



Comet-Vision

SE6361.001 SPRING 2022

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Problem Statement

The problem of	Visually impaired people unable to safely navigate indoors in buildings on campus at UTD due to certain limitations of preexisting tools such as a cane, dog, or an assistant
Affects	Visually impaired students, faculty, staff, or visitors
The impact of which	Getting injured due to undetected obstacles, getting lost while navigating to their destinations, and arriving to class or desired destinations late and not on time
A successful solution will be	Creating a smartphone application that will help the users navigate safely and promptly to their destinations by providing clear and accurate directions (# of steps, which direction to turn, obstacle detection)

As-Is & To-Be Scenario I

AS-IS

Adam is a visually-impaired student and wants to attend his Requirements Class and doesn't have any clue where to take turns. This results in Adam missing his turn and getting lost in ECSS.



As-Is & To-Be Scenario I

TO-BE

Adam lets the app "Comet Vision" know that he wants to attend his RE class with the help of voice recognition. The app will navigate him by letting him know how many steps he to take and in which direction to get to his class safely and on time.



As-Is & To-Be Scenario II

AS-IS

Suddenly, Adam comes across an obstacle while heading to his destination but is not aware of it. This results in Adam running into the trashcan and getting injured by falling or tripping.



As-Is & To-Be Scenario II

TO-BE

Comet-Vision will immediately detect the obstacle and notify Adam with a voice feature and a sound alert so that he doesn't fall and get himself injured.



Questionnaire

QUESTIONNAIRE

This is a short questionnaire that will help the development team of *Comet-Vision* determine how helpful the application will be for visually impaired students, faculty, and staff to navigate indoors of ECSS at The University of Texas at Dallas. This will be used to understand any problems or struggles that are currently being faced and to help brainstorm ways to improve and solve those issues.

Background Information

Age Range: ☐ 15 – 21 ☐ 21 – 30 ☐ 31 – 40 ☐ 41 – 50 ☐ 51 – 60 ☐ 61 or above

Role at UTD: ☐ Student ☐ Faculty ☐ Staff ☐ Visitor

Phone #:

Email:

1. How often do you use your cellular device?

☐

☐

☐

☐

Never

Monthly

Weekly

Daily

2. Are you comfortable with using a cellular device?

☐ Yes ☐ No

If not, please explain:

3. What do you use your cellular device the most for?

☐ Internet

☐ Social Media

☐ Music

☐ Camera

☐ Map

☐ Calls/Text Messages

☐ Games

☐ Other:

4. How often do you come to campus?

☐

☐

☐

☐

Never

Monthly

Weekly

Daily

5. What are the reasons you come to campus (select all that apply)?

☐ Attending Class

☐ Studying

☐ Meeting Instructors

☐ Social Events

☐ Meeting Friends

☐ Other:

6. Do you currently have any concerns when walking indoors from one place to another?

☐ Yes ☐ No

If yes, please explain:

7. Do you currently use any tools to help navigate indoor spaces?

☐ Yes ☐ No

If yes, which tools do you use?

If yes, what are some things you like or that are helpful about the tool you use?

And what are some things you dislike or that are difficult about the tool you use?

8. What are some challenging obstacles you run into when walking indoors?

9. Are there any obstacles that you had a hard time detecting with your tool?

10. What is the most challenging part when navigating indoors for you?

11. What do you currently do if you need assistance (ex. get lost, run into someone, etc.)?

12. Have you ever asked anyone for help when navigating to your destination?

☐ Yes ☐ No

If yes, were their directions ever confusing or hard to understand?

☐ Yes ☐ No

If yes, please explain/describe further about the situation:

13. Do you always take the same route when going from one place to another?

☐ Yes ☐ No

14. What factors do you consider when choosing a route?

15. Would you be comfortable with taking a different route that is unfamiliar to you?

☐ Yes ☐ No

16. What is a feature that could be helpful for you to navigate around indoors?

17. What emergency systems do you currently use in case of falls or accidents?

18. Suppose you have fallen or are in trouble. Who would you want your phone to first contact? Please rank them in order.

Contact Person (family, friends, etc)

UTD Office of Student AccessAbility

9-1-1

University Police

Other (please specify):

19. What form of measurement would you prefer for quantifying distances?

☐ Meters

☐ Feet

☐ Steps

☐ Other:

20. What are some kinds of icons or menu items you would like to have access to when first opening the application?

21. Would you be comfortable with using headphones to use this application?

☐ Yes ☐ No

Please let us know any comments, requests, or questions:

7. Do you currently use any tools to help navigate indoor spaces?

☐ Yes ☐ No

If yes, which tools do you use?

If yes, what are some things you like or that are helpful about the tool you use?

And what are some things you dislike or that are difficult about the tool you use?

12. Have you ever asked anyone for help when navigating to your destination?

☐ Yes ☐ No

If yes, were their directions ever confusing or hard to understand?

☐ Yes ☐ No

If yes, please explain/describe further about the situation:

Questionnaire Sample Questions

Stakeholders

FOR

Visually impaired

- Students
- Staff
- Faculty
- Visitors

Assistants (trusted individuals)

Police (9-1-1 & UTD Campus Police)

UTD Office of Student Accessibility

BY

Development Team of Comet Vision

- Requirements Engineers:
Vishakha, Jun & Jeongwon
- Test Engineers:
Jyothise & Miao
- Software Engineers:
Pragya & Abishek

OF

Comet-Vision Team of UTD

Issues with the Domain

Domain Issue ID	Domain Issue Description
DI_01	How to define “visually impaired” people? There are many categories of visual impairments with varying levels of impairment or impact.
	Option 1 This application is designed to help all types of visually impaired people.
	Option 2 This application is designed to help mainly blind people.
	Choice Option 2
	Rationale There are some visual impairments, such as color blindness, that cannot be assisted by this smart phone app.

Issues with the Domain

Domain Issue ID	Domain Issue Description
DI_02	How to define “indoor”? In which building and on which floor of the building should the application be able to work?
	Option 1 This application should be able to work in any building of the UT-Dallas campus.
	Option 2 This application should be able to work in ECSS (Engineering & Computer Science South) building and on any floor of the building.
	Option 3 This application should be able to work in ECSS (Engineering & Computer Science South) building and only the 2 nd floor of the building
	Choice Option 3
	Rationale Due to the limited access to UT-Dallas campus geographic information, this application can only support the navigation on the 2 nd floor of the ECSS (Engineering & Computer Science South) building.

Issues with the Domain

Domain Issue ID	Domain Issue Description
DI_03	How does the user input the destination location into the application? The domain description is ambiguous regarding the input methods the application supports.
	Option 1 This application only allows its user to type in the destination location via a keyboard.
	Option 2 This application only allows its user to set the destination location via voice input.
	Option 3 This application allows its user to set the destination location via both a keyboard and voice input.
	Choice Option 3
	Rationale According to the definition of stakeholders of this application, the user may be a blind person or his/her caretaker. Therefore, this application should support both the traditional way of input and the voice input.

Issues with the Domain

Domain Issue ID	Domain Issue Description
DI_04	How to define “the most desirable route”? The definition of desirable is vague. Is the level of desirability based on the time cost, the length of the route, the crowdedness, or the user’s preference?
	Option 1 This application will provide the user with the shortest path to the destination.
	Option 2 This application will provide the user with multiple paths each with respect to least time cost, shortest length, or least crowdedness.
	Option 3 This application will provide the user with multiple paths each with respect to least time cost, shortest length, or least crowdedness. If the user has saved a preferred path before, the application will provide the user with his/her favorite path.
	Choice Option 3
	Rationale The definition of the most desirable may vary from one user to another. Users might not always deem the shortest path as the most desirable path. The application should allow the user to have multiple options.

Issues with the Domain

Domain Issue ID	Domain Issue Description
DI_05	How to define “intelligently detect potential dangers”? What are the potential dangers? How will these potential dangers be captured?
	Option 1 The application will detect the obstacles in front of the blind person within one meter using its camera and send a voice alert to help the blind person avoid the obstacles.
	Option 2 The application will detect the obstacles in front of the blind person within one meter or the fast-moving objects using its camera and send a voice alert to help the blind person avoid the obstacles or dangers.
	Choice Option 2
	Rationale Option 2 has dealt with more types of dangerous scenarios which might be faced by the blind people in their daily life.

Issues with the Domain

Domain Issue ID	Domain Issue Description	
DI_06	“If any accidents should happen to the user, the application will dial the emergency call immediately.” Should the decision to dial the emergency call be made by the user or by the system? Should the application ask for the user’s permission before making an emergency call?	
	Option 1	The application will dial the emergency call immediately if there is a potential fall being detected.
	Option 2	The application will ask the blind person for their permission with the help of voice assistance to make sure there is an actual emergency happening and an emergency call is necessary, then the system will perform the action of calling.
	Choice	Option 2
	Rationale	Option 2 makes sure that the application will not make wrong emergency calls to cause unnecessary trouble for the blind people.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_01	The primary person using the application will be visually impaired, so it is particularly important to make sure the interface of application is catered to their needs as someone without sight.
	Option 1 The system shall provide interfaces that have large, tappable regions for the users.
	Option 2 The system shall play pre-recorded audible introduction sound on each app page to the user.
	Choice Options 1 & 2
	Rationale Options 1 & 2 makes sure blind people can interact with the application better.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_02	When the system has received the user's destination, the system shall produce a route to get to the destination. What if there is no possible route from the user's current location and their destination? Or, what if the user has given an invalid destination?
	Option 1 Tell the user that route could not be calculated and try another destination.
	Option 2 Call a live assistant or a nearby person to take them to their destination/help with input.
	Choice Option 1
	Rationale Option 1 responds immediately to the user and asks them to enter a legitimate destination. Considering the absence of people around, Option 2 is not appropriate and is not reasonable.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_03	The system shall play pre-recorded introduction sound on each app page to the user. What if the volume is down on the phone?
	Option 1 Force phone volume to be at an audible level.
	Option 2 Make a noise to nearby people to assist the user.
	Option 3 Vibrate the phone to alert the user to turn up the volume and use morse code to provide instructions.
	Choice Options 1 & 2
	Rationale Options 1 & 2 automatically assist users interact with application instead of asking users to operate on their phones. Also, morse code asks too much for users to use.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_04	The system should be able to tell users which direction they should go to reach their destination. What if the user takes the wrong turn or steps too many/too little number of times leading them to the wrong destination?
	Option 1 Have the application alert the user when they have messed up so they can retrace their steps.
	Option 2 Have the application adapt to the user's current location, so it will recalculate the best route based on where they currently are if they go off course.
	Choice Option 2
	Rationale Option 2 relocates the location of users synchronously and recalculates the optimal routes to the destination when they fail to reach their destination.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_05	The system shall be able to transform users' speaking into text input. What if the host phone does not have the right hardware to do this?
	Option 1 Make sure that before installing the app, the phone has the bare minimum hardware to meet this requirement.
	Option 2 Require text input from the keyboard.
	Choice Option 1
	Rationale Option 1 ensures the availability of the function of transforming users' speaking into text input. Text input will always be available regardless of this issue for secondary stakeholders who does not need this feature to access the application.

Issues with Functional Objectives

Functional Objectives Issue ID	Functional Objective Issue Description
FOI_06	If any emergencies occur, the app shall contact the user's emergency contact immediately. What if users are not familiar with this feature?
	Option 1 Notify the user about it when providing instructions.
	Option 2 Provide emergency detection (i.e., when the user falls, or they are screaming in pain) to automatically make an emergency call.
	Choice Option 1
	Rationale Option 1 makes sure users understand how to use emergency call (i.e., long-press the button).

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description	
NFOI_01	The system shall be able to open the homepage within 5 seconds. What if the host phone does not have the right hardware to do this?	
	Option 1	Make sure that before installing the app, the phone has the bare minimum hardware to meet this requirement.
	Choice	Option 1
	Rationale	Option 1 ensures that the application responds instantly.

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description
NFOI_02	The system shall calculate the best route within 1 minute. What does “best route” mean?
	Option 1 The route with the shortest ETA.
	Option 2 The route that suits the user’s preferences
	Option 3 The route with the least number of turns.
	Choice Options 1 & 2
	Rationale Options 1 & 2 ensures that the application will provide the best route that the users may already be familiar and comfortable with.

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description	
NFOI_03	Audible introduction sound shall be put in the system. What happens when the files get deleted and no sound is available?	
	Option 1	Every time the application is started up, retrieve from the cloud the most up to date introduction to play.
	Option 2	Call for help from nearby people.
	Choice	Option 1
	Rationale	Option 1 ensures the availability of all audible functions before the application starts.

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description
NFOI_04	The system shall avoid navigate the user into an area that is marked as dangerous. What if the user proceeds into the dangerous area, beyond the application's instructions?
	Option 1 Alert the user that they are heading into the dangerous area
	Option 2 If the user is deep into the dangerous area, alert safety officials.
	Choice Options 1 & 2
	Rationale Both options ensure maximum security for those using the application to prevent any emergency occurring.

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description
NFOI_05	The system shall be able to guide the users to safely reach their destination in 15 minutes. What does “safe” mean?
	Option 1 Make sure that the user of the application is unharmed during their trip to the destination.
	Option 2 Make sure nobody else is harmed during the blind person’s trip.
	Choice Options 1 & 2
	Rationale People related to the user - loved ones, caretakers, and the police want to ensure the utmost safety for the person using the application to prevent any problems that could cause some stress or costs.

Issues with Non-Functional Objectives

Non-Functional Objectives Issue ID	Non-Functional Objective Issue Description	
NFOI_06	Buttons in the system shall have divergent functionality. What does “functionality” mean?	
	Option 1	Each button has a purpose and is not useless to the user.
	Option 2	Each button does not take up an amount of unnecessary space for its function, as largeness of buttons will be important to the unsighted person.
	Option 3	For every action that the user can perform, have a button that will resemble it.
	Choice	Options 1 & 2
	Rationale	Since the software has limited page space, it ensures the usefulness of each displayed function button.

Functional Requirements

FR_ID	Description
FR_01	The system shall locate the current location of the user
FR_02	The system shall display an interactive interface for both the user and their assistant (friends, family, etc.,)
FR_03	The system shall allow the user to customize the notification sounds
FR_04	The system shall allow the user to add their preferences regarding their emergency contacts
FR_05	The system shall give directions to the users
FR_06	The system shall detect obstacles and warn the users to avoid collision
FR_07	The system shall tell the users when to stop at the right place for a turn or change in direction
FR_08	The system shall contact the user's emergency contact or other services based on their preference via call or text message when detecting a fall or an accident
FR_09	The system shall alert and notify the user when they start navigation and when they have arrived at their destination

Functional Requirements continued

FR_ID	Description
FR_10	The system shall find multiple routes to the user's destination and choose a route based on their preferences
FR_11	The system shall be able to identify the destination based on the room number
FR_12	The system shall keep track of shortcuts or favorite routes taken by the user
FR_13	The system shall push notifications according to the user's course schedule or personal schedule registered into the system

Non-Functional Requirements

NFR_ID	Description
NFR_01	The system shall help the user safely navigate indoors
NFR_02	The system shall be user-friendly
NFR_03	The system shall be reliable
NFR_04	The system shall be maintainable
NFR_05	The system shall be portable
NFR_06	The system shall be adaptable
NFR_07	The system shall be ubiquitous
NFR_08	The system shall be responsive
NFR_09	The system shall be customizable to every user based on their preferences
NFR_10	The system shall be extensible to accommodate different variations in interface, language, new features, new sensors and hardware, etc.,

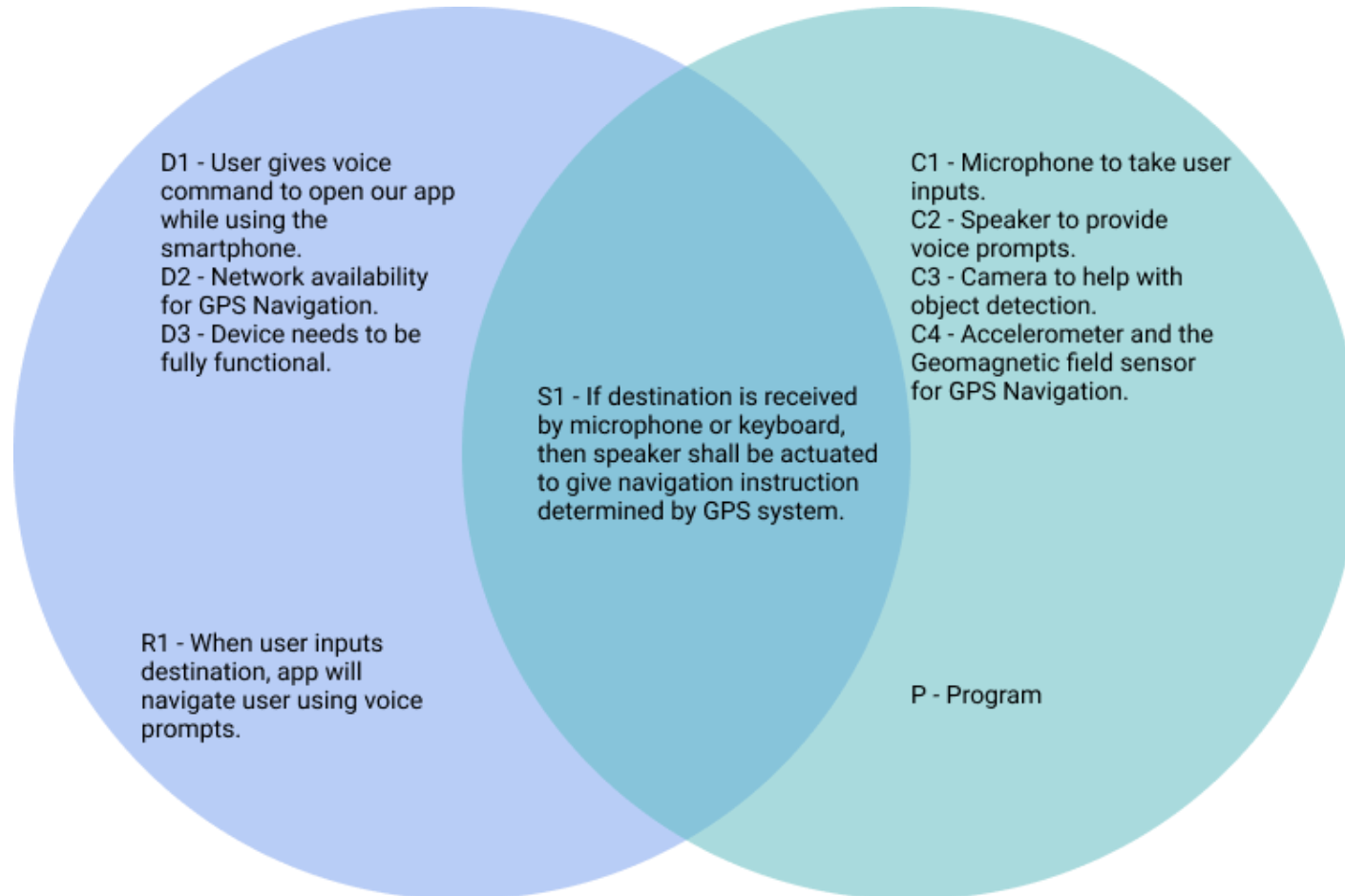
Functional Specifications

FS_ID	Description
FS_01	The system shall be able to accept voice input (speech-to-text) from the user utilizing the device's built-in microphone or from their headphones/earphones
FS_02	The system shall be able to accept text input from the built-in keyboard on the device
FS_03	The system shall utilize GPS location (geomagnetic sensor and accelerometer) and the CAD map to identify both the user's current location and their desired destination
FS_04	The system shall utilize vibration motor to produce vibrations when notifying the user when they start and end navigation
FS_05	The system shall utilize the built-in accelerometer and gyroscope sensors to track the user's movements and detect when the user is falling
FS_06	The system shall utilize the built-in proximity sensor to measure the distance between the user and the detected obstacle(s)
FS_07	The system shall utilize the alarm system of the device to send alarm notifications to the users based on their schedule and preferences

Traceability Matrix of FR <--> NFR

	NFR_01	NFR_02	NFR_03	NFR_04	NFR_05	NFR_06	NFR_07	NFR_08	NFR_09	NFR_10
FR_01	×	×								
FR_02		×								
FR_03				×					×	
FR_04				×				×	×	
FR_05	×	×						×		
FR_06	×					×	×			×
FR_07		×	×				×			
FR_08		×						×		
FR_09					×			×		
FR_10		×	×			×				
FR_11		×				×				
FR_12				×			×			
FR_13		×						×		×

WRSPM Model

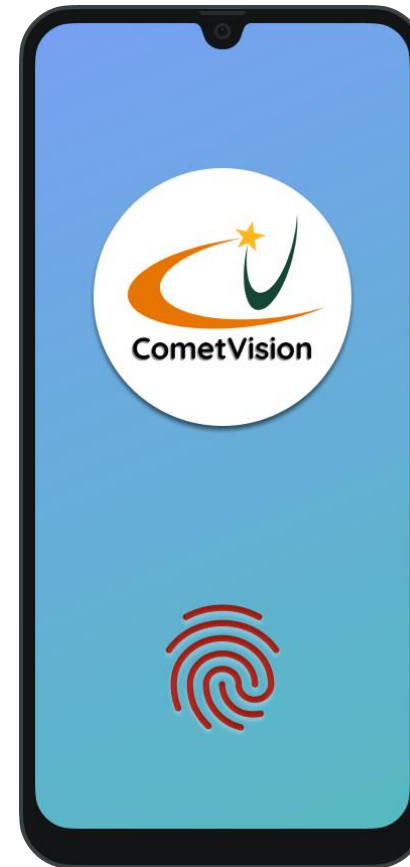


Prototype I

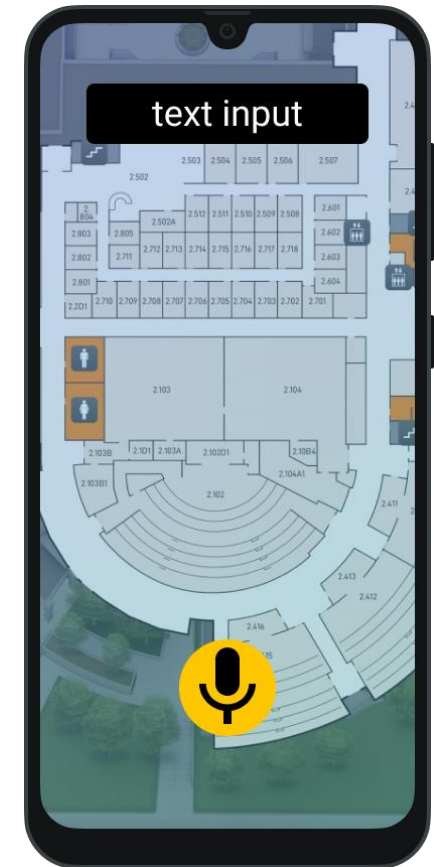
Sam, who is visually impaired, uses CometVision App to safely navigate ECSS during his class days.

To get started, Sam provides Voice Access command "Open CometVision" to his smartphone, which pulls up the app's **Login Page**. Here, Sam is required to provide his fingerprints, which is used to authenticate his identity, before granting him access to the app.

After validation, Sam is navigated to the app's Main Page. Once on the **Main Page**, the app uses voice prompt to guide him through entering his desired destination.



Login Page



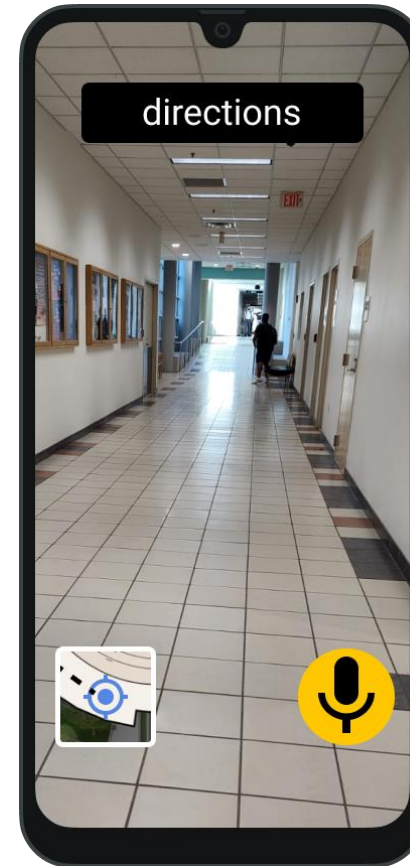
Main Page

Prototype II

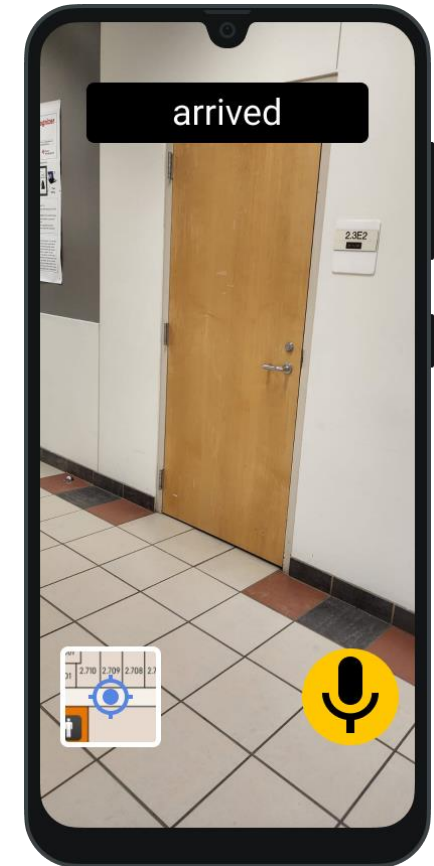
Based on Sam's destination, CometVision App finalizes on a route and starts the navigation process. First, Front-facing camera is turned on and then navigation direction are given out to Sam via Speaker.

While on route, the GPS system is keeping track of his location on the map and the camera is looking out for any potential obstacles, to ensure accurate navigation and safety.

At the end of navigation, Sam is alerted by voice prompts and phone vibration to let him know that he has arrived at his destination.



Start of Navigation

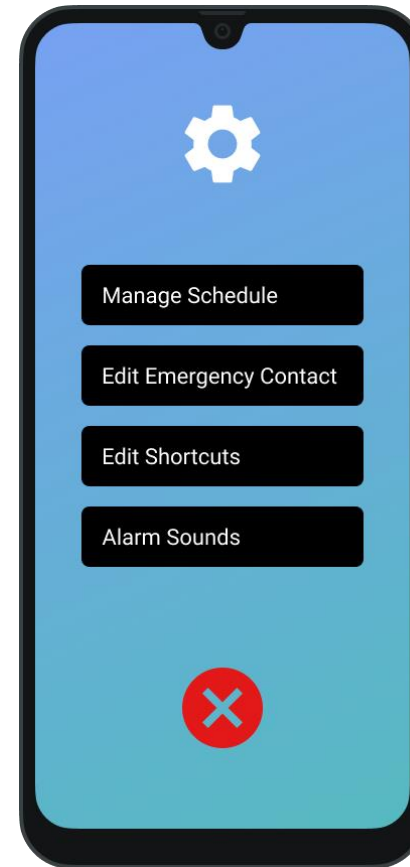


End of Navigation

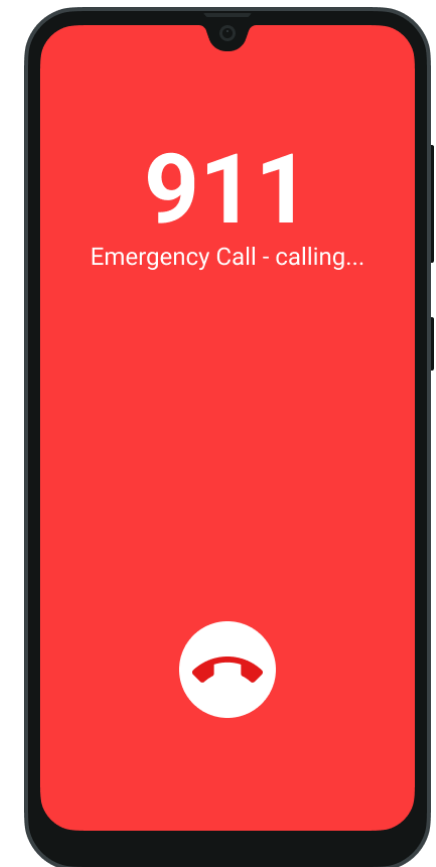
Prototype III

Sam can also configure CometVision App's setting by using voice prompt. After landing on **Settings Page**, Sam is made aware of the four options, namely, Manage Schedule – to add or remove Sam's class schedule; Edit Emergency Contact – to add or edit Sam's emergency contact; Edit Shortcuts – to add or edit Sam's preferred routes; and Alarm Sounds - to switch between alert sounds.

Lastly, if Sam encounters an emergency en route to his destination, the app will automatically make a call to his emergency contact or 9-1-1.



Settings Page



User Emergency Page

Requirements Creeping Rate

We estimate our requirements creeping rate to be low ($< 20\%$). We came up with 13 functional requirements, and 2 of them were modified through requirement analysis and negotiation. Our final requirements creeping rate is around 15%. The following factors contribute to our low creeping rate:

- We started early in the semester and conducted the weekly meetings to make incremental process.
- We had good and effective discussions between team members. And each member gave feedbacks actively.
- We designed the questionnaires based on potential real-world scenarios to better understand the functional and non-functional objectives.
- Issues and clarifications were identified early, and were corrected, modified accordingly.

Why is Comet-Vision the Best?

- It is built **by UTD students for UTD students** which means we understand the struggles of navigating indoors in between classes.
- Our team has a **solid understanding** of software requirement analysis. We designed and improved the requirements with the help of questionnaires and various requirement models.
- We have designed every aspect of our application to be both **useful** and **user-friendly** to the blind people.
- We have kept a **clear traceability** between problems and goals, functional requirements and non-functional requirements to make sure each problem raised is provided with a solution and all requirements are **well managed** and **implemented**.
- Our team has **extensive** software engineering and mobile application development knowledge.