Lab Report of EEE 187L Final Project

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Abstract - **This report contains the procedures and findings from the cat bot and mouse bot project. The project has two autonomous robot cars fulfilling the roles of a cat and a mouse. The project aim was to emulate a mouse trying to avoid being captured by a cat.**

Keywords - Autonomous robot cars, cat bot, mouse bot

I. INTRODUCTION

This project was inspired from a Sega Dreamcast game called Chu Chu Rocket. The premise of the game was that the player must guide mice through a maze to reach a goal while avoiding cats in the maze. This project emulated the action of the mice and the cat. However, all actions are controlled purely by the autonomous robot cars used as the cat and mouse.

II. COMPONENTS USED

TABLE I
COMPONENTS USED IN THE MOUSE ROBOT

Component	Purpose
Raspberry Pi 3B+	Control Systems
L298 Motor Driver	Locomotion Control
2x 6V DC Motors W/ Encoders	Locomotion
Caster Wheel	Stability
AA Battery Holder (8)	Power
Phone Battery Bank	Power
TCRT5000 (QTI) IR Sensor	Detect Line for Following
Ultrasonic Ping Sensors	Sensor for detection
LM2596s Voltage Regulator/ Buck Converter	Battery Manager

TABLE II
COMPONENTS USED IN THE CAT ROBOT

Components	Purpose
Parallax Activity Board	Control Systems
L298N H-Bridge	DC Motor Control
2x 6V DC Motors	Differential Drive
Caster Wheel	Stability
1x 6V battery	Power to parallax board
1x 14V battery	Power to DC motors
4x Ultrasonic Sensors	Distance Reading

III. ACRONYMS AND DEFINITIONS

Autonomous Robot - A machine equipped with various sensors which was capable of reacting to the environment it is in from the feedback it receives from its sensors.

QTI - This is an infrared light sender and receiver sensor. This sensor can send a 0 signal or a 1 signal to the control system as feedback. It will send a 0 if the sensor is facing a light absorbing surface, ie black electrical tape. On the other hand, it will send a 1 if the sensor is facing a light reflective surface.

Ultrasonic Sensors - This is a sensor which emits and listens to a high frequency sound to measure distance. This calculation is done by measuring the time taken for the sound to leave the sensor and heard by the sensor. Which is then divided by the speed of sound to find the distance between an object the sound bounced off and the sensor.

Differential drive system - This is a drive system which allows a wheeled machine to perform sharp turns in one spot without moving forward or backwards. This maneuverability is capable only because of the two motors which provide movement to the machine. Generally, the two motors are placed opposite of each other and are attached to a wheel.

ICC - Instantaneous Center of Curvature; It is the point at which a car turns.

Activate Range - Both the QTI and Ultrasonic sensors have an activate range. This is the distance a sensor will provide feedback to the control system. The distance on the QTI can be physically changed. This is due to the potentiometer on the QTI sensor, which controls the input voltage for the sensor. On the other hand, the ultrasonic sensor activate range is controlled through the control system. Therefore, the range can be coded to any length between the range of distance the ultrasonic sensor is capable of reading.

IV. PROJECT PROCEDURES

A. *Experimental Details*

For this project, our goal was to replicate the cat and mouse behavior. We originally wanted the cat to work by pathfinding the mouse and the mouse to navigate the maze with ultrasonic sensors but due to time constraints we were not able to implement the systems like that. For the construction of the robots, each robot was built by different groups, and thus the parts and implementation of each bot varies.

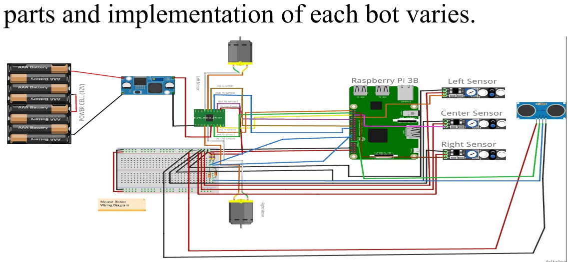

Figure 1: Mouse Bot Wiring Diagram

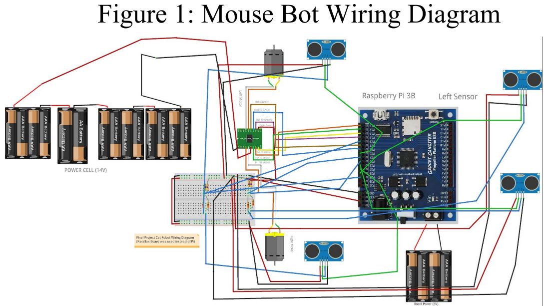

Figure 2: Cat Bot Wiring Diagram

The control systems are similar in design but different for each of the two robots. While the cat bot used a Parallax WX Activity Board, the mouse bot used a Raspberry Pi 3, as indicated in Table 1 and Table 2 above. There are a few other differences to the robots like the different power supplies but were not done out of necessity but due to implementation. Wiring Diagram for the mouse bot is shown in Figure 1 and the cat bot's wiring diagram is shown in Figure 2.

Due to the nimbleness needed to emulate cat and mouse behavior, the two robot cars are built on differential drive systems. A differential drive system consists of two motors in parallel powering a car. Table 3 shows how the differential drive works.

The rate of change in direction depends on the speed of the countering action. For example, if the cat bot needs to immediately turn right. The left motor will continue to rotate in a forward direction and the right motor can rotate in the opposite direction or the right motor can stop rotating. These actions will make the cat bot perform an immediate right turn. However, if the right motor was rotating at a slow revolution than the left motor. The cat bot will perform a right turn but at a slower speed as the ICC is farther out from the cat bot. The ICC of the cat bot when it makes an immediate right turn is the center of the right wheel.

TABLE III
THE STATES OF A DIFFERENTIAL DRIVE

States	Explanation
Both motors are rotating in the forward direction	This will move the car forward.
The left motor is rotating in the forward direction but the right motor is rotating in the opposite direction	This will make the car ------perform a right turn.
The right motor is rotating in the forward direction but the left motor is rotating in the opposite direction.	This will make the car perform a left turn.
Both motors are rotating in the backwards rotation.	This will move the car backwards.

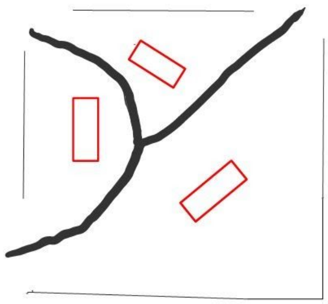

Figure 3: Maze Design

The maze design used is shown in Figure 3 with the obstacles in red and the thick black lines in the maze being the black tape for the mouse's path. For testing and demonstration, the mouse bot and cat bot are placed in a said maze in Figure 3. The cat bot's role was to simply hit/catch the mouse bot. The mouse bot's role was to traverse the maze and find itself out of the maze. In practice, the cat was not aware of where the mouse is, and aims to go to the nearest object in the hopes that the object it hits was the mouse. For the mouse, we implemented navigation through line following - we put black tape throughout the maze and the robot can find its way out using QTI sensors attached to the front of the car.

QTI sensors are short range infrared light emitters and sensors. The sensor will output an IR light and the sensors will receive a digital signal of 0 if it detects a non-reflective surface. Since the maze has a black tape path, which was a non-reflective material, it will provide the necessary feedback to the sensors which will allow the robot to go out. In addition to the QTI sensors, the mouse bot was also equipped with an ultrasonic sensor. The mouse bot will use the ultrasonic sensory data to stop moving if it senses anything in front of it. In this case, if the mouse bot detects the cat bot when it was in front of it, the mouse bot will stop moving until the cat bot was out of the activate range of the ultrasonic sensor which will signal the mouse bot to move again. We also had a mode for the mouse that allows us to control the mouse through the Pi wireless capabilities.

The cat bot also uses ultrasonic sensors. Two sensors in the front and one on each side of the bot. The cat will begin to move in the direction of the nearest object. This means if the cat detected an obstacle in the maze first, it will begin to move towards it. However, if the cat bot detects anything closer, it will change its direction to the nearest object. Since the cat's goal was to catch the mouse, the cat will have to travel along the maze. However, it was impossible since the cat was incapable of detecting the black tape which was used by the mouse to navigate. Figure 4 shows the mouse robot while Figure 5 shows that cat robot.

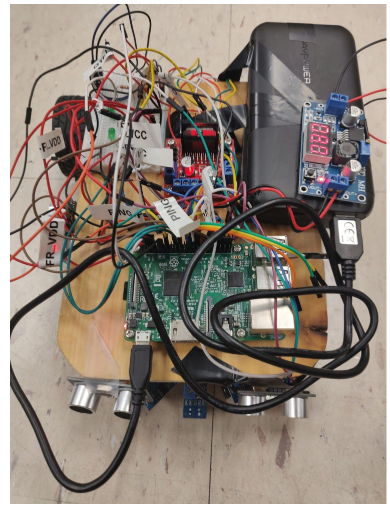

Figure 4; Mouse Robot

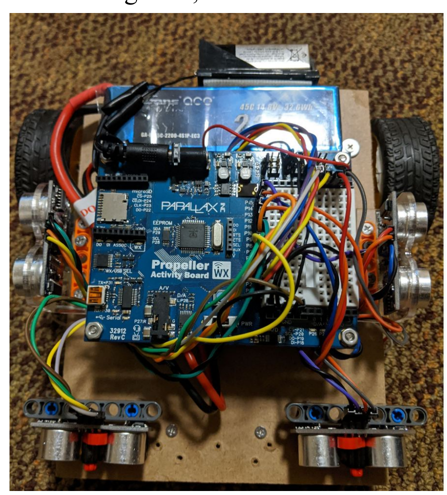

Figure 5: Cat Robot

V. PROJECT FINDINGS

A. Results

[FIRST STRIKE.mp4]

[user_demo.mp4]

Two demonstrations were done. The first demonstration was to show the cat working successfully and the mouse in its autonomous mode. During the demonstration, the cat runs its algorithm to run to the nearest object and the cat bot successfully caught the mouse bot.

The second demonstration was to show the user control mode and to show the cat not working successfully. The mouse bot successfully avoided the cat and exited out the maze.

VI. CONCLUSION

Trying to replicate actions and roles found in nature was a difficult task to take on. However, by observing and simplifying the action, nature's role can be replicated and applied with ease to the robot cars. This project reflects such observations and implementations to a certain accuracy. Because of the simplification of the actions covered by the cat bot and mouse bot, it does not reflect the actions of a cat and mouse found in nature. The goal for the project was to replicate a cat capturing a mouse and the mouse trying to avoid capture. A visual demonstration can be seen in the link below.

Demo Video of Mouse Capture
https://drive.google.com/drive/folders/17rV9WMjB8mJcbn_jgieVNMQelAcDGj2j?usp=sharing

VII. REFERENCES

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