Disaster RescueBot™

Patented by: Hannah Nelson, Taylor Johnson, Colin Frank, & Kyle Springborn

Section 5 | 12.10.22

Problem Statement

There have been many recent natural disasters (hurricanes in particular) along the United States east coast. Families in this area want to be assured that they will receive quick assistance in the event that they need emergency help. Disaster relief teams are used to find trapped victims, clean up debris, and notify first responders about waste. There needs to be a near-immediate response to these tragedies, and there isn't enough time, manpower, and financial support being put toward this. Our solution is to send in multiple *RescueBot™(s)* as part of the first responder team and gather information on the location of victims and scattered debris. This data is then sent to other first responders in a safe location to aid in the relief effort and get rescued persons back to safety. (https://usafacts.org/articles/are-the-number-of-major-natural-disasters-increasing/)

Application Narrative

Every year, over 100,000,000 people are affected by natural disasters. According to the Red Cross, in 2010 alone, 314,503 people were killed by these disasters. As global warming continues to rise and devastating natural disasters are happening with increased frequency, the need for automated disaster aid is growing. The US and other parts of the world are facing disasters of increased magnitude, such as the recent hurricane in western Florida that devastated communities not usually prone to hurricanes. First responders cannot safely reach victims in flood waters and other dangers in such cases. It is essential that we harness technology to our advantage and serve those in vulnerable positions post-disaster.

However, we are dedicated to finding effective solutions that not only help thousands of people but also decrease the risk for first responders and other disaster relief organizations. We will partner with Iowa State University to develop the latest technology that can save many lives when used before/after natural disasters.

Our methodology builds upon our previous projects for the Red Cross. We will use similar technology to develop a bot that can withstand disaster-stricken areas and safely guide victims to safety or first responders to victims. With extensive modeling and testing, we will ensure accurate detection of danger, such as holes in the ground, debris, and cliffs.

Empathy Maps

Victims

DO	THINK
Preparing safe house before disaster hit Victims communicating back to first responders Can get stuck/lost in hard-to-reach areas	"I wish I knew when the eye of the storm will pass through." "We only have 1 more day of clean water." "I am going to be here forever."
SAY	**FEEL**
"The north side of the town got hit worse than the south side." (To family/friends) "Let's hope disaster relief comes quickly!" "We need to make sure we stay calm."	Scared: if the rescue team will be able to find them Nervous: if the first responders can't get a complete sweep of the area promptly Panicked: if no one knows they are hurt or stuck

First Responders

DO	THINK
Determine victims' locations Rescue victims Remove debris from the area	"We need more data to help predict these disasters." "We need to find the survivors quickly." "This is too dangerous for a first responder to go through"
SAY	FEEL
"Need a way to get these medical supplies to these people that got hit by an earthquake." "The environment is decreasing rapidly, we need to move quickly." "These victims must be transported to the hospital as soon as possible."	Uncertain: if they cannot identify all the waste that needs to be extracted and avoided Stressed: it is their job to ensure the safety and rescue of disaster victims Courage: they need to be brave when facing danger

POV Statements

Red Cross:

- The Red Cross needs the assistance of new technology that can adapt to environments that humans cannot easily access because that will maximize disaster relief (such as cleaning debris, and rescuing citizens) efforts in areas that are difficult and dangerous for human responders to reach.

First Responders:

- First Responders need a versatile machine that can navigate air and water, perform automated scans for human activity, and deliver medical supplies to difficult-to-reach places because they need a safe and effective method for providing aid.

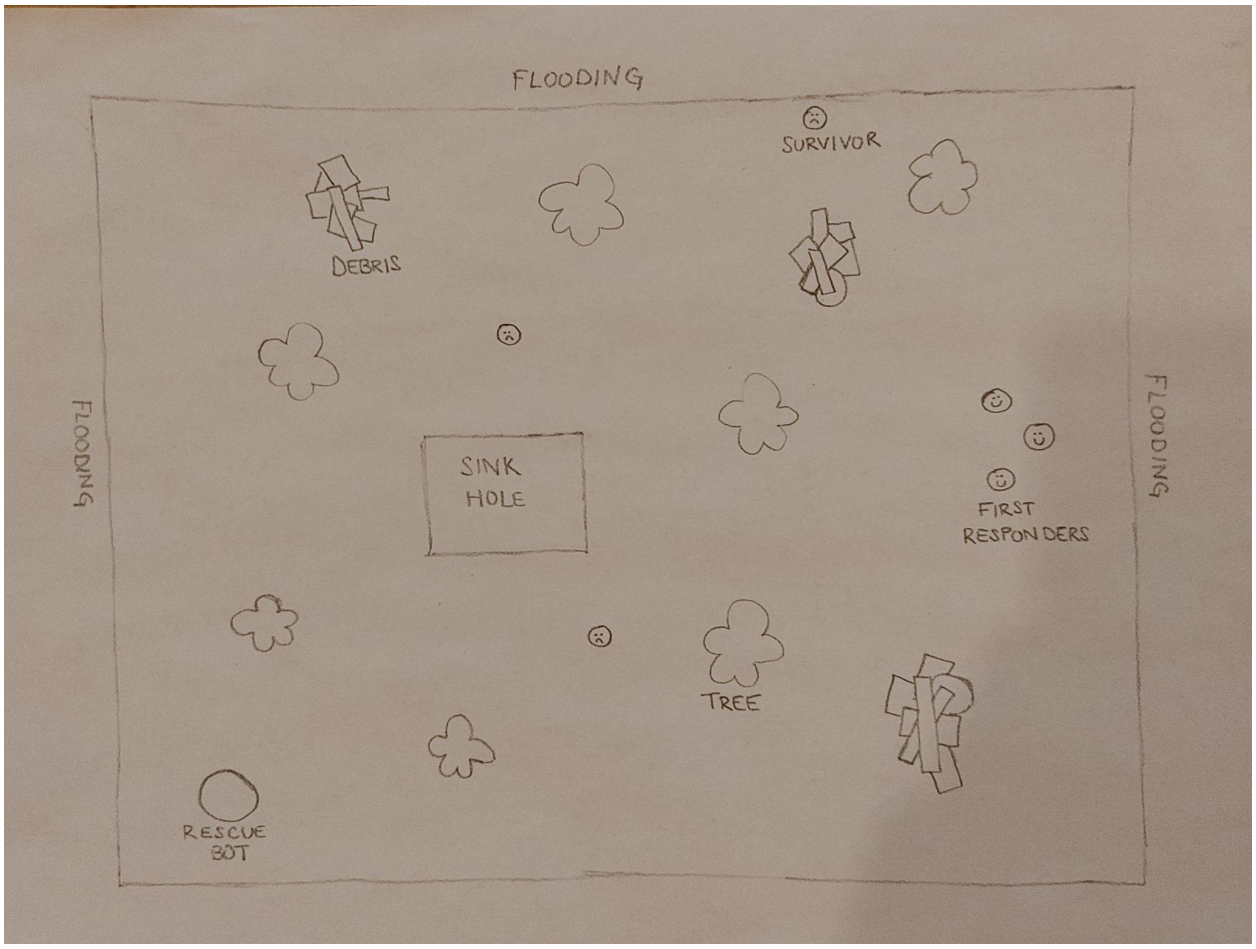
Disaster Victims**:**

- Disaster victims need a *RescueBot*™ that helps victims by giving immediate aid because lives are at stake.
- Disaster victims need technology that can predict future disasters because that will help victims flee at risk areas prior to a natural disaster event.
- Disaster victims need technology that communicates with first responders from inaccessible areas, and ultimately get to safety faster.

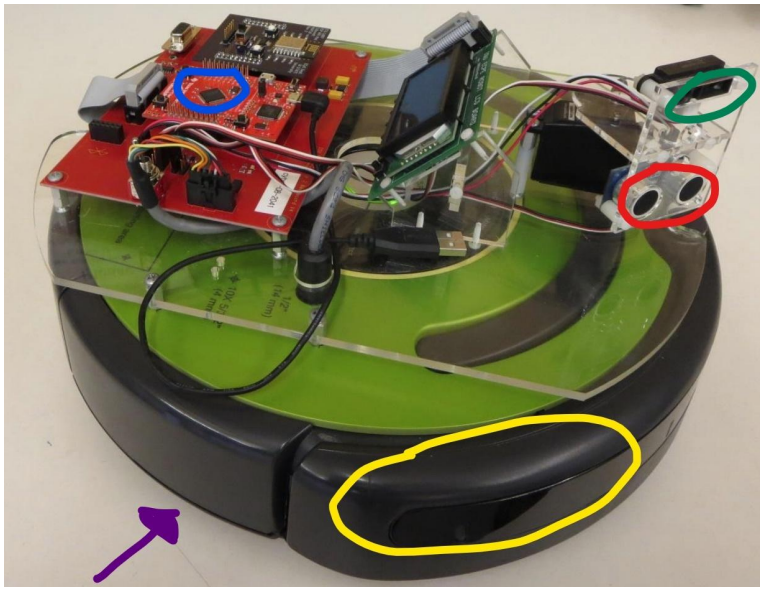
Prototype

User-Centered Sketch:

RescueBot™ will navigate through dangerous objects to find victims trapped in a disaster. This will be done by scanning for potential sinkholes, trees, water, nuclear materials, etc. Once the *RescueBot*™ finds a human, it will alert first responders with a message and send location data to a receiver in a safe location.

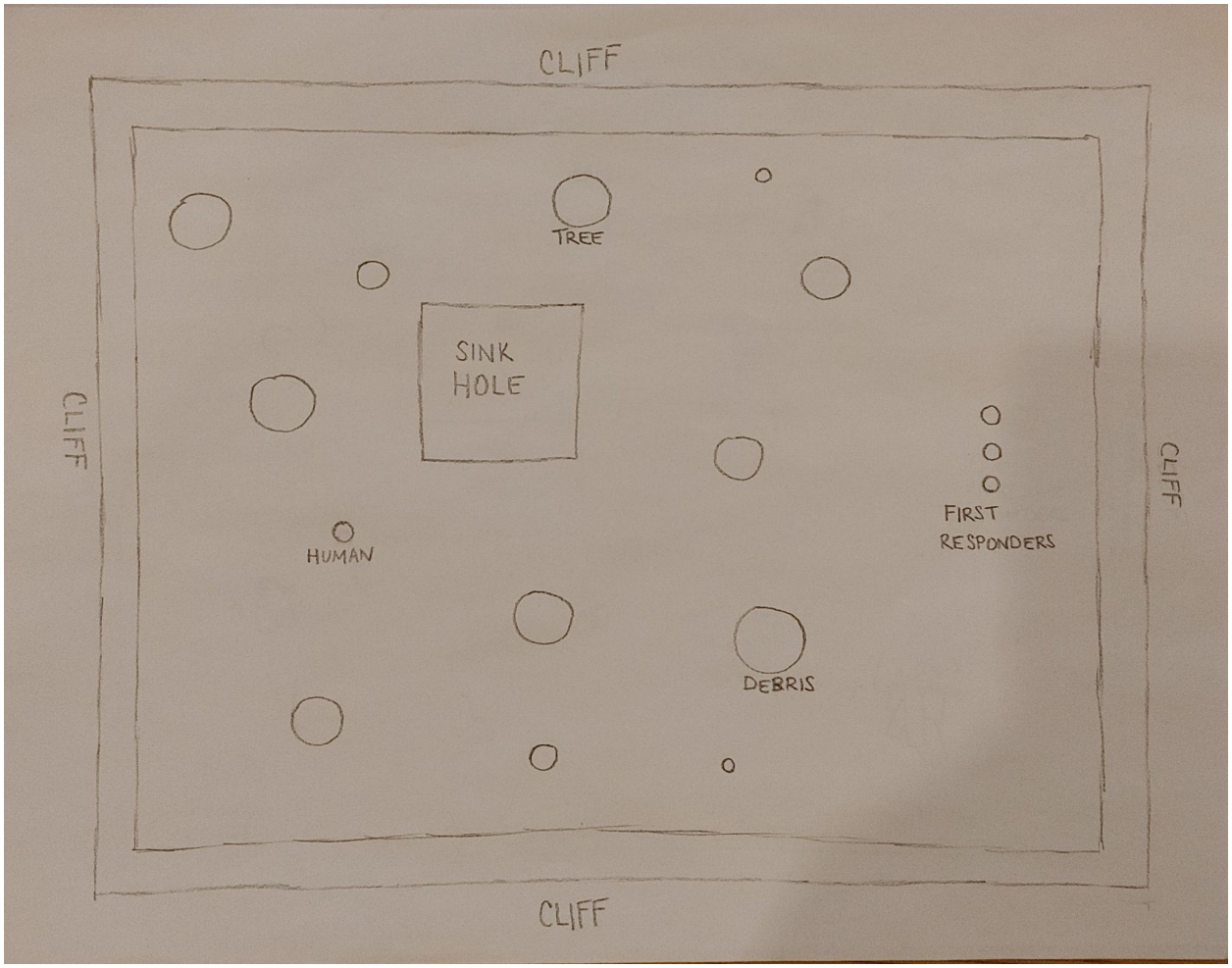


Technical Centered Sketch:



1. TM4C123GH6PM Microcontroller
    a. Enables the cyBot to use features that will allow us to detect locations of victims and report back to the first responders.
2. Wheels
    a. Allows the cyBot to move to better detect where victims are (precise location).
    b. Move around objects such as trees, holes, and small/large debris.
3. IR Sensor
    a. Scanner to detect location (angle) of objects and victims.
    b. Used in initial detection (180 scan) to gather information on whereabouts of all objects/humans nearby.
4. Ping Sensor
    a. Sensor to detect distance of objects and victims.
    b. Used in secondary scan for accurate readings on location (distance) of victims and objects
5. Bumpers
    a. Allow cyBot to detect objects smaller than scanner height.
        i. If the cyBot runs into an object, it backs up and moves over in order to gather its surroundings.
    b. Detects objects, then navigates accordingly in order to continue the rescue.

Test Field Sketch:



CyBot Capabilities

Basic Test Field Elements	Application
Tall Wide Objects	Tree
Short Objects	Small debris
Pillars (tall and thin)	Human victims
Holes	Sinkhole
Out of Bounds	Cliff
Destination Zone (3 tall and thin pillars)	First Responders
Anything Larger	Debris

Base Functionality

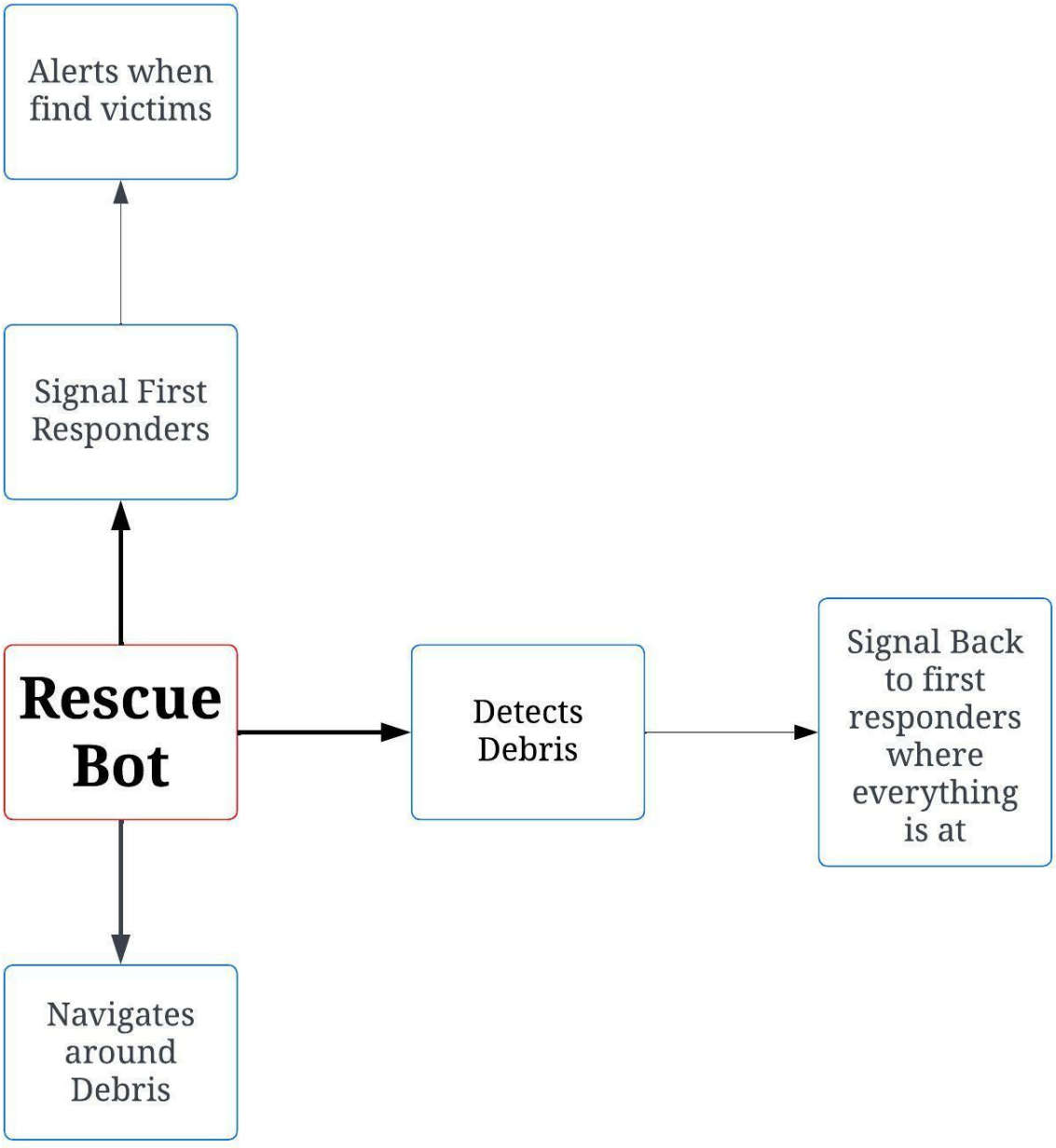
Base Functionality	Mapping to Application Narrative
CyBot Communication	First Responders need accurate location data of disaster victims.
CyBot Movement	First Responders need RescueBot™ to reach victims in areas with limited human access.
Object Detection	First Responders need RescueBot™ to differentiate between victims and debris/dangerous materials.
Object Avoidance	First Responders and victims need RescueBot™ to remain undamaged and aid in timely relief.

Boundary Adherence	First Responders need RescueBot™ to stay within hard to reach areas and specifically programmed boundaries.
Arrival at Destination	Victims need RescueBot™ to return to its destination zone and share further information with First Responders.
User Interface	First Responders need to communicate with and take control of RescueBot™ while on mission.

Mapping Test Elements

Base Capability Types	Default Usage
Open Interface	Movement Functions
Interrupts	Ping Sensor
Wifi and UART	Communication with RescueBot™
ADC	Infrared
Input Capture	Ping Sensor
PWM	Servo Motor

Lotus Blossom Diagram



Research

User	Observations	Source
Red Cross	Fit where humans can't, don't get tired, operate in difficult environments	https://emerj.com/ai-sector-overviews/search-and-rescue-robots-current-applications/ (News article) J. Walker, "Search and rescue robots - current applications on land, sea, and Air," *Emerj Artificial Intelligence Research*, 21-Nov-2019. [Online]. Available: https://emerj.com/ai-sector-overviews/search-and-rescue-robots-current-applications/. [Accessed: 01-Nov-2022].
First responders	Helpful for underwater rescues such as boat and marine accidents, drone searching	Center for Robot-Assisted Search and Rescue, "Responses 2001 - 2016," *YouTube,* May 28, 2016, Available: https://www.youtube.com/watch?v=1jqdL2cL8Og&t=85s. [Accessed: 01-November-2022].

First Responders	Helpful for performing scans or area, identify/locate victims and hazardous materials, deliver medical supplies	https://doi.org/10.1002/rob.21651 (Journal Article) H. Balta, J. Bedkowski, S. Govindaraj, K. Majek, P. Musialik, D. Serrano, D. Alexis, K. R. Siegwart, G De Cubber, "Integrated Data Management for a Fleet of Search-and-rescue Robots," *Journal of Field Robotics*, vol. 34, no. 3, pp. 539–582, Apr. 2017.
First Responders / Victims	Can give immediate aid supply, prediction of future disasters, victims can get help faster	https://singularityhub.com/2019/04/12/ai-and-robotics-are-transforming-disaster-relief/ M. D. Peter H. Diamandis, "Ai and robotics are transforming disaster relief," *Singularity Hub*, 18-Mar-2021. [Online]. Available: https://singularityhub.co

		m/2019/04/12/ai-and-robotics-are-transforming-disaster-relief/. [Accessed: 01-Nov-2022].

Contributions

Name	Individual Contribution	Description of Contribution
Taylor	Empathy Map, User Research, Drop Sensor	Did research for user application and needs, cited sources, added material to empathy map that connected to user needs
Hannah	User and Test Field Sketches, Application Narrative, Drop Sensor	Drew sketches of user and test fields relating to CyBot capabilities, wrote application narrative that connects to real-world application
Kyle	Technical Centered Sketch, Problem Statement, Debugging	Edited the photo of cyBot and described how each function would assist our problem. Wrote the problem and described our solution in terms of the cyBot.

		Handled debugging of code and added specific cases for object typing and detection.
Colin	Lotus Blossom diagram, Empathy map, Research, Bot handling and testing	Looked up research for the problem statement, empathy map, etc. Used the research to develop an empathy map based on how the user and victims would think, do, feel, and say. Used cyBot capabilities to develop lotus blossom based off of what the cyBot was capable of completing.