Justifications

This system have many features. These features are explained below,

- **Voice Command for Destination Input -** Because the watch screen is so small, typing on it would be extremely difficult. A verbal command makes it a quick and simple task for the user.
- **Typing Command for Destination Input -** If a user's voice is unable to be heard or understood, due to medical or other reasons, then user can manually type in the destination.
- **Calibration of Orientation-** Because the watch is constantly switching to different positions as user walks. An initial calibration would be needed.
- **Feedback After Calibration** - This is to ensure that the user knows that the calibration process is finished.
- **Voice Mapping -** Verbal commands allow you to hear directions without having to look down at your watch. They have to be clear and concise enough so that user understand where he needs to go.
- **Purpose of Vibration and Its Pattern -** The vibrations are a way to receive your directions if you are unable to hear the verbal commands. The vibrations would have to be distinguishable enough that user can interpret without mixing up different patterns.
- **Feedback Upon Arrival** - There has to be a way for the user to know when he has arrived at his destination, so he knows when to stop.

Relative Strengths and Weaknesses

Strength

- Vibrations are good for people with disabilities
- Verbal commands is good for people that is still in process of figuring out the vibration pattern.
- Convenient, user does not have to pull it out of his pocket. Conveniently attached to user's wrist.
- Vibration feedback works well in the crowd where the noise would submerged voice command.

Weakness

- Verbal commands bad if user is in a crowded area
- High learning curve, you have to know what each vibration means to know directions
- Display screen is very small. Hard to type.

Summary and Reflection

We experiment three very different ways to solve indoor navigation. Each of them has certain limitations.

For drones, the main problem we are having is how to handle multiple drones that are flying around in the same time. 'Hover' technology would be a solution, where the drone is just a ball hovering around. Each drone will be so tiny that no one will be bothered. But technology is not ready at the moment. Additional accessory can be added to improve usability; For example, a companion smartphone application could be used to queue and prepare for drone usage, as well as stopping the drone.

For Mobile app, the main problem we face is how to do 3D mapping of the entire buildings. It will require lots of manual labor to take lots of pictures to model the whole interior. How can we automate this process remain the biggest unsolved challenge. Maybe we can use a drone to do a flyover of the entire building.

For watch, the main problem we are having is the initial learning curves. User would need to be trained to understand vibration patterns to know the direction. How to teach our users in a short amount of time remains as a challenge. A potential solution is to let the watch say the direction out loud in the first few time, until users are comfortable with the vibration pattern. Another problem is for the voice input. Most of time, users will wear the watch in a loud metro area, which makes the watch difficult to do voice recognition.Therefore, an alternative solution for input need to be provided. Either through a smartphone mobile app, or use a crown to select a list of frequently used orsaved destination.

After carefully evaluating all the pros and cons of three different designs, we are focusing on the mobile application efforts at the moment. This solution requires the least amount of hardware and we can quickly prototype our ideas on our phones. Another factor that motivates us to focus on mobile efforts is the class scope. We are more confident that we can get some kinds of working prototypes on the mobile application instead of building a drone system or design a watch from ground up. It is more practical and it has equal potentials of helping people navigate to their destination.

Indoor Navigation

Part 3 - System Prototype and Evaluation Plan

(Ratchapong Tangkijvorakul, Zeheng Chen, Joshua Lill, Anh Tuan Van)

Project Description

Navigation is essential to most people's daily life these days. People can get to places much easier by using smartphones as a GPS device through Google Maps/Apple Maps. But GPS doesn't work indoors. In order to go to a certain room/place, a floor map is needed with clear numbering of the room. However, most of the times, people get lost and wasted a lot of time navigating through the building when the floor map is confusing and not well documented. Hence, finding places indoor can be very challenging and time consuming. There are many attempts to solve this problem by using various technologies such as wifi pining(Google's), active RFID, computer vision and bluetooth(Apple's iBeacon and Nokia's Here). None of them are good enough that get mass adoptions yet. Therefore, instead of focusing on one technology, we plan to experiment with various technologies(GPS,bluetooth,wifi,RFID) to come up with a more hybrid solution that is easier for buildings/venues to deploy and a more seamless integration with current major navigation provider such as Google and Apple's Map.

Our project is an indoor navigation system that helps individuals to find rooms in a building through their mobile phones. It is relatively easy to find a building because of GPS. However, indoor navigation can be quite a troublesome process to many people.When an individual is inside the building, indoor navigation will provide a set of directions to guide an individual to their destination.

There are quite a few mapping and navigation apps out today, however there are none that allow you to be able to navigate inside of a building. Our application, NavIn, allows the user to see their position inside of a building, and instantly find the room, or the professor that they are looking for. Our app would then provide the user with step by step instructions on how to navigate to this room for their current location. NavIn would not only give users a top down view of the floor plan, but also the ability to see the building from a three dimensional perspective, to ensure that you know exactly where you are at all times.

Requirements

To ensure that the Indoor Map works properly, we created it with set goals in mind that it could accomplish. We wanted our app to be able to accomplish quite a few tasks.

Narrative Walk-Through

1. User should be able to find their destination on the app.
2. User should be able to follow navigation instruction in no time.

Design Summary

The prototype is an animated iPhone mock up that demonstrates how the user will use it to find their destination. In the default screen, we put interesting point of interest, in our case, professors on the map. There is a small circle that has the professor's face in it. The target audiences of these apps are students that are interested in finding where the professor is, so it's natural to put professor on the map. If I tap the professor's face, a detail screen about professor's information will pop out from the button up.This screen contains the basic information about the professor, his/her room location, a brief bio and phone number and website information. If the user tap the professor's head again, it will go to the screen to the navigation preview screen. The user can have a basic idea how to get to the professor on a 2D screen. Once the user hit start navigate, it will enter a turn by turn navigation screen. This is what set our map application unique. Out navigation will be a 2D/3D mesh. We will have traditionally Google Map Style 2D mapping on the top, but we will have real time image on the bottom of the screen. The user can compare that image with what he/she saw lively while she is there, this way, he/she won't need to walk a few steps and then see if they are in the right direction, because they can simply look up to see if what in front of them is on the phone app. If user prefer to see all 3D mapping, he can slide the 3D map from bottom up, then a 3D image view will show up with green direction allow overlays on the button on the image. The user can simply follow that direction to navigate to the destination. if the user prefer to go back to 2D/3D screen, they simply just need to slide from top to bottom.

Detailed Prototype Demo and Description

Narrative Walk-Through

The main feature of this mobile application implementing indoor navigation is that it has a two dimensional map, as well as a three dimensional map. The two dimensional map would just be a simple floor plan of the building with a red line leading to the room that user is trying to get to, as well as an indicator of user's current location. However, the three dimensional design is more complex, and gives user a physical 3D look of the building, so that user is able to look at the hallways and rooms in an intuitive manner.

Click App

User simply click the icon that have an implied meaning of "navigation".

Enter Destination

User then enter the destination into touch screen. Touch screen will assist user with smart auto-completion. Touch screen also match user conceptual model of navigation application such as Google Maps.

Follow path

A display and a red path will intuitively show user the correct way to his destination. User will also be informed of the current floor he is on by looking at the box at the top of the screen. This box color can be customized by user. User can choose between 2D or 3D mode for navigation. An blue circlie will act as a feedback to user of the current mode he selects.

demo_icloud_final.m4v

Implementations Challenges

Using Keynote to implement the interface involves a lot of learning. In addition, the most difficult problem that we faced was on how to properly design the indoor navigation system in a way that the directions were clear and easy enough to follow so that the user doesn't get lost. A common problem even for normal outdoor navigation applications are directions that confuse people and allow them to take the wrong exit or turn. There is nothing more frustrating than that experience. However, this is not always the case for outdoor navigation, as the roads are usually relatively spaced out, and the roads are very big and it's simply hard to miss the turn. Indoor navigation is completely different from that. Sometimes the pathways can be quite narrow and there are so many that are interconnected and many different pathways that all lead to the same place. So,how can a user not be confused while follow our navigational instructions? How can the user know exactly which direction to go? Which turn to take? These are all questions that we had to think about and design around. Our answer came in the form of our unique 2D/3D mesh display. It's a hybrid between traditional 2D navigation mapping and a 3D live preview of what suppose to be in front of you. This way, you will follow the direction, compare the 3D image with what you see in your eyes, if they match, you know this is the right way to go. It's this feature that we believe makes our design unique and special and addresses the problem that we were facing.

Justifications

We experiment three very different ways to solve indoor navigation. Each of them has certain limitations.

For drones, the main problem we are having is how to handle multiple drones that are flying around in the same time. 'Hover' technology would be a solution, where the drone is just a ball hovering around. Each drone will be so tiny that no one will be bothered. But technology is not ready at the moment. Additional accessory can be added to improve usability; For example, a companion smartphone application could be used to queue and prepare for drone usage, as well as stopping the drone.

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For the watch, the main problem we are having is the initial learning curves. User would need to be trained to understand vibration patterns to know the direction. How to teach our users in a short amount of time remains as a challenge. A potential solution is to let the watch say the direction out loud in the first few time, until users are comfortable with the vibration pattern. Another problem is for the voice input. Most of time, users will wear the watch in a loud metro area, which makes the watch difficult to do voice recognition.Therefore, an alternative solution for input need to be provided. Either through a smartphone mobile app, or use a crown to select a list of frequently used or saved destination.

After carefully evaluating all the pros and cons of three different designs, we are focusing on the mobile application efforts at the moment. This solution requires the least amount of hardware and we can quickly prototype our ideas on our phones. Another factor that motivates us to focus on mobile efforts is the class scope. We are more confident that we can get some kinds of working prototypes on the mobile application instead of building a drone system or design a watch from ground up. It is more practical and it has equal potentials of helping people navigate to their destination.

Here are the list of why we chose to implement the interface the way we did,

- **Choice of Icon** - Icon has to be easily identifiable so that it does not get lost in user's pages of applications. The application icon has a metaphorical and logical reasoning behind it.
- **Design of the Input Screen** - The design is similar to input screen of Google Maps. This maintain the conceptual model of many users and reduce the learnability curve.
- **Smart Auto-Completion** - Help to assist user who cannot remember the spelling of the destination. This saves user time as well.
- **Color for Path** - Design make use of selective attention, we chose color because it will grab the users attention and also it is easy to follow.
- **Current Floor Display -** Conveniently remind user of the current floor. User does not have to look for sign or try to count the floor by looking down. Custom color allow user to choose the color that he feels the most comfortable about.
- **3D Mode** - Shows the user exactly what he is looking at, and overlays a navigational arrow on top of it. It is easy to follow and hard to get lost.
- **2D Mode** - Provides the 'traditional' method of mobile navigation. It also provides the user the whole map and allows them to look ahead.

Finally, using application is good because

- One of the strengths of this design is the three dimensional modeling of the buildings itself. This creates something visual that the users can utilize and makes the directions clear and concise, for there is no way to confuse directions when you can physically see the path.
- The system is design so each user have his own system. Just by owning a smartphone.

Evaluation Plan

There are a variety of usability evaluation methods. Some methods use data from users. Our system will choose a method while considering cost, time constraints, and appropriateness.

Cognitive Modeling Methods

To evaluate the system learnability, efficiency we can use cognitive modeling method. We can use cognitive modeling to estimate how long it takes people to perform a given task.
One modeling method example is GOMS.

- GOMS stands for goals, operator, methods, and selection rules. It is a family of techniques that analyzes the user complexity of interactive systems. The goal is to reach the destination in the building. An operator is an action performed in pursuit of a goal which involves accessing the system and input the destination location. A method is a sequence of operators that accomplish a goal. For example, the user first access the system followed by entering the location and after that follow the guide suggested by the system. Selection rules specify which method satisfies a given goal, based on context. This involves choosing the system language, assistance in disability etc.

A/B Testing

To evaluate the system efficiency, A/B testing can be used. A/B testing represents randomized experiment with two groups, A and B. A represents the controlled group, in this case the group using the old system and B represents the group that is in evaluation. This test will compare the time taken for each group to perform the same task. This helps to evaluate whether the new system use lesser or more time to find reach their destination in the building.

Questionnaires/Surveys

To evaluate satisfaction, errors and frequency of being late, we can use surveys to let the users provide feedback about our system. Surveys have the advantages of being inexpensive, require no testing equipment, and results reflect the users' opinions.

Summary and Reflection

Throughout designing our application we were able to finally able to take our ideas and flesh them out into something real. It was quite difficult making the choices about how the application should be designed, especially because we weren't just designing the system for ourselves or for professors. For most classes, you have a set product that you have to create, sometimes you get the freedom to create it your own way, but the end product must be the same as everyone else. However, with this product, we had complete and utter control over every aspect of the design. We had to make all of the decisions on our own, and not only that but we had to keep an audience in mind. We had to design the application as if it was actually going to be released to the public, and we had to ensure that it was actually able to used. It couldn't be too difficult or too simplistic, we had to find the right mix of elements so that it accomplished its task without putting to much strain on the user. Overall it was a fantastic experience and we can't wait to see how the users react, when we get to test it and evaluate it next time.

Indoor Navigation

Part 4 - System Prototype and Evaluation Plan

(Ratchapong Tangkijvorakul, Zeheng Chen, Joshua Lill, Anh Tuan Van)

Evaluation Techniques Description

We have a series of 5-10 tasks/features that users are unknowingly being tested and timed on. Half of the users are given step by step instructions on how to complete the task (Step 1 go to the navigational page, step 2 navigate to Dr. Melody's room, step 3 switch to mesh view, 4 switch to full 3D view). The other half are just told to navigate to Dr. Melody's room. We write down the time it takes for each of the tasks to be completed. We have a specific time that we feel these tasks should be completed in, and use this as a method to determine whether the task is a success or failure. The average of the times it takes users to complete the tasks, gives us the designers the ability to see what features need to be improved upon. The blind users gives us a rough time estimate for new users. The instructed users, gives us a rough estimate for users who know what they're doing.

Tasks and Techniques

Blind Test Task:

This Blind Test is used to test overall application experience, does this app do its job, navigate you to your destination?

1. Time the user how long it takes he/she to navigate from the home screen to the navigation screen.
    i. Benchmark to pass is 7 seconds (7 seconds were chosen due to prior testing by the group members which end up with a value of 5 seconds as average)
2. See if they will use the smart search option (tapping the profile icon) rather than using the traditional search bar.
    i. True/False format
3. See if they can figure out the transition from 2D to 3D without seeking assistance.

i. True/False format

4. When encounters a screen which have no back button, will the user intuitively swipe left?
   i. True/False format
5. When encounters a screen which have a back button, will the user intuitively click it to go back?
   i. True/False format
6. When at the screen before beginning the navigation, does the user know how to start the navigation?
   i. True/False format
7. See if they can figure out the transition from 2D to 3D without seeking assistance.
   i. True/False format

Individual/Walk-through Test:

1. Navigate to Dr.Melody's office. The lady on the screen is Dr.Melody. What will you do to get there?
   i. Answer:
      a. Tap her head (TRUE)
      b. Tap Search Bar (FALSE)
         a. Test to see if that profile icon will give people hint that is a Point of Interest?
2. Ask, now you want to go back to home screen, what will you do?
   i. Measure the number of people that tap the return navigation bar item.
   ii. Measure the number of people that try to swipe to left (This won't have any effects)
      a. Test to see with a navigation bar, people know how to go back.
3. Repeat Step 1, ask them to tap profile icon in the map. Now the screen is the detail of Dr. Melody's information. Ask them what to do now to start navigation.
   i. See if they tap the profile icon
      a. See if this design is effective, or is we need to replace profile icon with some text like Start or a road sign
4. Now in the Navigation Preview Step. Ask them what will they do if they want to cancel the navigation trip. (Note, there is no navigation return bar)
   i. Measure the number of people try to swipe to left
      a. Test to see if people need to have a navigation bar to figure out how to get back to previous screen.
5. Go back to Step 4 screen, ask them to start navigation.

    i. No need to measure anything.

6. Now in the 2D/3D mesh view. Ask them if they want to bring the view into a full screen 3D view, what will they do?
    i. Measure the number of people tap.
    ii. Measure the number of people slide up.
        a. Test to see if the slide up design is legit, or should change it to tap.

Interview Questions

To evaluate users' satisfaction, we use surveys to let the users provide feedback about our system. Surveys have the advantages of being inexpensive, require no testing equipment, and results reflect the users' opinions.

1. What was your overall experience with the app?
2. Was there anything about the app that you found difficult to understand?
3. Did you ever find yourself confused or lost at any time during your time with the app?
4. If so, when?
5. What was your favorite feature of the app?
6. What was your least favorite feature of the app?
7. Is there anything that you would want to be changed in the app?
8. Would you use this app again, if you had the opportunity?
9. Why or Why not?
10. How much would you pay for a full version of this app?

Users Involved

12 Users were selected to test our prototype. Most of the users are campus students. These users have the following characteristics:

Physical Characteristics

- Age group: 18-23.
- Sex: M/F

Perceptual Abilities

- Vision: Fully-able
- Hearing: Fully-able
- Touch: Fully-able

Knowledge and Experience

- Education Level: College students
- Native Language: The majority of users’ native language is expected to be English.

IT and Computer Experience

- Computer Literacy: Users are familiar with the basic operation of smart device. This includes knowing how to press the button on the screen and typing in the locations using the device keyboard.

Evaluation Technique Rationale

We used both qualitative feedback as well as quantitative feedback in order to analyze the features and functionality of our interface.

Qualitative Evaluation

By employing the thinking-aloud verbal protocol, we can observed the users' interaction with the interface. This allows us to study and analyse what is the common thoughts among the pool of users. We can also be aware of our flaw in the design which causes the users to encounter difficulty in operating the system.

Empirical Evaluation

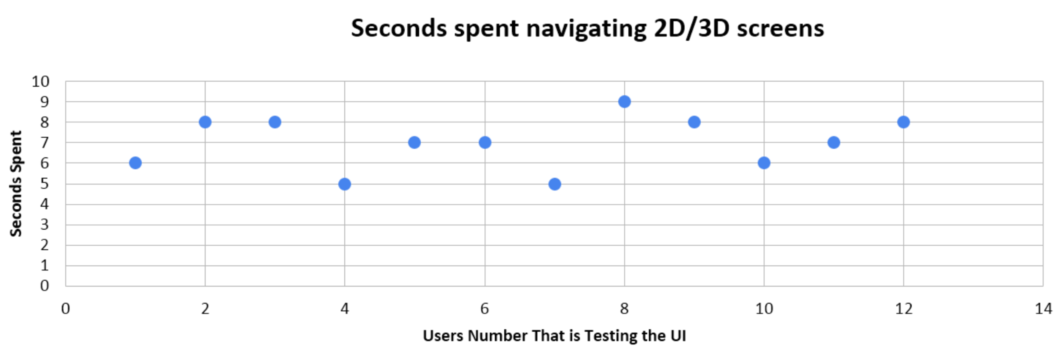
This rational is more practical and numerical in the sense that we time the user so that we get the rough idea of how long the user will take to operate the system. The time is then compare with a benchmark time to evaluate user's learnability.

The data that we would collect from our evaluation would be able to be instantly put to use in updating and fixing any problems that we find in our design. The tests that we created for our evaluation, allow us to see exactly which feature is having problems. If we believe that switching to the 3D screen should only take users 2 seconds to figure out, but the average user that we test takes 5 seconds, then we have a serious design flaw that will need to be addressed. The interview at the end of the testing period, is another good way to get further information on the users' experience with our app. Instead of quantitative data on the app we get qualitative information on the users themselves. We get to hear about their experience with the app, what they liked and hated, and whether or not they would use it again. Even if our app performs perfectly, it wouldn't succeed if users hated it, or couldn't understand how it functions.

Results of Studies and Analysis of Results

Data Collection 1 - Did they pass the benchmark time?

User Number	Time Spent for 2D/3D Screen	Pass Base Line (Time Spent > 7)
1	6	TRUE
2	8	FALSE
3	8	FALSE
4	5	TRUE
5	7	TRUE
6	7	TRUE
7	5	FALSE
8	9	TRUE
9	8	TRUE
10	6	TRUE
11	7	TRUE
12	8	TRUE
	Mode: 8 **Mean: 7**	**Mode: 1** **Mean: 0.75**



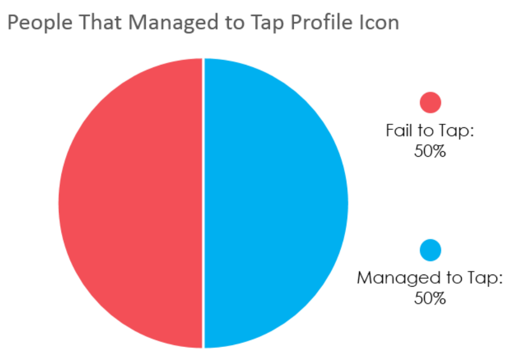
Analysis

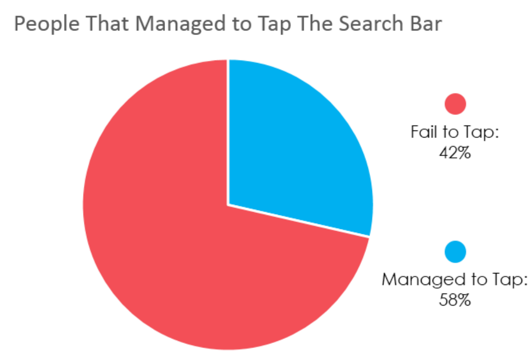
- Standard deviation is 2.063
- Most people passed the base line, leading to a mode of 8. On average people took 7 seconds to accomplish the tasks.
- There was a low variance, only 1.2. This means that most people were either between 6-8 seconds. This is a good time frame.

Data Collection 2 - Did they utilize the smart search functionality?

Navigate to Dr. Melody's Office.
The lady on the screen is Dr. Melody. What will you do to get there?

User Number	Managed to Tap Profile Icon	Managed to Tap Search Nar
1	TRUE	FALSE
2	TRUE	FALSE
3	FALSE	TRUE
4	FALSE	TRUE
5	TRUE	FALSE
6	FALSE	TRUE
7	TRUE	FALSE
8	FALSE	TRUE
9	FALSE	TRUE
10	TRUE	FALSE
11	TRUE	FALSE
12	FALSE	FALSE
	Mode: 1 **Mean: 0.5**	**Mode: 0** **Mean: 0.41667**





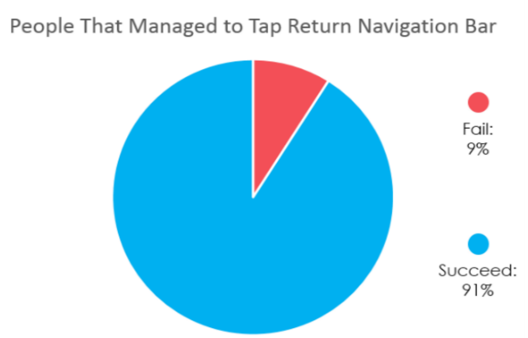
Analysis

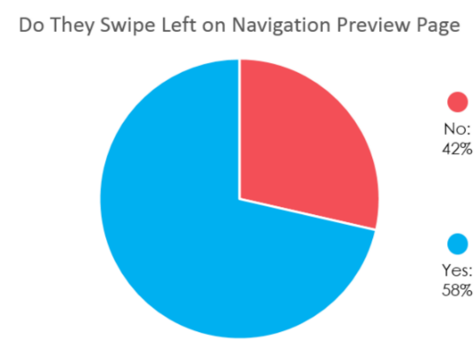
- Half the people figured out that they can tap the profile icon.
- A slightly lower rate was similarly found for tapping the search bar.
- We need to make what to touch/press obvious - remedies include visual and aural clues implementation.
- Possibly, we might move the UI around, and use more obvious affordances.

Data Collection 3 - Did they intuitively know how to return to previous screen?

Ask: Now You Want to Go Back to Home Screen, What Will You Do?

User Number	On Screen 2. Do They Tap Return Navigation Bar	On Screen 3 Do they swipe left? (The Navigation Preview Page)
1	TRUE	FALSE
2	TRUE	FALSE
3	TRUE	TRUE
4	TRUE	TRUE
5	TRUE	TRUE
6	TRUE	TRUE
7	TRUE	TRUE
8	TRUE	FALSE
9	TRUE	FALSE
10	FALSE	FALSE
11	TRUE	TRUE
12	TRUE	TRUE
	Mode: 1	**Mode: 0**
	Mean: 0.9167	**Mean: 0.58333**





Analysis

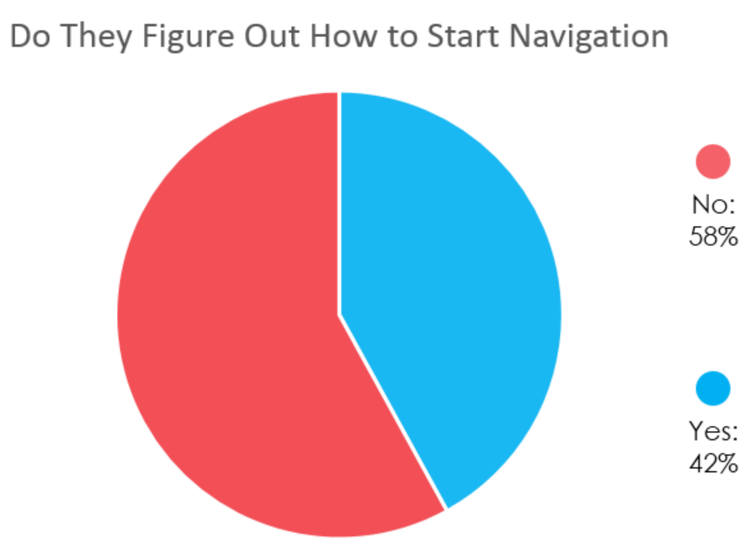
- 91% people figured out how to return using the navigation bar.
- Only 58% people swipe left to return. We need to make it more obvious.
- A flashing left symbol, nudges or vibrations may help.
- Need to make use of the concept selective attention to make a better cues.

Data Collection 4 - Did they maintain enough conceptual model from other Apps(Google) to start the navigation?

Now the Screen is the contains Melody's information.
Ask: What to Do Now to Start Navigation.

User Number	On Screen 2. Do They Tap Return Navigation Bar
1	TRUE
2	TRUE
3	TRUE
4	TRUE
5	FALSE
6	FALSE
7	FALSE
8	FALSE
9	FALSE
10	TRUE
11	FALSE
12	FALSE

Mode: 0
Mean: 0.41667



Analysis

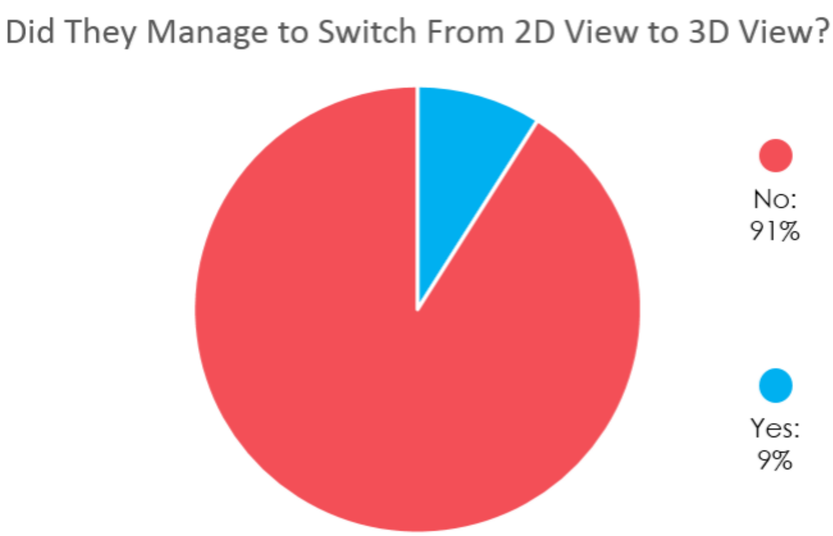
- 58% people could not figure it out. We need to provide more cues on how to start navigation.

Data Collection 5 - Do they know how to switch between different modes?

Can People Figure Out How to Switch From 2D to 3D View?

User Number	Manage to Figure Out
1	FALSE
2	FALSE
3	FALSE
4	FALSE
5	FALSE
6	FALSE
7	FALSE
8	TRUE
9	FALSE
10	FALSE
11	FALSE
12	FALSE

Mode: 0
Mean: 0.08333



Analysis

- 91% people can't switch between 2D and 3D view.
- There is a need to better design the transition.

Overall Analysis

There are some issues that we need to improve with current design. Notable issues include switching from 2D view to 3D view, starting navigation and swiping left to return.

Implications of the Results

From the time spent from home to 2D/3D navigation screen, the data showed that majority people hit 7 seconds. The implication of this showed that our overall design is solid and people can figure out our basic functionality, which is a navigation application. This tells us, there is no need to change the overall navigation flow.

On the homescreen, we are testing to see if using Melody's icon acts as a visual cue. So the idea here is we want to see, if we put people's face on the map, and if you want to find them, you will simply tap their face. Traditionally, people will always have to go to search bar and search the destination. But here we are experimenting let people tap the point of interest directly and go. Half of the people choose to tap Melody's head. Therefore, this cue is helpful. We want to keep this feature.

On Navigation Bar return and Swipe Left return. The implication is, users these days still really need to see a Navigation bar return symbol in order to navigate back. We thought that these days, people are used to gesture interaction. But this is not what we see on the data here.

We confirmed again that user are not used to gesture based system based on the data that 91% of the user don't know they can swipe up to transit from 2D to 3D view.

Prototype Design Improvements

From our data analysis and the implication it showed us, we believe that we can improve users' familiarity with our gesture based control with a tutorial video to demonstrate how to swipe to the left to return to previous screen and swipe up to transit from 2D to 3D view.

We will also improve some of our visual cues such as the Start Navigation. Currently we use people's head to represent start the navigation. But this is not a very good analogy. We will replace this with text such as Start or with a road sign.

Project Poster Presentation