A(maze)ing Robot Navigation

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Introduction

Robots are everywhere—from automatic vacuum cleaners in your home to self-driving cars on the road to delivery robots in warehouses. As robots become more integral in daily life, finding ways to improve upon the self-navigation of these machines is a highly necessary task. A self-navigating robot must be efficient, with little prep work and the ability to reach destinations quickly and reliably. The goal of this study is to find the ideal method of self-navigation among existing methods using the Boe-Bot.

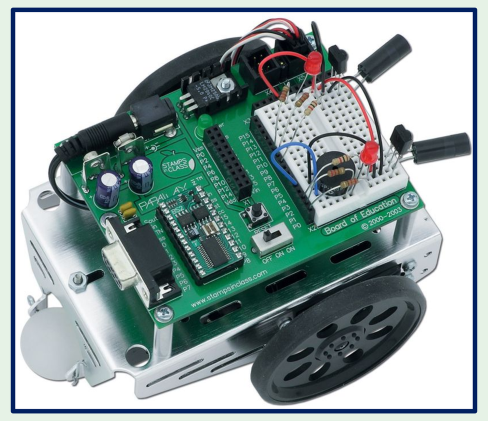
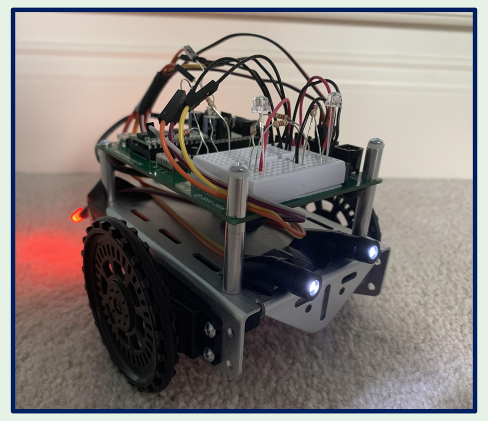



Figure 1 *and* ***Figure 2****: Examples of Boe-Bot*

Navigation Techniques

Dead Reckoning

- Follows a fixed route based on pre-programmed movements.
- No intelligent systems or sensors involved.

Whiskers

- Operates by detecting frontal collisions with obstacles to make necessary corrections to movement.
- No user input required.

Phototransistors

- A user guides the robot through an environment by shining light on light-detecting sensors in varying manners.

Infrared (IR) Sensors

- The proximity detection of obstacles using IR transmitters and receivers enables to robot to navigate itself through an environment.
- No user input required.

Remote Control

- The user controls every movement of the robot
- A universal remote is programmed and the control pressed tells the robot where to navigate.

Materials

- Parallax, Inc.'s Boe-Bots
  - The robots used to carry out the experiments.
- BASIC Stamp Editor Version 2.5
  - Software used to program Boe-Bots
- Parallax BASIC Stamp Module
  - Programmable microcontroller utilized in the Boe-Bots
- Electrical Components
  - Resistors, wires, LEDs, servos, sensors, universal remote

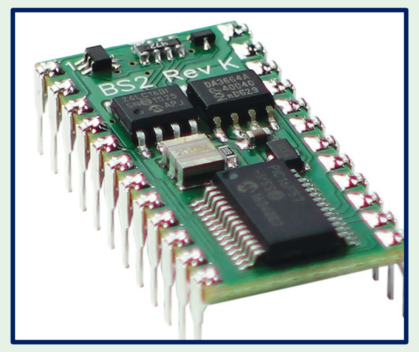


Figure 3*: BASIC Stamp Module*

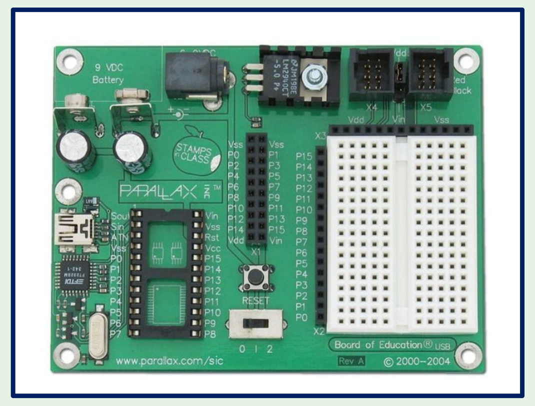
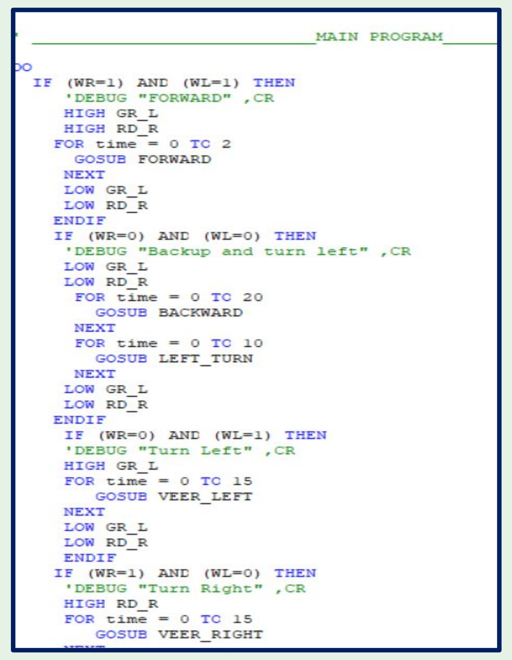


Figure 4*: Boe-Bot Circuit Board*



```
'______________________________MAIN PROGRAM______
DO
 IF (WR=1) AND (WL=1) THEN
   'DEBUG "FORWARD" ,CR
   HIGH GR_L
   HIGH RD_R
  FOR time = 0 TC 2
    GOSUB FORWARD
   NEXT
   LOW GR_L
   LOW RD_R
  ENDIF
  IF (WR=0) AND (WL=0) THEN
   'DEBUG "Backup and turn left" ,CR
   LOW GR_L
   LOW RD_R
    FOR time = 0 TC 20
      GOSUB BACKWARD
    NEXT
    FOR time = 0 TC 10
      GOSUB LEFT_TURN
    NEXT
   LOW GR_L
   LOW RD_R
  ENDIF
   IF (WR=0) AND (WL=1) THEN
   'DEBUG "Turn Left" ,CR
   HIGH GR_L
   FOR time = 0 TC 15
      GOSUB VEER_LEFT
   NEXT
   LOW GR_L
   LOW RD_R
   ENDIF
  IF (WR=1) AND (WL=0) THEN
   'DEBUG "Turn Right" ,CR
   HIGH RD_R
   FOR time = 0 TC 15
      GOSUB VEER_RIGHT
```

Figure 5*: Example of whiskers program*

Methods

- Boe-Bots were used to test which navigational technique would be most efficient in performing various functions.
  - The Boe-Bots have a coherent circuit board that can be wired for different tasks.
- Five navigational forms were selected: Dead Reckoning, whiskers, phototransistors, IR sensors, and remote control.
- 8 unique mazes were then developed as navigation courses for testing each method except Dead Reckoning, which was tested on simple linear paths.
- The times taken to traverse the mazes were recorded, documented, and compared to see which navigational form was most efficient.

Figure 6*: Example of Maze*

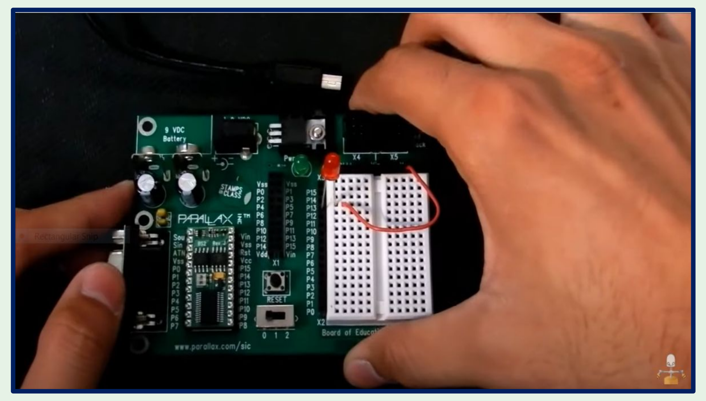


Figure 7*: Wiring of the Boe-Bot breadboard*

Results

Dead Reckoning

- Was capable of navigating predetermined paths such as the perimeter of a square and triangle.
- Proved to not be very versatile due to the inability to automatically adapt navigation in different environments/paths.

Autonomous Navigation

- Neither whiskers or the IR sensors were clearly shown to be more efficient than the other.
  - Performance depended on each specific maze setup.
- Other factors included the positioning of the sensors, the current applied to the IR transmitters, and the timings of the movements.

User-Controlled Navigation

- The remote control and phototransistor navigation were quite comparable in their efficiencies.
- The phototransistor's performance was strongly influenced by the strength of the light source used.

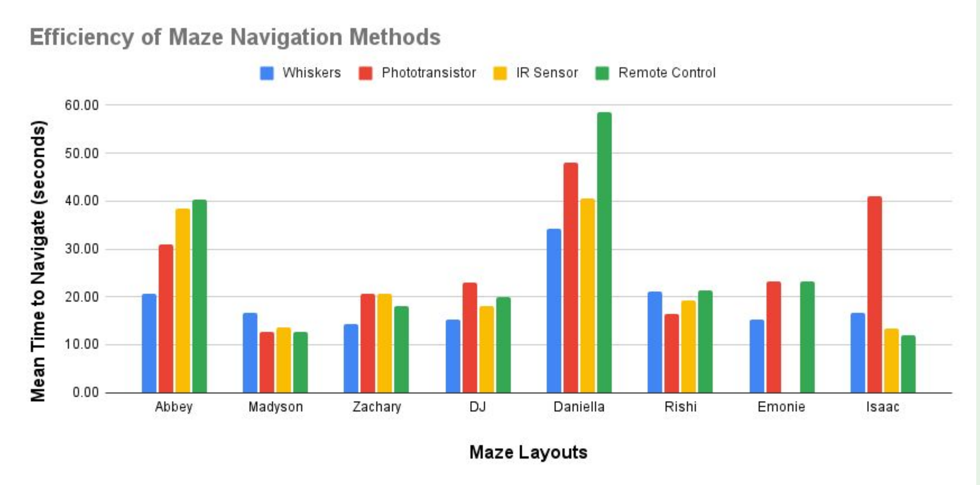


Figure 8*: Efficiency of Maze Navigation Methods*

Conclusions

- User error is a notable variable in user-controlled navigation.
- Due to the differences between the courses, one ideal method is not possible within the different techniques used for this experiment.
- Overall, certain navigation techniques work better with certain obstacles. From the efficiency graph, it can be concluded that there is no navigation technique that is superior for all courses.

Acknowledgements

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