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.

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 2nd 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 2nd 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.

Improved Domain

The purpose of Comet-Vision is to help blind people to navigate around the 1st floor of ECSS (Engineering & Computer Science South) building, which can possibly host classrooms, offices, restrooms, lounges, elevators, etc...

Comet-Vision provides below high-level functionalities:

- ❑ Plan and optimize routes based on user's preference.
- ❑ Navigate indoor with voice instructions.
- ❑ Detect obstacles in the way and help user avoid falling.
- ❑ Detect falling and contact emergency contacts.

User Summary

Name	Description	Responsibilities
The visually impaired students, faculty, staff, and visitors of UTD	The primary end user of the application. The application provides voice assistance for users to navigate indoors.	- Use the application to navigate indoors - Use the application to send emergency messages if any accidents occur
UTD emergency department (ex. campus police)	The secondary end user of the application. Provide help and emergency support for the visually impaired people when emergency messages are received.	- Receive emergency messages if any accidents occur - Produce emergency reports
Family members or caretakers of the visually impaired people	The secondary end user of the application. Set up the application for visually impaired people. Provide care needed by visually impaired people.	- Set up the application for visually impaired people - Receive emergency messages if any accidents occur

Non-User Stakeholder Summary

Name	Description	Responsibilities
Project Manager	Working as the coordinator among everyone who is involved in the development process. Manage the resources and set up timeline for development.	- Monitors the project's progress - Coordinate with all stakeholders - Assign tasks among stake holders - Manage project resources
Product Manager	Study the market demographics and the current available applications in the market. Design the product features to ensure the project success.	- Ensures that there will be a market demand for the product's features - Design features for the product - Study other competitor applications available on the market
Requirement Engineer	Gather information to correctly describe and translate the requirements given by the customers.	- Communicate with project manager and software developers - Correctly translate what the customer needs into requirements - Provide an explanation for both parties if needed
UI/UX Engineer	Create the design of user interface for software engineers to implement. Improve the user experience of the application.	- Create user-friendly interfaces that are easy to use - Improve user experiences

Non-User Stakeholder Summary Cont.

Name	Description	Responsibilities
Software Architect	Create and maintain the infrastructure of the application and communicate with every stakeholder to make sure all requirements are met.	- Ensures that the system will be maintainable - Create the high-level architecture of the application - Ensure both the technical team and product team can understand the architecture of the product. - Understand the technical details of the system and provide guidance for the development team
Software Developer	Develop the code to implement all features and user interfaces for the application.	- Write code to implement product features and make sure the assigned tasks are accomplished on time with excellent quality - Communicate and coordinate with the project manager and other developers if any issues need to be addressed
Quality Assurance Engineer	Perform system testing to make sure all features are correctly implemented and behaved	- Perform various tests against the system to ensure a decent quality of the system - Ensure features are correctly and completely implemented

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).

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

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.

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,.

Traceability Matrix

	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
NFR_01	X				X	X							
NFR_02	X	X			X		X	X		X	X		X
NFR_03							X			X			
NFR_04			X	X								X	
NFR_05									X				
NFR_06						X				X	X		
NFR_07						X	X					X	
NFR_08				X	X			X	X				X
NFR_09			X	X									
NFR_10						X							X

Questionnaire 2

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 create the most optimal application.

Background Information

Age Range: ☐ 15 – 20 ☐ 21 – 30 ☐ 31 – 40 ☐ 41 – 50 ☐ 51 – 60 ☐ 61 or above
Role at UTD: ☐ Student ☐ Faculty ☐ Staff ☐ Visitor
Phone #: _____
Email: _____

[Current Issues]

1. What is the most difficult part of navigating indoors for you?

_____
_____
_____

a. Can you explain what your concerns or issues are, if you have any?

_____
_____
_____

b. Can you think of anything that would make it easier/more pleasant for you to navigate indoors? Please explain.

_____
_____
_____

2. What are some common obstacles you encounter when walking indoors?

_____
_____

[Current Tools & Assistance]

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

☐ Yes ☐ No

a. If yes, which tools do you use? Please name the tools for us:

_____
_____

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

_____
_____

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

_____
_____

d. Can you explain how your tools could be improved to provide better assistance for you?

_____
_____
_____

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

_____
_____

a. Can you name some obstacles that your tool often fails to detect?

_____
_____

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

☐ Yes ☐ No

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

☐ Yes ☐ No

[Route Distance]

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

☐ Meters ☐ Feet ☐ Steps ☐ Other: _____

a. Would you prefer to have an option to have a combination of measurements stated above?

☐ Yes ☐ No

b. If yes, which two measurements would you like a combination of?

_____
_____

2. What are some factors you desire when choosing a route to take to get to your destination?

_____
_____
_____

3. What are some factors you wish to avoid when choosing a route to get to your destination?

_____
_____
_____

[Application Usability]

Please answer the following questions after trying out our first prototype of Comet-Vision.

On a scale of 1 to 5, 1 being strongly disagree and 5 being strongly agree, please rate the following:

		Rating
1	The application was easy to install.	
2	The application was easy to set up and customize to my needs.	
3	It was easy to understand how to use the application.	
4	The instructions of the application were easy to follow.	
5	The application gave clear navigation instructions to my destination.	
6	The application helped me avoid obstacles.	
7	The application easily contacted a third-party assistant to help me.	

[Application Features]

1. What are some features you liked or felt were necessary to have in the application?

_____
_____
_____

2. What are some features you disliked or felt were unnecessary to have in the application?

_____
_____
_____

a. Please explain how you feel they could be improved.

_____
_____
_____

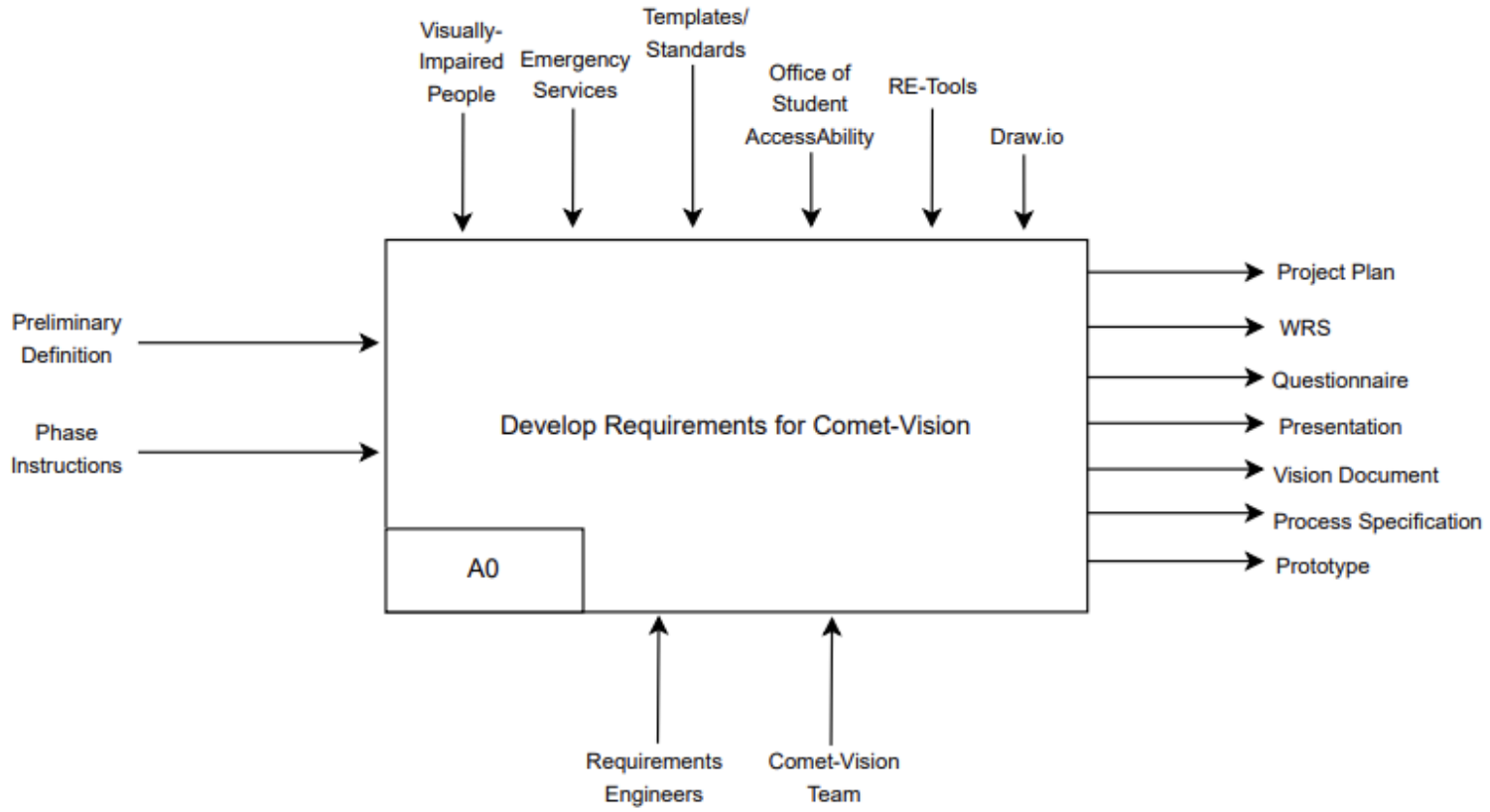
3. What are some additional features you would like to see in Comet-Vision to improve your experience?

_____
_____
_____

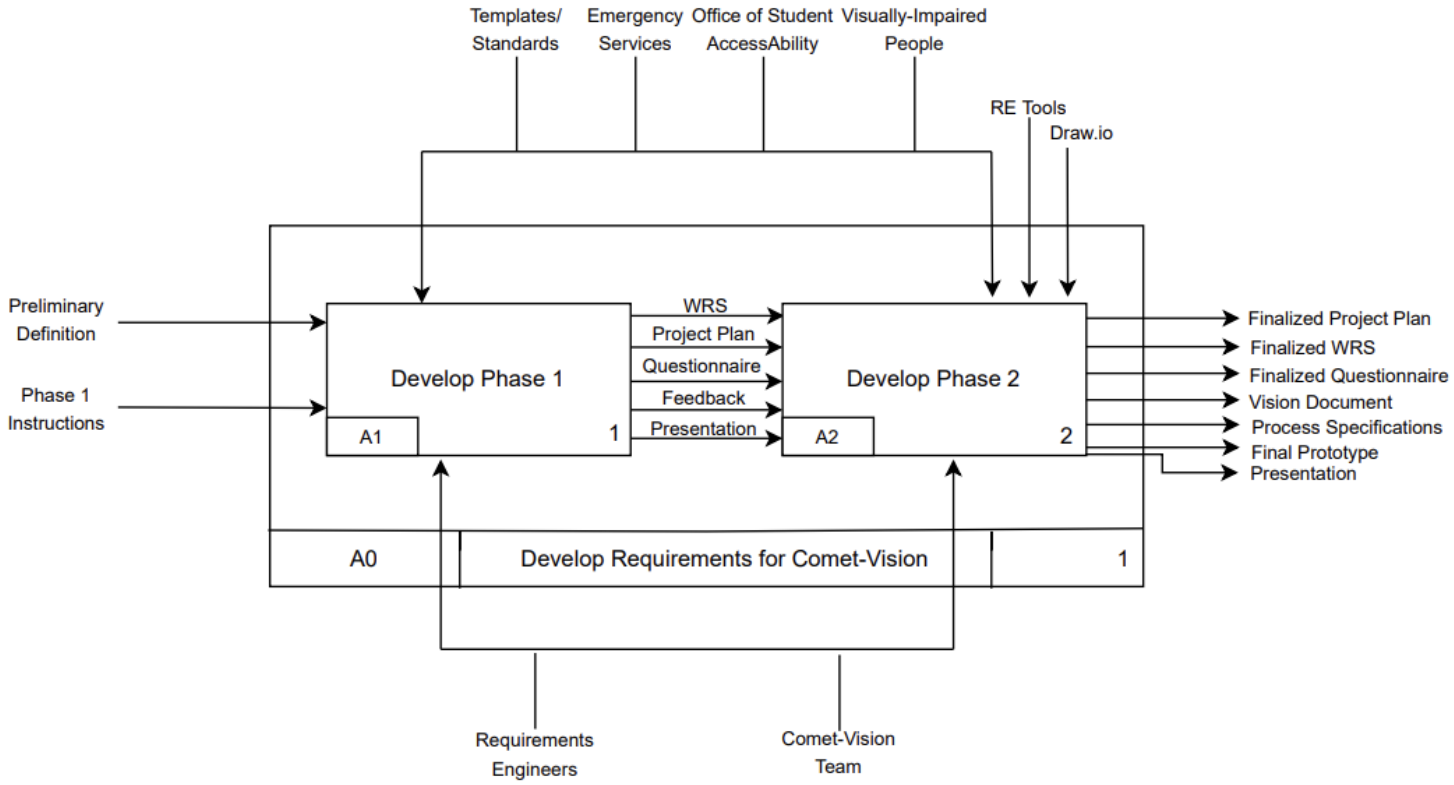
Please let us know any additional comments, requests, or questions:

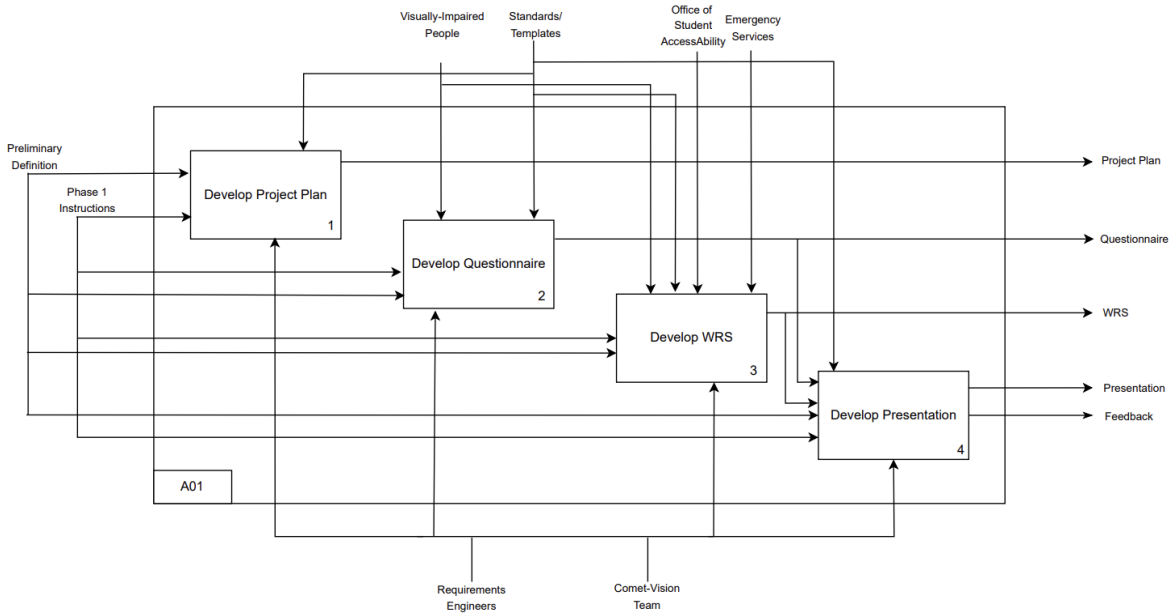
_____
_____
_____

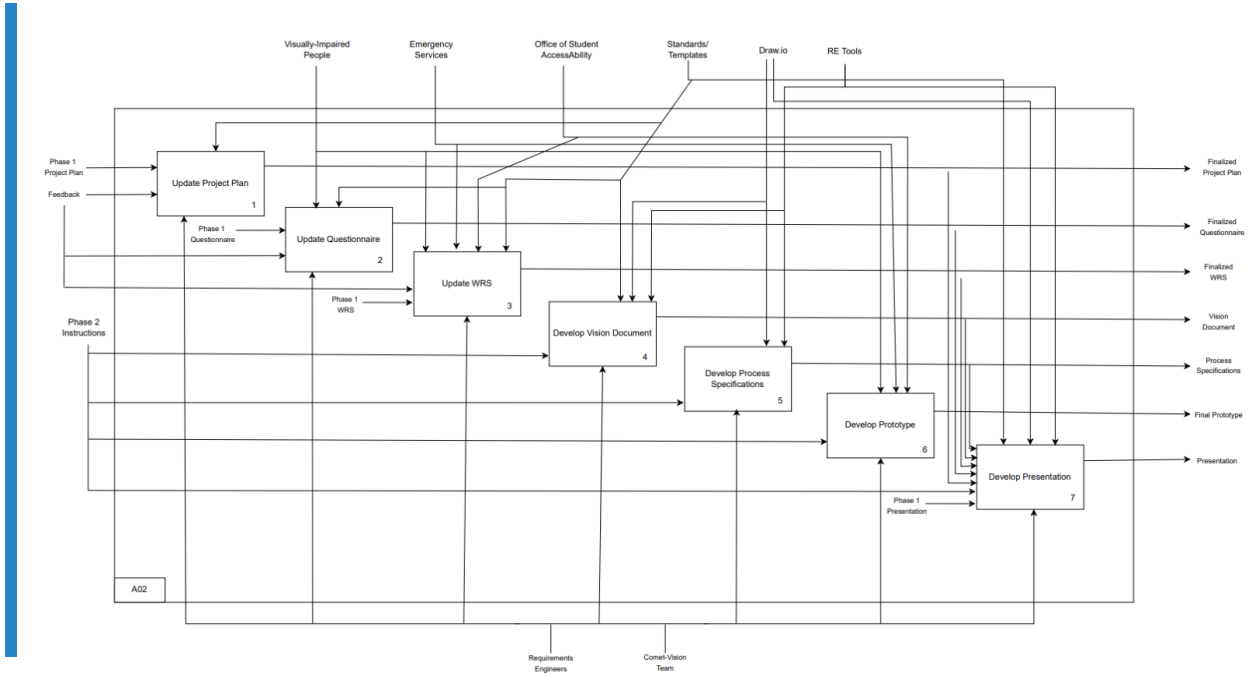
IDEF0 Diagram - Level 0



IDEF0 Diagram – Level 1

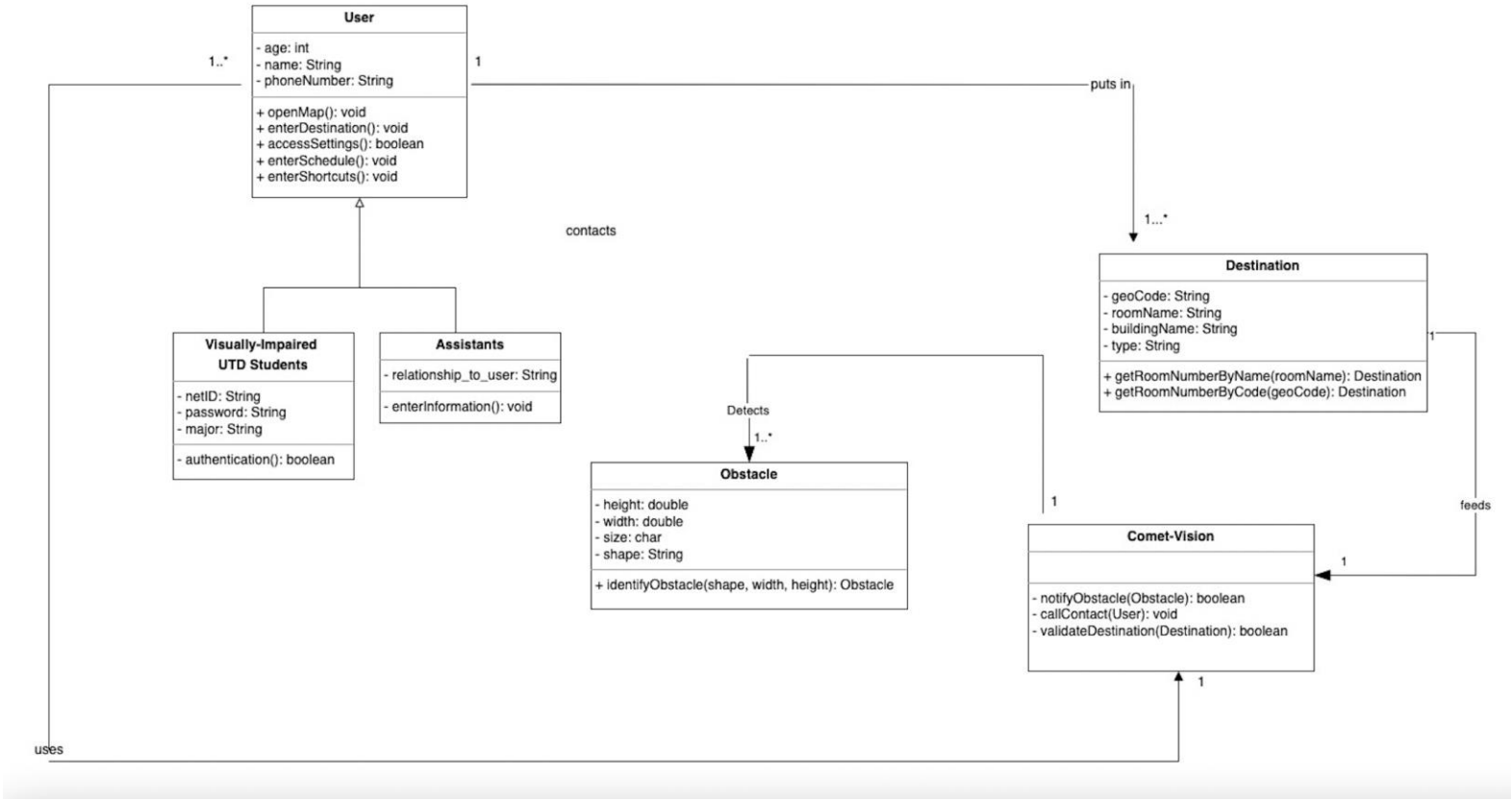




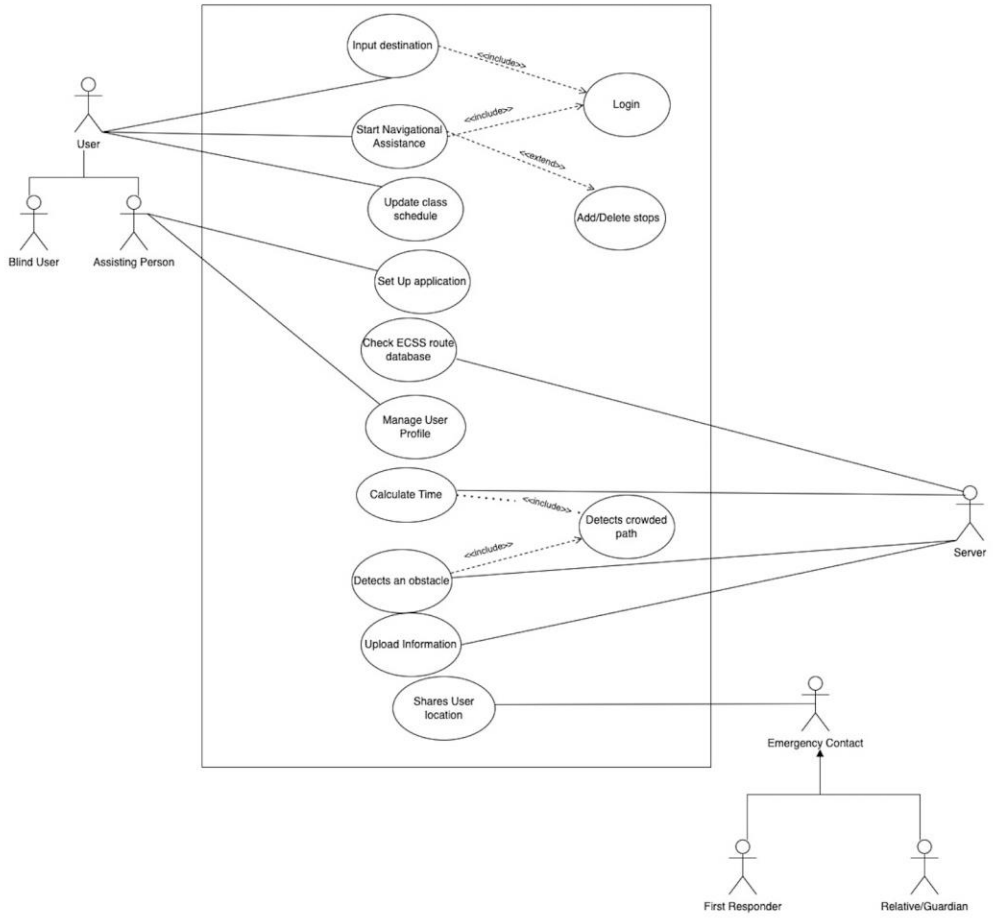


IDEF0 Diagram – Level 2

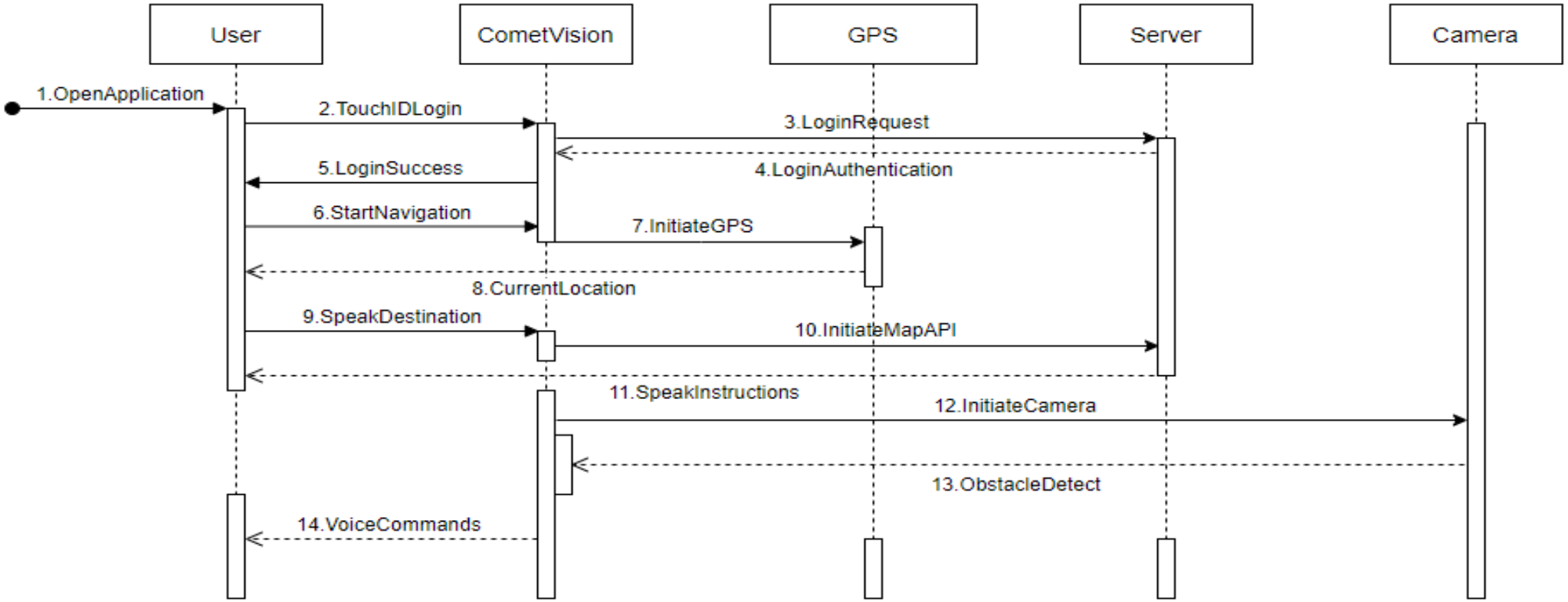
Class Diagram



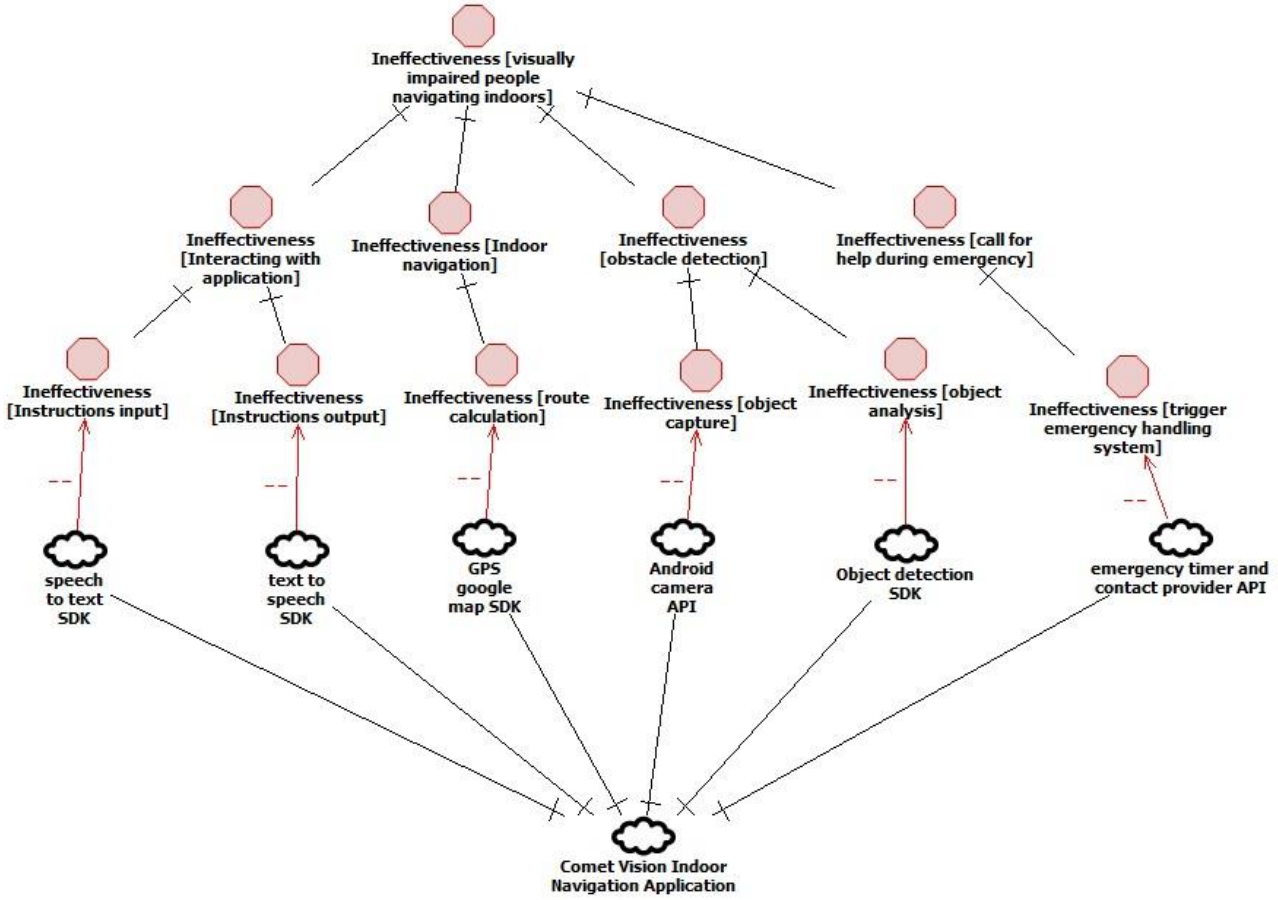
Use Case Diagram



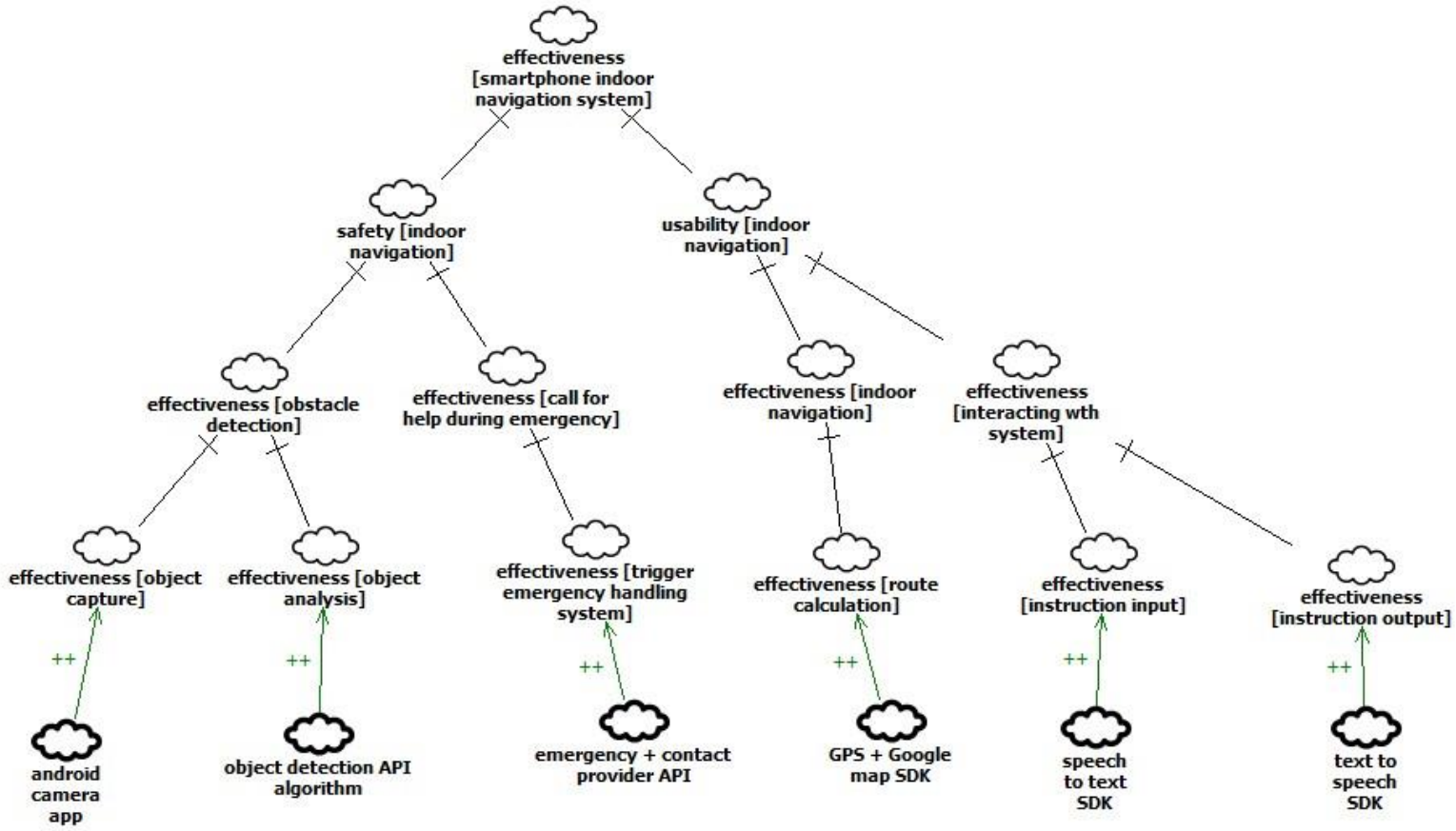
Sequence Diagram



Problem-Interdependency Graph(PIG)

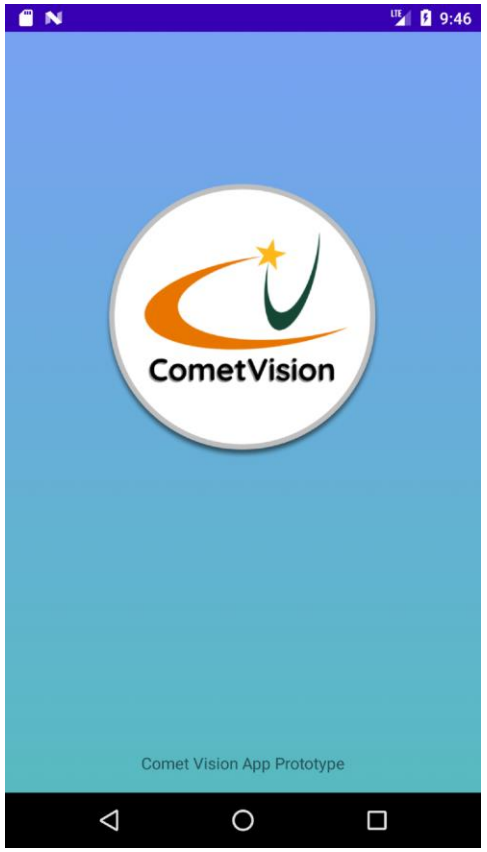


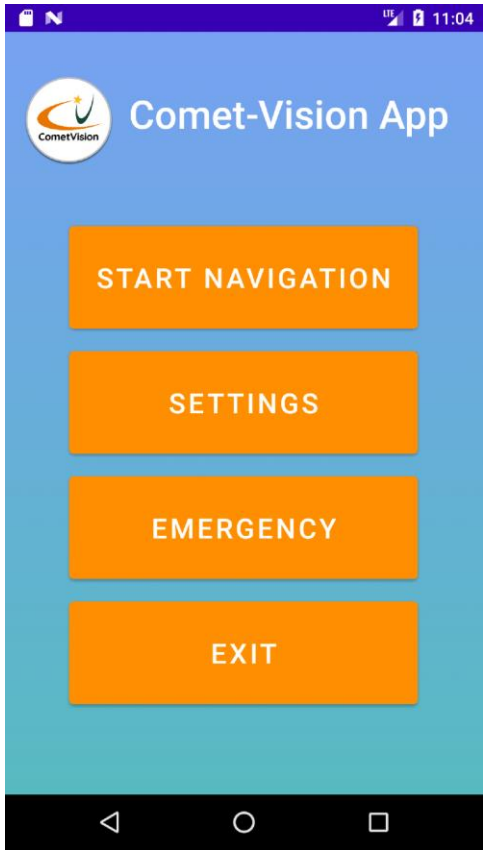
Soft-Goal Interdependency Graph (SIG)

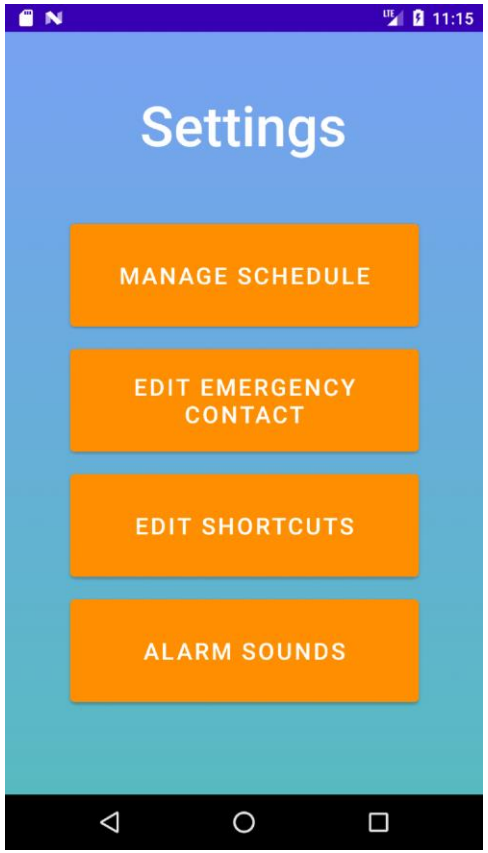


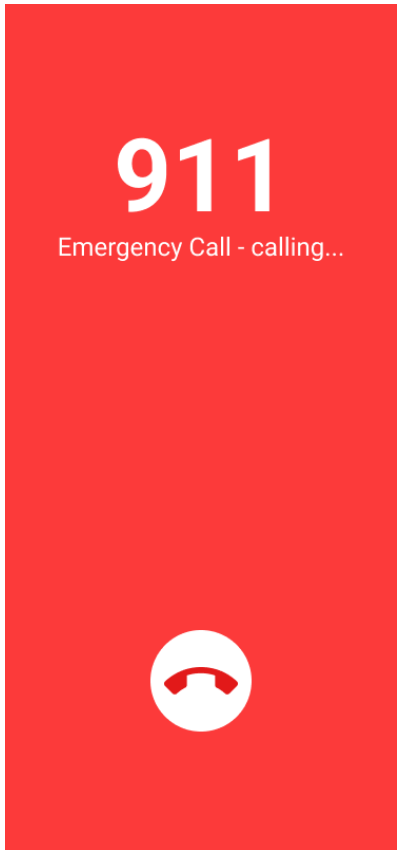
Demo

Comet-Vision App Prototype I

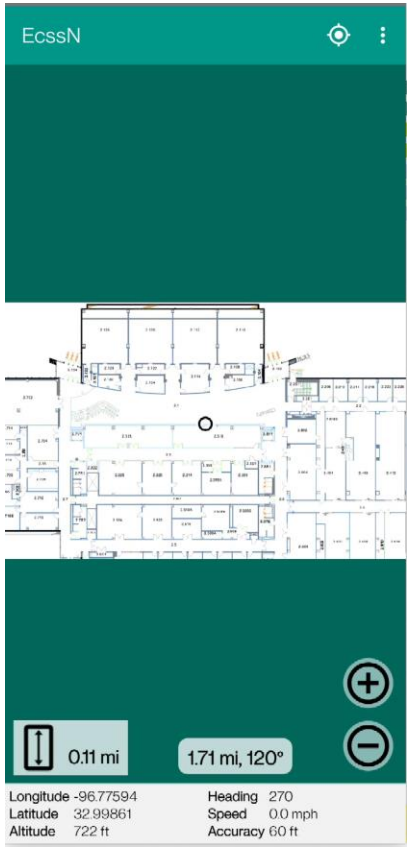


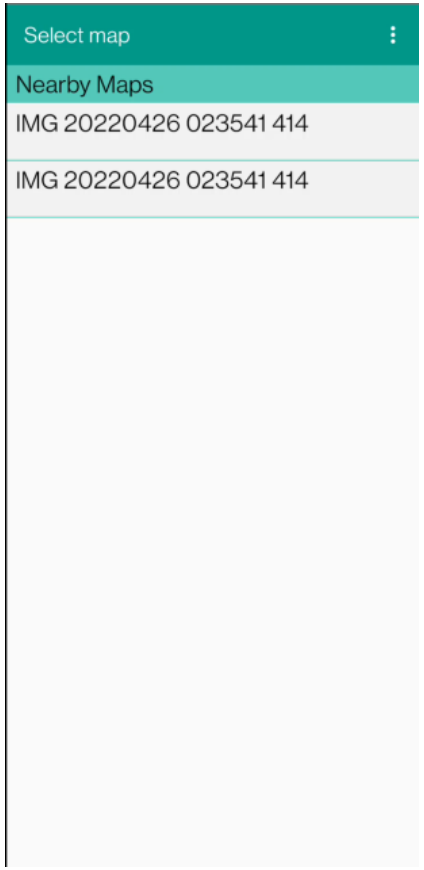


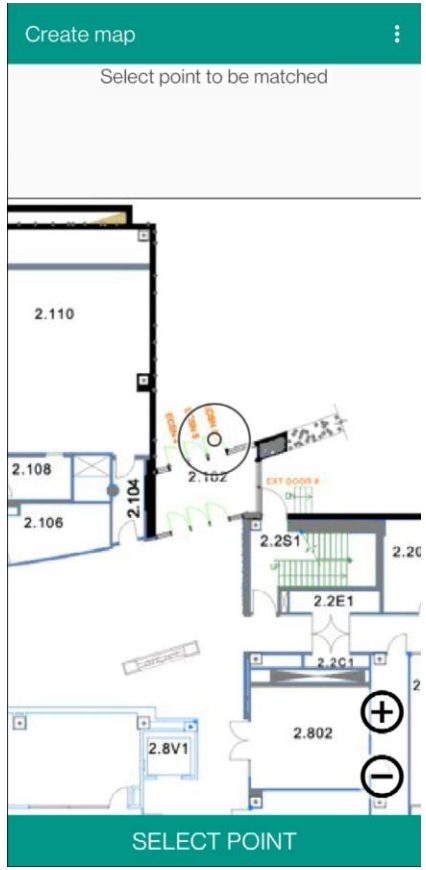


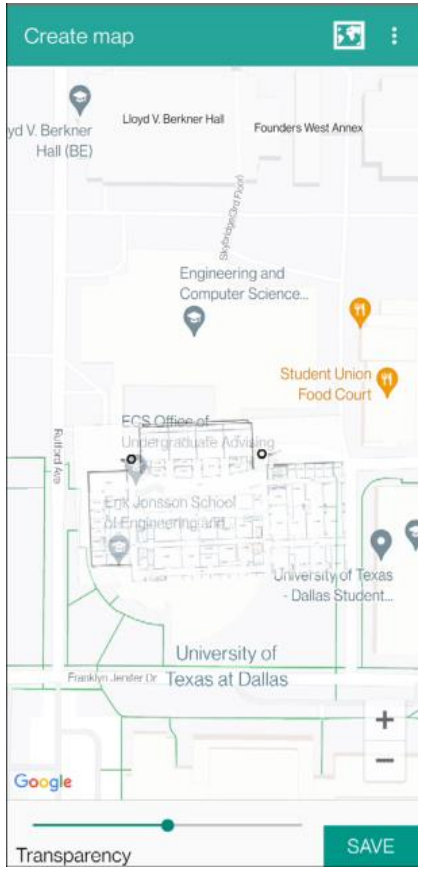


Comet-Vision App Prototype II









Requirements Creeping Rate

We estimate our requirements creeping rate to be ***low*** (< 20%).

We have 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 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.