Software Engineering

Group 8

Search And Rescue Assistant (S.A.R.A.)

https://abhiek187.github.io/emergency-response-drone/

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Individual Contributions Breakdown

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Customer Problem Statement

Customer Statement of Requirements

Search and rescue operations can often involve first responders and volunteers trying to cover a vast area in as little time as possible to save the most lives. These operations can be categorized by the environment take place in. They can further be categorized by the specific type of operation that needs to take place, such as in urban areas or in remote mountainous regions. The circumstances that could merit such operations could involve natural disasters such as earthquakes and hurricanes. Regardless of the type of operation, technology is being increasingly used to streamline the efforts of first responders and volunteers in their efforts to try to save as many people as possible. There have been many search and rescue missions in the past. Many of these missions involved the use of large amounts of people and resources. Even with all the effort put by the people involved many lives were lost in the process. One such organization that is involved in search and rescue operations is the Coast Guard. The table below illustrates the statistics of these operations conducted by the Coast Guard from 2011 through 2015.

Fiscal Year	Cases	Responses	Sorties	Lives Saved	Lives Lost	Unaccounted Lives
2011	20,512	43,954	21,566	3,793	735	392
2012	19,787	43,940	21,609	4,037	713	440
2013	17,803	38,272	19,420	3,753	651	252
2014	17,508	38,282	19,032	3,443	595	308
2015	16,456	37,215	18,781	3,536	603	330

The sheer number of cases and responses conducted by the Coast Guard shows how big of an issue search and rescue missions are in the United States. The table also emphasizes that concept that these operations are not always successful or efficient. This is based on the number of lives lost and the number of people not accounted for along with a high number of responses for the cases. Our method looks into a possible alternative approach to these search and rescue missions.

The Search and Rescue Assistant, or S.A.R.A. will modernize the techniques employed by first responders on search and rescue operations. A drone can cover more distance than a single person is able to. Currently, the most frequently used techniques to cover a lot of areas very quickly is to either use a helicopter or to use a lot of people. The problem with helicopters is that they usually have to fly in from somewhere else and that can take time. Another problem with the use of helicopters is its lack of ability to search in narrow or tight areas. The issue with using a lot of volunteers is that people end up risking their own lives to find survivors. Often times these search parties tend to be time-consuming and depending on the circumstances, unorganized.

Ready-to-launch drones can be set up in minutes, which will save time. By attaching a camera to the drone the user will able to see the video feed that the drone is transmitting. Doing so will reduce the risk of potentially sending people in harm’s way to get the most accurate information about where people might be trapped. Additionally, this would also be cost-efficient. This would reduce actual labor since we would mainly be investing in developing an efficient algorithm, and the device. This algorithm would take one initial investment and would be developed for improvement. Due to the cost effectiveness of the device and the reusability of the algorithms involved, if the resources were to be available, it should be rather simple to manufacture multiple devices.

Naturally, an important aspect of an aerial vehicle of this nature is whether or not it can survive the challenges/harsh conditions it can face while in the field. To bolster S.A.R.A's ability to withstand these conditions, it will be able to avoid obstructions in its' path, in part due to the implementation of ultrasonic sensors. Using these sensors, and the usage of the primary camera, the user can easily maneuver through different obstacles that he/she may encounter during a search and rescue mission. To assist the end-user in knowing the immediate environment, a thermal imaging attachment will be mounted to the mobile phone that serves as the drone's primary camera. Image processing will not occur on the drone itself, but instead on a centralized hub located back on an emergency vehicle, which receives relayed images/video real-time so that emergency responders can quickly determine the best course of action. The sensors/equipment necessary to accomplish this will be either be purchased or obtained by the team members from existing laboratories/organizations.

Regarding the working environment, S.A.R.A. will have to be able to maneuver in potentially tight/enclosed spaces. In such an environment, being able to receive data on how close an object is to the drone is a specialized function ultrasonic sensors can provide. The drone can then properly take a course of action based on the proximity data it receives, such as change the amount of thrust in a particular direction or instead start pushing in an entirely different direction. With regards to processing visual data, the S.U.R.F. identification algorithm can be used to accurately determine an image's correlation/accuracy to a specific desired target object. In this case, the target would be the human faces/heat signatures.

Even with many solutions to search and rescue operations, S.A.R.A. offers a new take on optimizing the field. One of the key priorities of search and rescue missions includes safety, not just for the missing people, but for the people involved in the rescue operation. This approach makes it easy for even a single person to actively investigate the search and rescue operation in a safe manner. There would be more focus on the actual goal of the mission instead of also worrying about the safety of the people working the rescue/search missions.

GLOSSARY OF TERMS

Database - Server that will keep data of the drone and pictures from the drone camera.

UI - A physical program that allows the user to see the environment from the camera, information of the drone speed and health, and distance away from the objects.

Controller - A device that will allow the user to control the drone movements and avoid any obstacles.

Proximity Alert - Internal mechanism that will use proximity sensors to see if the drone is getting dangerously close to any obstacles in the flight path.

Wireless Connection - The connection between the drone, controller, and database that allows the user to stay in control of the drone.

Drone Sensors - Devices that allow the drones to detect its speed, distance from user, stability, to detect obstacles, the drone's health, etc. Examples include an IR/Thermal sensor, Accelerometer, and Gyroscope.

S.U.R.F.(Speeded Up Robust Features) - an algorithm that finds key points of an image using Hessian Matrices and scaled space, making it simpler to compare different images and see if they correlate appropriately.

System Requirements

FUNCTIONAL REQUIREMENTS

REQ1 - Database/Server
REQ2 - UI Screen
REQ3 - Controller
REQ4 - viewDroneCondition
REQ5 - Proximity Alert
REQ6 - Wireless Connection
REQ7 - GPS tracking
REQ8 - Infrared Sensor

Requirement	Priority	Description
REQ1	5	Data server that will store the information from the drone and allow the user to access it
REQ2	2	The user interface will allow the user to see the drones footage and any other relevant information
REQ3	1	The user should be able to control the drone's movements
REQ4	4	The drone will send a signal to the controller to notify of its operating status
REQ5	1	The drone should be able to correctly identify any close obstacles and be able to able to avoid them.
REQ6	2	A connection between drone and controller
REQ7	2	The user will be able to know exactly where the drone is.
REQ8	3	This sensor will allow the user to detect heat signatures through any material walls

NONFUNCTIONAL REQUIREMENTS

Usability - User will figure out that it is easy to learn the functions of the drone using the inputs and outputs involved in the system

Security - User will be able to use the interface without having to jeopardize his/her safety by using the drone from a reasonable distance.

Accessibility - The user will be able to run the software to operate the drone, on any smartphone regardless of the OS on the device.

Efficiency - User will be able to use the software with any accompanying hardware through a wireless connection.

Recovery - User will be able to recover the drone if the signal is lost. If the drone software is program to auto course to controller and land back safely.

USER INTERFACE REQUIREMENTS

Requirement	Priority	Description
REQ1	1	The controller for the drone will have a live feed of what the camera is seeing
REQ2	3	It will also display various properties of the drone. Some properties include speed of motors, drone battery level, wireless connection etc...
REQ3	2	Proximity alerts will be sent to the controller so the user know which direction to avoid
REQ4	4	The operating status of the drone will be sent to the controller so the user will know if they have to pull the drone back in case of low battery level.

Image 1

Functional Requirements Specification

Stakeholders

Stakeholders

- Licensed User
- First Responders
    - Police Officers
    - Authorized Volunteers
    - Firefighters
    - EMT’s
    - Emergency Dispatchers

Actors and Goals

Actor	Type	Actor's Goal	Use Case Name
User	Initiating	To control the drone	MoveDrone (UC-1)
User	Initiating	To view a live video feed of the drone	ViewCamera (UC-2)
User	Initiating	To get the drone's current location	GetLocation (UC-3)
Drone	Initiating	To check for and avoid obstacles	CheckObstacles (UC-4), AvoidObstacles (UC-5), GetLocation (UC-3)
User	Initiating	To get the drone's operating status	GetStatus (UC-6)
First Responder	Initiating	To identify the emergency from the drone	ViewCamera (UC-2), GetStatus (UC-6)
Sensors	Participating	To locate nearby objects	CheckObstacles (UC-4), AvoidObstacles (UC-5)
GPS	Participating	To track the current location of the drone	GetLocation (UC-3)
Server	Participating	To store all of the data that the drone has obtained	getData (UC-7), GetStatus (UC-6)
Drone	Participating	To return to home when the signal is lost for more than a certain time.	ReturnToHome (UC-8)

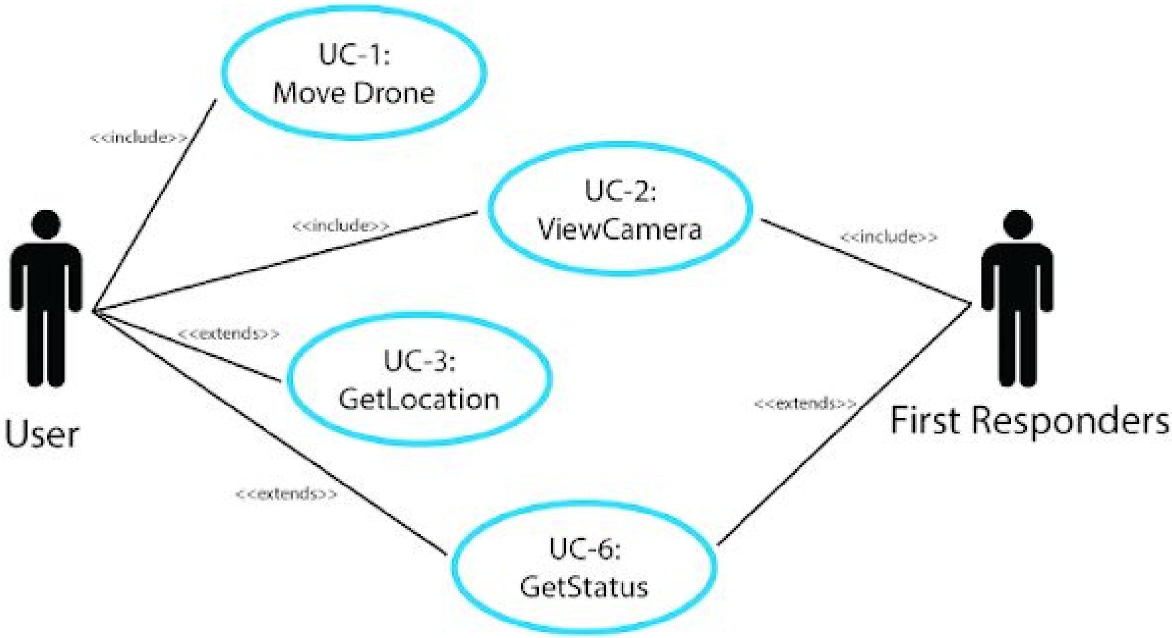
Use Cases

Casual Description

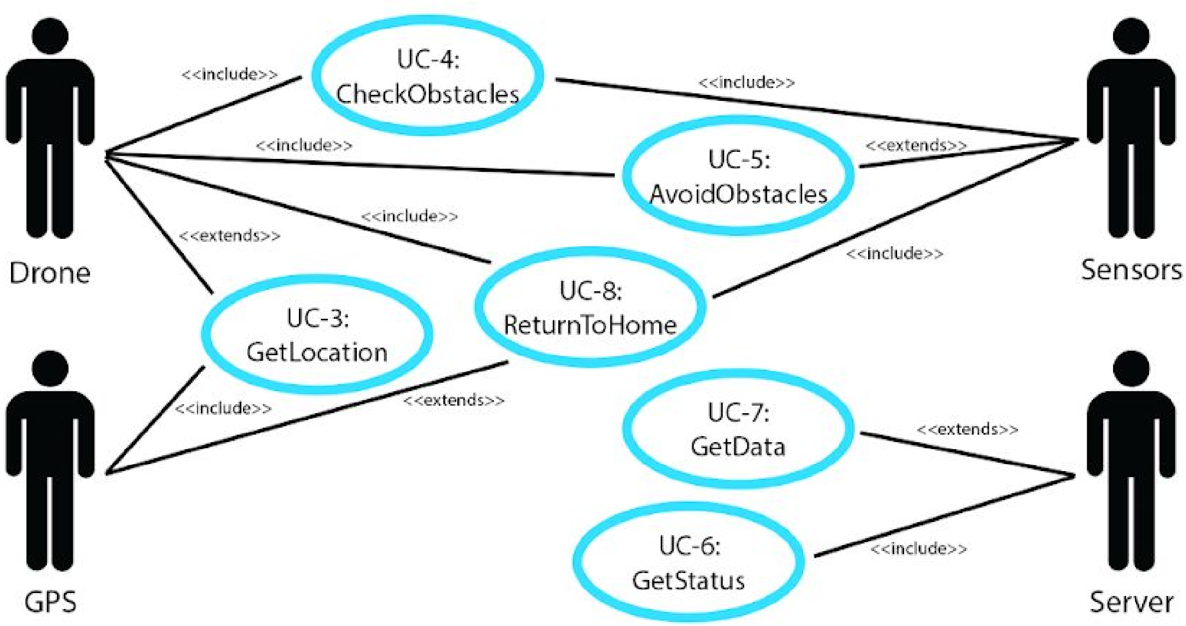
Use Case Name	Description	Requirements
MoveDrone (UC-1)	The user can move the drone using the controller.	REQ3, REQ6
ViewCamera (UC-2)	The user can view a video of the drone.	REQ2
GetLocation (UC-3)	The user can detect the drone's location using GPS.	REQ2, REQ7
CheckObstacles (UC-4)	The drone can detect obstacles in its path.	REQ5, REQ8
AvoidObstacles (UC-5)	The drone can avoid obstacles based on its surroundings.	REQ5, REQ8
GetStatus (UC-6)	The user or a first responder can check the current state of the drone based on the emergency.	REQ1, REQ2, REQ4
GetData (UC-7)	The user can check all of the data that the drone is transmitting.	REQ1, REQ6
ReturnToHome (UC-8)	The drone can safely autopilot back to the home (controller) in case the connection is lost. The user will know the drone's last location until it gets back.	REQ5, REQ7, REQ8

Use Case Diagram

Use Case Diagram: Human Interaction



Use Case Diagram: Drone Operation



Traceability Matrix

Requirements	Priority	UC-1	UC-2	UC-3	UC-4	UC-5	UC-6	UC-7	UC-8
REQ1	5						x	x	
REQ2	2		x	x			x		
REQ3	1	x							
REQ4	4						x		
REQ5	1				x	x			x
REQ6	2	x						x	
REQ7	2			x					x
REQ8	3				x	x			x
Total Priority	-	3	2	4	4	4	11	7	6

Fully-Dressed Description

Use Case 6: GetStatus

Related Requirements: REQ1, REQ2, REQ4

Initiating Actor: Drone

Goal: To get the drone's operating status

Participating Actor: Server

Preconditions: A signal between the drone and the controller is available

Postconditions: Allows the user to know if the drone in active or not.

Main Success Scenario:

1. The user will know if they need to turn the drone on.
2. The user can tell if the connection between the controller and drone is established.

Use Case 7: GetData

Related Requirements: REQ1, REQ6

Initiating Actor: User

Goal: Collect data on the various operations of the drone

Participating Actor: Server

Preconditions: Drone is on and a connection between the drone and controller is established.

Postconditions: Allows the user to manipulate and store that data.

Main Success Scenario:

1. The user can adjust motors speeds based on collected data.
2. The user uses the controller to move the drone if needed based on altitude.

<u>Use Case 8:</u> Return to Home

Related Requirements: REQ5, REQ7, REQ8

Initiating Actor: User

Goal: Ability to have the drone return to it original location/ user.

Participating Actor:	Drone, Controller
Preconditions:	Drone is active Controller is Available
Postconditions:	Allows the user to turn off and pack up the drone.

Main Success Scenario:

1. The user lands the drone near them.
2. The user uses the controller to turn off the drone.

<u>Use Case 3:</u>	Get Location
Related Requirements:	REQ2, REQ7
Initiating Actor:	User
Goal:	Ability to detect the current location of drone
Participating Actor:	Drone, Controller
Preconditions:	The GPS is on and in a working condition. The connection between the drone and controller is stable.
Postconditions:	Allows the user to retrieve the current

location of drone displayed on the controller.

Main Success Scenario: 1)The controller receives the GPS signal from the drone.
2) The user can see the current location of drone.

<u>Use Case 4:</u> Check Obstacles

Related Requirements: REQ5, REQ8

Initiating Actor: Drone

Goal: To enable drone to detect obstacles in its path.

Participating Actor: Sensors

Preconditions: The sensors are on and in a working condition.
The physical mechanism of drone is undamaged and operable.

Postconditions: Allows the drone to detect obstacles that can possibly damage or interrupt its mission.

Main Success Scenario: 1)The sensors built on drone detect the obstacles.
2) It alerts the user, thus the user can maneuver the drone.

<u>Use Case 1:</u> MoveDrone

Related Requirements: REQ3, REQ6

Initiating Actor: User

Goal: Ability to move the drone using a controller

Participating Actor: Drone, Controller

Preconditions: Drone is available
Controller is Available

Postconditions: Allows the user to maneuver the drone using a controller and a camera

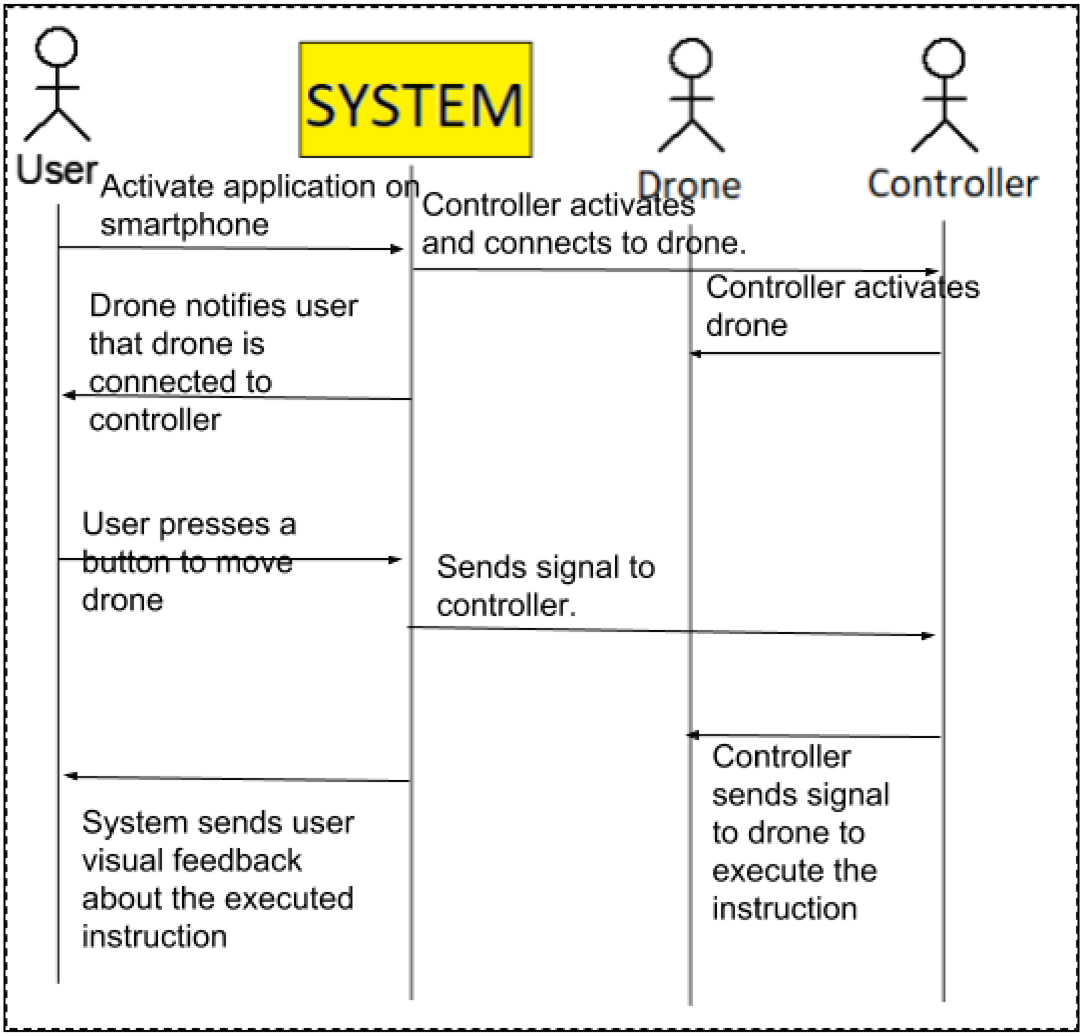
Main Success Scenario:

1) The user sets the drone on the field.
2) The user uses the controller to test the drone's ability to move.
3) The controller will send signals to drone which will allow the user to control and move it.

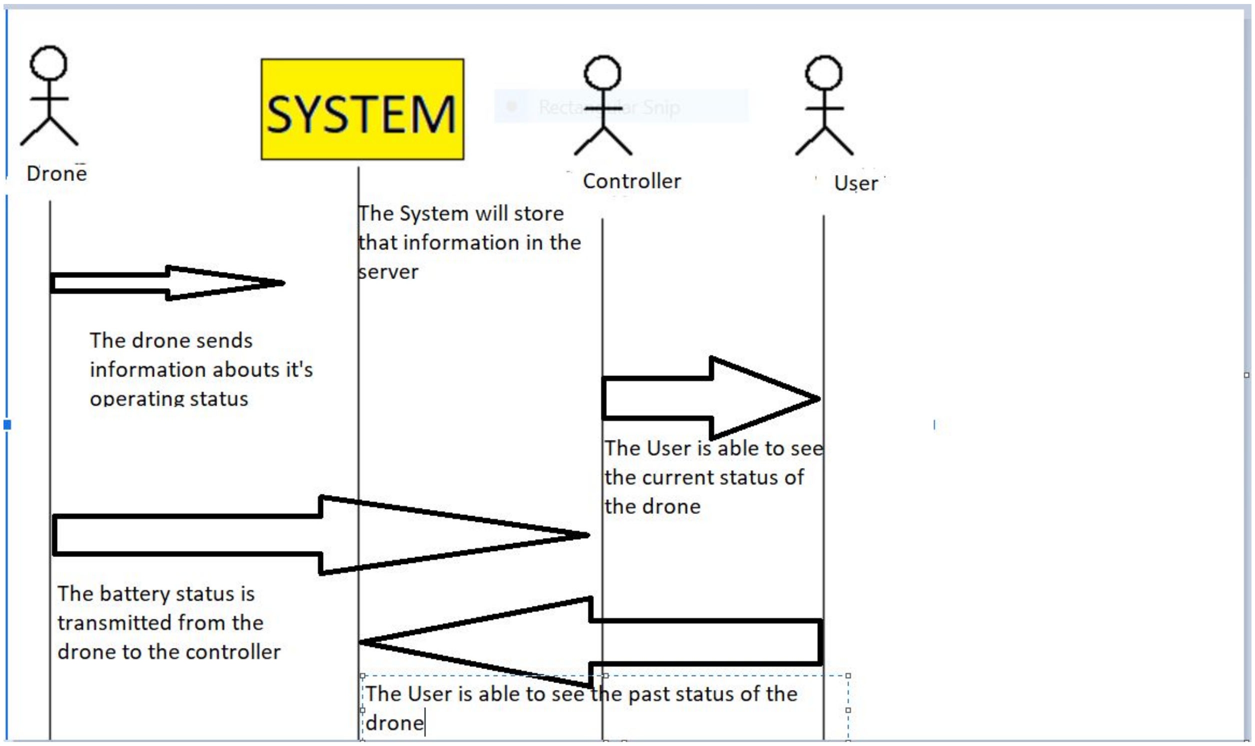
<u>Use Case 2:</u>	View Camera
Related Requirements:	REQ2
Initiating Actor:	User
Goal:	Ability to view a live video of drone.
Participating Actor:	Drone, Controller
Preconditions:	The camera is on and in a working condition. The connection between the drone and controller is stable.
Postconditions:	Allows the user to view the live feed of drone on the controller.
Main Success Scenario:	1) The controller receives the data for a live feed from the drone. 2) The user can see a live video from the controller displaying it.

System Sequence Diagrams

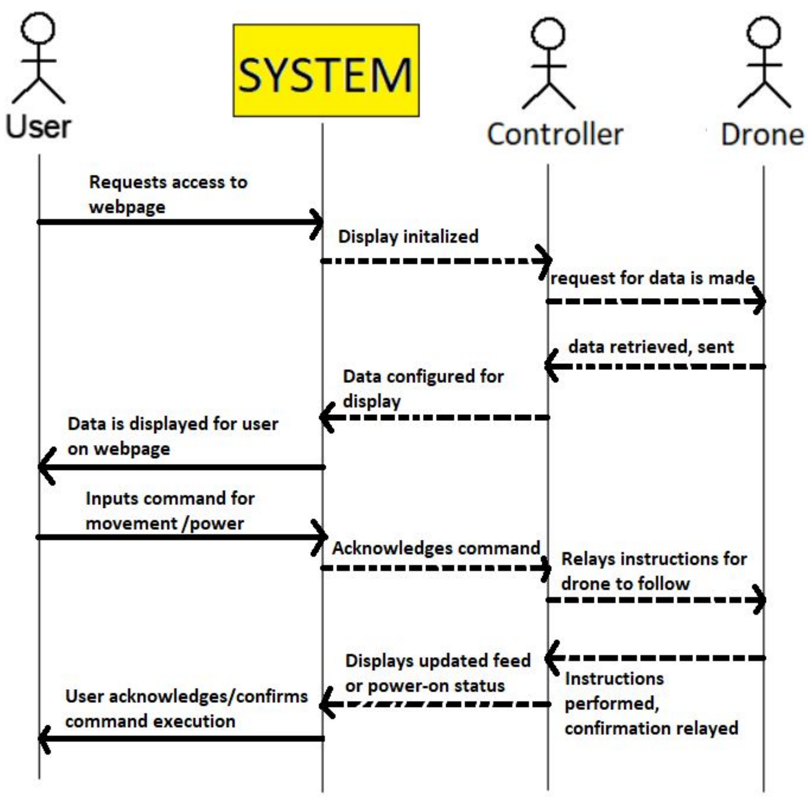
Use Case 1: MoveDrone



Use Case 6-GetStatus:



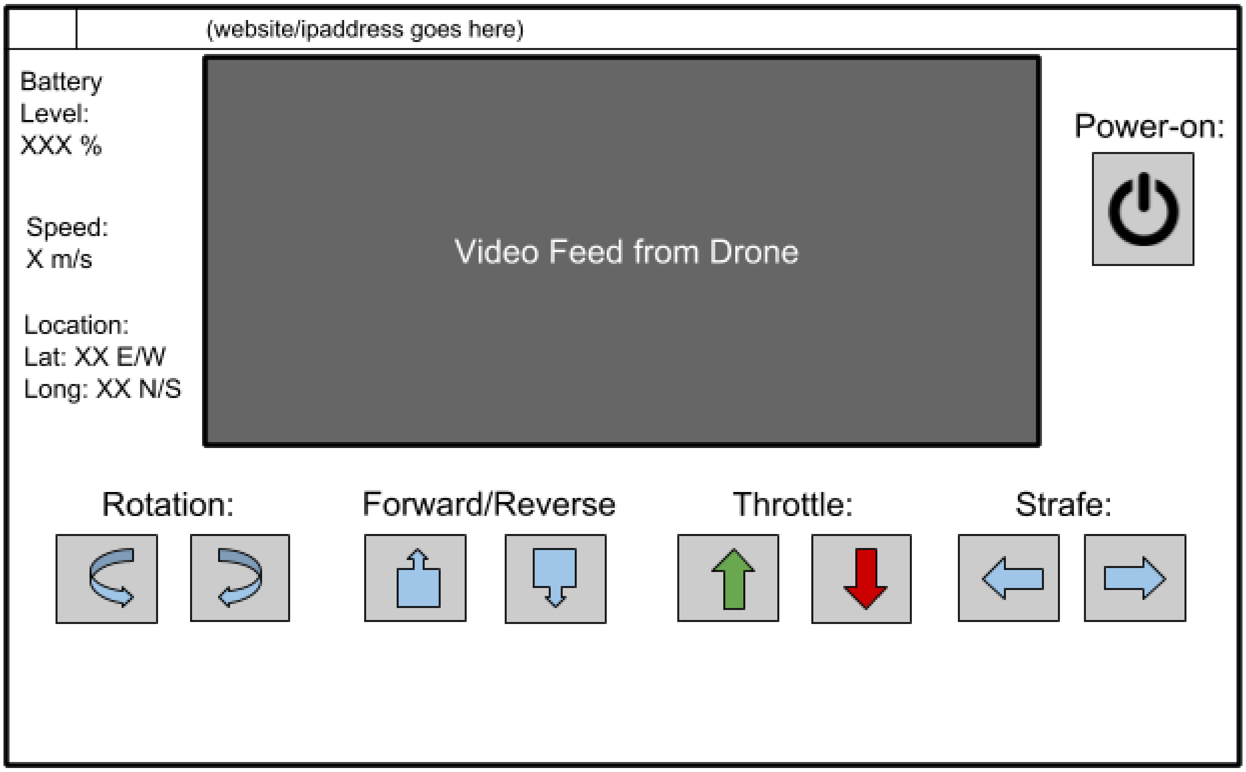
Usercase7:GetData



User Interface Specification

Preliminary Design

Tablet(Landscape View):



The user is able to control the path of the drone by using the navigational buttons that will appear on the screen above. This is what the user would see if they opened up the webpage that holds all of this data.

To illustrate, for use case 7(getdata):

1. The user would enter the ip address/webpage at the top of their desired browser page
2. A screen mirroring the above mockup in appearance would show on their screen, providing the control buttons, drone data, and video feed.
3. The user could then initiate whatever commands they want regarding navigational control from the buttons on screen, and be updated of their happenings via the live camera feed.

User Effort Estimation

1. NAVIGATION: total 1 phone click, 1 manual entry as follows
    - Open any preferred browser
    - Enter in the drone specific IP address/url into the search bar
    - Navigational webpage available for use by operator
2. DATA ENTRY: total 10 button pushes, as follows (all buttons will be accessible via the on-screen webpage)
    - Press the power icon button once to start the aircraft's motors.
    - Press the clockwise/counter clockwise rotation buttons to point the nose of the aircraft either right and left.
    - Press the forward/backwards buttons under "Forward/reverse" to move forwards and backwards.
    - Press the green/red arrows under "throttle" for appropriate movement up or down.
    - Press the left/right arrow buttons for directly moving left/right (Strafing)
    - Press the power icon button to turn the drone off(after having properly landed it).

Project Management

Shantanu came up with the project idea and was able to explain how we could contribute to the project during weekly meetings.

Krishna Mahadas created and shared the Google Drive for our project so we could easily collaborate on creating the reports.

Abhishek manages the GitHub repository to maintain the project code and divide the work among the team.

A website is going to be made and developed with relevant updates to the project. This will be managed by Abhishek. Other team members will help.

We divided the project into four categories:

- Visual Data Processing (Abhishek, Shantanu, Krishna Mahadas)
- Location Data (Avnish)
- Physical Data (Sahana, Won Seok, Sri Sai Krishna Tottempudi)
- Obstacles (Vishal)

All other contributions to the project can be found in the individual contributions breakdown matrix on page 2.

References

https://www.dronesense.com/?gclid=EAIaIQobChMIqo-45_Gx4AIVwoCfCh2CbA0QEAAYASAAEgKMu_D_BwE

Image 1:
https://s.yimg.com/ny/api/res/1.2/2P8Y6UqlB8dKOiVIg9Rscg--~A/YXBwaWQ9aGlnaGxhbmRlcjtzbT0xO3c9ODAw/http://media.zenfs.com/en-US/homerun/digital_trends_973/8122e594705a009db372bf32720d9fe9

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Coast Guard Table:
https://www.dco.uscg.mil/Portals/9/CG-5R/SARfactsInfo/SAR%20Sum%20Stats%2064-16.pdf