CPR E 288 Final Project
Fall 2023
Project Group 3 - Section 4

The Project

Bomb retrieval. CyBot navigates the test field to find a ticking bomb.

Application Problem Statement and Narrative

We will be modifying the CyBot to create a robot capable of safely locating a bomb. Our CyBot will navigate through a course full of obstacles to find a mock-bomb. This bomb will be emitting sound, a ticking noise, that will alert the CyBot of its presence. Once the CyBot has successfully navigated to an adequate distance from the bomb, it will stop and alert emit a noise from the speakers to show it has completed the task. Then, the mission is complete.

The largest market for bomb defusing technology is the military. The reason for buying a bot to defuse a bot is to keep people safe; specifically, keeping the person defusing the bombs safe. Being able to keep humans farther away from dangerous explosives is the biggest concern in an encounter with an explosive. To accomplish this, we will have wireless control of the bot. The user also cares about efficiency because bombs are often time-sensitive, so we will have the bot scan and move as quickly as we can while preserving accuracy.

Collaboration

As a project group, we worked together to create a vision for our final product. Similar to members of a design team, we all contributed many ideas, built on each other's ideas, and finally came to a consensus. Then, we divided the work. Movement and Scanning was handled by Laith and Daniel. The GUI was divided between Logan and Sullivan. Sullivan implemented the microphone.

Empathy for Users

Military User Empathy Map:

Many military personnel put themselves in danger every day by defusing, disabling, and dismantling unexploded bombs. These bombs can explode at any time. In fact, there are more than 100 million of them scattered across the globe.

Do	Think
- " Try to keep the militery personnel safe". - "Doing the job away from dangrous areas" - "Needs to be operated wirelessly" - "adaptable to the environment surrounding it"	- Completing the mission Safely. - Removing the dull, dirty and dangrous job. - Protect others.
Say	**Feel**
- "It involves alot of danger". - "Put their life on the line". - "This job required a lot of accuracy and efficiency."	- "It is a scary mission". - "Makes the mission easier" - "Makes them feel safe"

Point Of View Statement:

What military customers would say:

- "The robot should be efficient and fast"
- "It should be easy to control and controlled wirelessly"
- "The bot should work in all environments"
- "The robot should identify the surroundings"

Construction User Empathy Map:

Because of past and ongoing wars, there have been many instances where construction companies excavating land digs up an old bomb. These cases are very dangerous if the bomb is active. Bombs are not the primary concern of a construction company, so an easy and user-friendly solution is in high demand. Bombs are also used for mining operations to create new holes. Sometimes, they do not go off and need to be extracted by personnel.

Do	Think
- Invested into robot rescue - Have personal bomb teams enter explosion area if bomb is found	- There is a way to prevent personnel from entering the bomb area to retrieve a dead bomb - Safe way to retrieve the bomb and transport to an area away from citizens
Say	**Feel**
- In Iraq a bomb team has said “they placed IED every 3 to 5 meters from each other” - After a Bomb was detonated in Germany “why wasn’t it discovered earlier” - Bombs found in Singapore “There have been several previous instances of construction work uncovering such unexploded ordnances and may not be the last”	- Safe when any unexpected problems occur with faulty bombs - Concerned for any citizens nearby

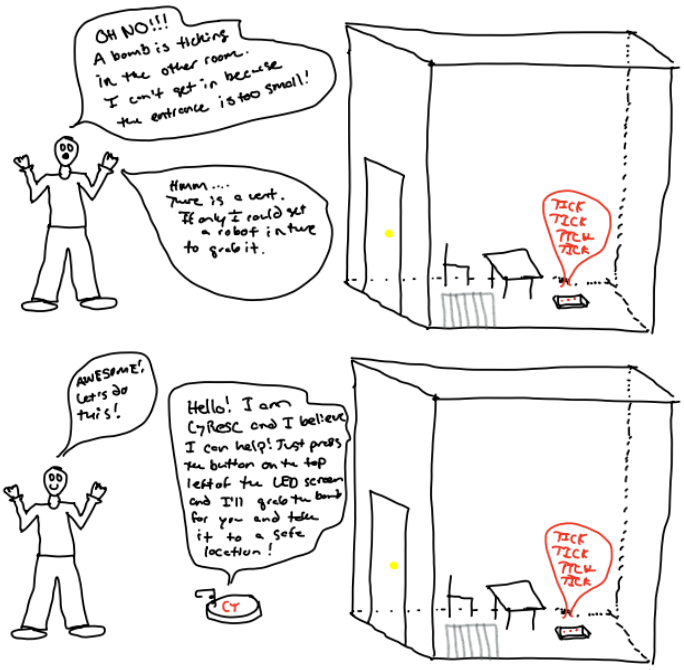
Point Of View Statement:

Construction workers need a bomb retrieval robot that is operated far enough away from the bomb field, can navigate to the bomb safely, and transport to a safe location because they cannot risk the safety of any workers, personnel, or citizens nearby to enter the area or be at risk of detonation if it were to happen.

Prototype:

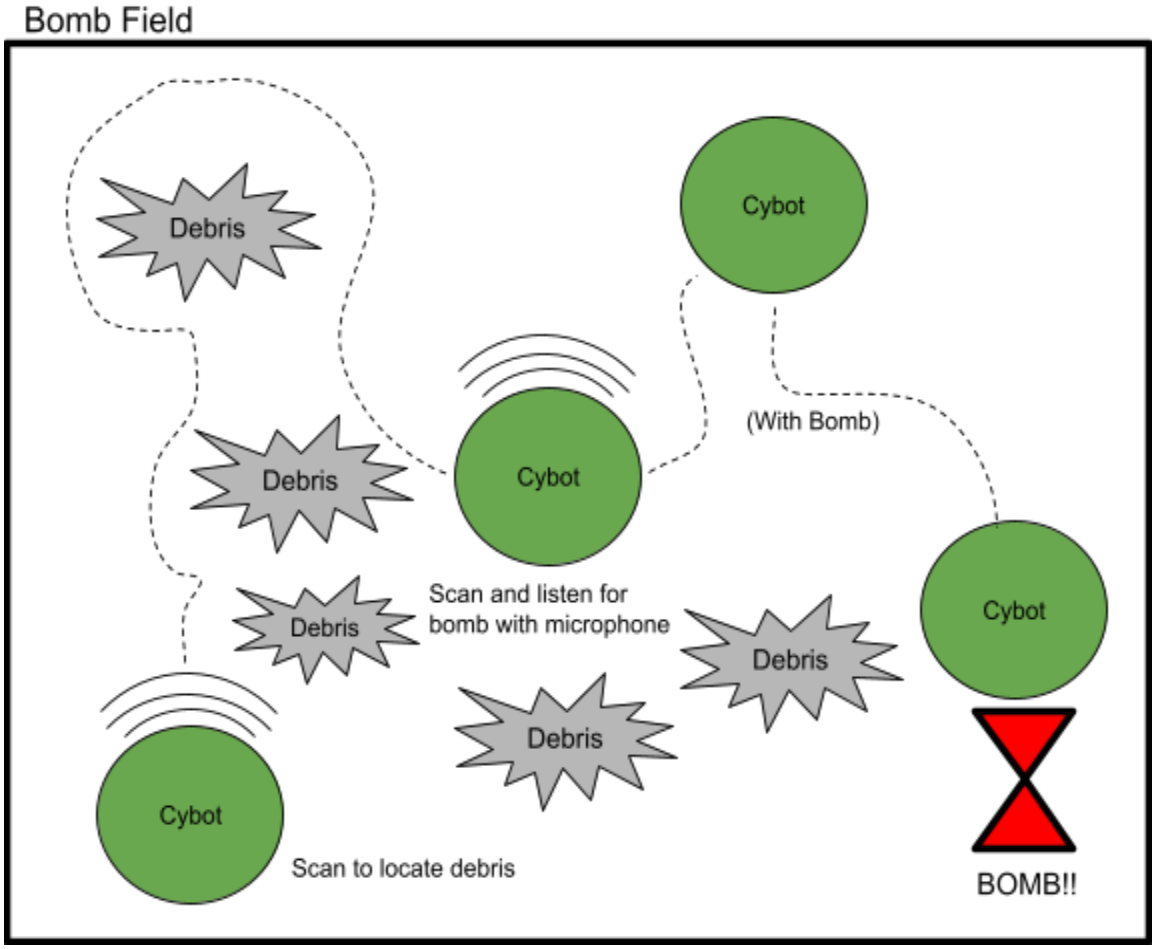
The overall goal of the project is to use the CyBot as a means to locate a bomb. The user will need a bot that acts quickly without sacrificing accuracy. In order to use the bot, the user will simply put it in any starting location and press a button. Due to the unexpected nature of the environments that the bot will be in, it will need to be able to detect and avoid obstacles on its path to retrieving the bomb. These include large debris, small debris, cliffs, and even holes!

User Deployment Sketch:



Testing

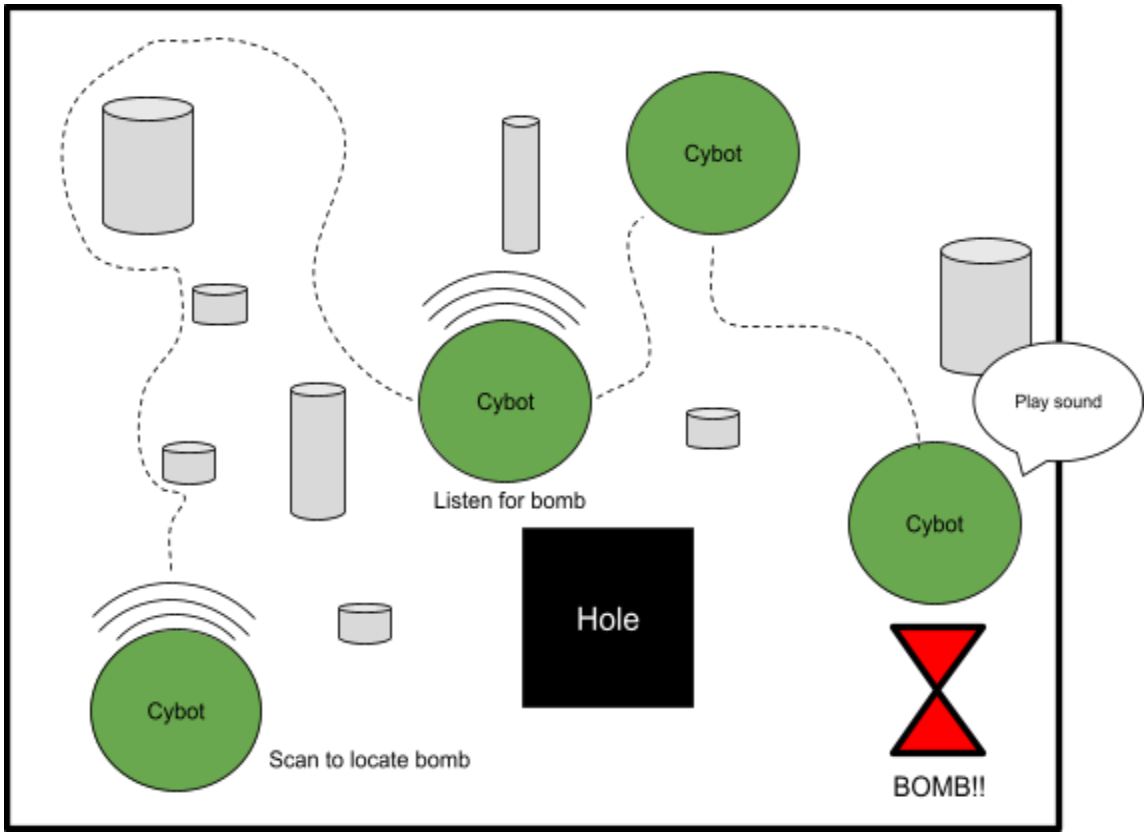
Field Sketch:



The Scene:

- The CyBot is placed into a bomb field
- The bomb field had previous CyBot's fail to do their task and blew up causing debris in the area
- There is an initial scan to locate objects in the path and to listen for the bomb
- If the bomb is not close, the CyBot will travel through the field to find another point to scan and listen from
- Once the bomb has been detected, the CyBot will travel to the bomb
- After the bomb has been located, the robot will alert that the mission is complete

Test Field Sketch:



Large Functional Requirements

Communication:

Using UART, the CyBot will report all sensor data after each scan to the user in a safe area. It will also communicate the pathing it takes. For example, it will report back that it turned a certain direction and moved a certain distance. Any unexpected events, such as a boundary, hole, or bump detection, a notification of the event will be sent back to the UI. Once the bomb has been determined as near the Cybot, the user will communicate that the bomb is picked up and heading back to the defusing area by playing a sound. Finally, it will signal that the bomb has been defused once it reaches its final destination by playing the sound again, once determined by the user that the bot is in the safe zone.

Movement:

The CyBot will move manually with autonomous safeguards. It will move through inputs of buttons pressed on the GUI. The key bindings are as follows:

- Move forward 20 cm
- Turn left 15 degrees
- Move backward 20 cm
- Turn right 15 degrees
- IR Scan
- Microphone Scan
- Microphone Read

Object Detection:

To detect objects, the CyBot will do an initial scan for any initial obstacles. This scan will detect the tall objects, both skinny and wide. For objects that are not detected by the scanner, it will use its bump sensors. The bomb will be detected by incorporating a microphone to the CyBot and listening to the ticking created by the bomb.

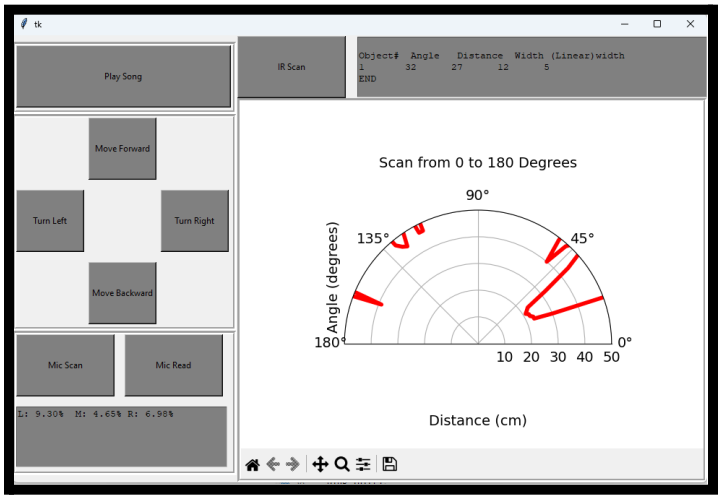
Object Avoidance:

To avoid objects, the CyBot will use its front bumpers for any objects that are not detected by the scan, move backward a few centimeters, and send a notification of which bumper was pressed to the UI. After a full scan, the robot will show the graph of objects and its information, so the user can navigate around the object. The bot will do a fast scan before each move forward to ensure it doesn't collide.

Boundary Detection:

The CyBot will use its cliff detection to spot the different color boundary lines along with any holes that will be present in the testing area. This same feature will be used for bringing the bomb back to the defusing zone.

User Interface:



The user interface will consist of buttons to move the bot forward, backward, turn left, and turn right. It will also have buttons to initiate an IR scan, initiate a microphone directional scan, and read from the microphone without moving it. After each scan, it will display an IR polar graph. After a scan, it will also include all objects that were detected, their distance, and their linear width. When a microphone scan or read is requested, it will display the volume percentage to give an indication as to how close the bot is to the bomb. For example, the percentage is close to 100% when the bot is next to the bomb and decreases as the bot is further away. For boundary, hole, and bump events, it will send a notification of the event so the user knows why the CyBot stopped moving.

Completion of Goal:

Once at destination, the CyBot will use its speaker to signal that the bomb is ready to be defused in the safe defusing area.

Large Functional Requirements:

User the PING sensor for object distance measurements	Use the IR sensor for object detection	Potentially add “compass” sensor	Addition of “sound detection” sensor to help locate the pinging bomb	Use bump sensor to detect whether contacting obstacle
Keep track of location of objects in some “virtual field”	Should move autonomously	Keep track of orientation	Has to detect bomb somehow	Needs to tell if it is hitting an object for quick correction
Use wheels to move with movement functions	Move around the field	**Grab the bomb!**	Needs to be able to grab the bomb	Use simple hook on back of robot to drag the bomb around
Use cliff sensor to detect holes	Needs to detect holes	User needs to interface with the robot	User can activate autonomous mode via button on bot or Putty	Bot updates user of movements using Python GUI
Emits sound when bomb has been grabbed	Different pitch sounds for distance relative to the bomb	Use speakers for alerts	User can interrupt the bot and tell it to come back at any point to avoid contact with bomb	User can select whether the bot brings bomb back to them or to a “drop off” location

*Base Capabilities Types**	*Default Usage*	*Project Usage (can use defaults) (opportunities for bonus)*
Open Interface	Robot Movement	Default
Interrupts	Ping Sensor	Default
WiFi-UART	Cybot Communications	Default
Analog to Digital Conversion	Infrared Sensor	Default
Input Capture	Ping Sensor	Default
Pulse Wave Generation (PWM)	Servo Motor	Default
Microcontroller Capabilities not Covered by Labs (opportunities for bonus)		
Output to speakers	Play a song	

Base Functionality	*Mapping to Application Narrative (In form of needs statements)*
Cybot Communication	Need to use Putty to send information on the scene to user and send instructions to bot
Cybot Movement	Need to navigate around objects to the mock-bomb
Object Detection	Need to determine if an object is a mock-bomb
Object Avoidance	Need to scan the area in front of the bot to avoid collisions
Boundary Adherence	Need to stay within the given area to stay on-target
Arrival at Destination (Completion of goal)	Need to know that it is in the correct final location
User Interface	Need to be easy to use for non-CPR E 288 students
Application Specific Functionality (opportunities for bonus)	
Audio input	Need to find the mock-bomb
Audio output	Need to alert that the area is clear

Basic Test Field Objects and other Elements	*Description of how Test Field Elements Map to Application Narrative*
Tall wide objects	Obstacle to avoid
Short objects	Bomb
Pillars (tall thin objects)	Obstacle to Avoid
Holes	Hole to avoid
Out of bounds	Area to stay within
Destination zone	Area to drop off bomb
Other Application-Specific Test Field Elements (opportunities for bonus: consult with TAs and Professor)	
Speaker	Combined with short object to make a bomb

Works Cited

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