Analysis of Mechanisms for an Autonomous Robot that has the Capability to Extinguish Two Target Lights.

Dr. Siva Thangam, Professor Joseph Miles, Mohammad Fardos, Sandeep Singh.
Stevens Insititue of Technology

Background

The usage of autonomous robots in the pursuit of space exploration has developed dramatically, recently, by complex autonomous robots such as RAVEN and the Mars Rover. However, complexity arises from simplicity. The Arduino Microprocessor is a common robotics platform capable of integrating the operations of the robot via light sensing photo sensitive resistors. This basic level of innovation is applicable to a more complex autonomous robots. The objective of this research is to develop a deeper understanding of the mechanisms of an Arduino based autonomous robot by extinguishing two target lights in a 4' x 8' arena in under thirty-five seconds. The stadium consists of two territories, white and black, which contain unique obstacles that challenge the capabilities of a simple autonomous robot.

Discussion

The autonomous robot was primarily constructed from plastic, screws, and string. This allowed for accuracy, while maintaining the integrity of creativity. Various screw sizes were used to hold together the robot as a whole. Trial and error was prevalent for hardware construction, since original ideas had to constantly change due to errors in judgement during the conceptual design phase of the project. The main components for electrical engineering were the Arduino Board and the Floor Sensor Module (FSM). The FSM was used to scan and record the voltage of the light reflected from the ground using photosensitive resistors attached to the Arduino's analog ports. This reading allows for the robot to determine whether the robot is on a black or white floor letting the robot differentiate between "home" and "enemy" territory. A low voltage reading means the robot is on a white floor whereas a high voltage indicates a black floor. The software for the autonomous robot was programmed using C++. This was done using the Arduino Integrated Development Environment (IDE). While other IDE's do exist, the Arduino was utilized due to it being geared towards electronic prototyping. Before any code was written, C++ code libraries were imported in order to access predefined functions, additional resources, an increase in efficiency, and a decrease in the amount of time needed for coding. Despite the code remaining constant when the robot is active, the robot itself has been programmed in such a way that it adapts and utilizes different aspects of its code according to various nuances in its environment. This was observed in the 4' x 8' arena containing obstacles that demonstrated the robot's responsiveness and adaptability. The robot will be tested to observe whether it is capable of extinguishing two target lights in under thirty-five seconds. The autonomous robot is best described as an intelligent adaptive robot, capable of recording information and responding accordingly due to its C++ code.

Abstract

Autonomous robots possess the ability to undertake a variety of tasks with regards to their environment. The Arduino is a common robotics platform that is capable of utilizing analog sensors to convert their input into voltage. Therefore, it can accommodate a photo sensitive resistor to implement light sensing capabilities. The Arduino serves as a model "organism" for more complex robots because of its simplicity. To obtain a deeper understanding of the mechanisms of such a robot, an Arduino controlled autonomous robot was constructed for the mission of extinguishing two target lights in under thirty-five seconds. The experiment was held in a 4' x 8' arena which was divided into white and black territory. The arena tested the Robot's mechanical, software, and electrical capabilities, while maintaining its integrity. By testing the autonomous robot's capability in a 4' x 8' arena, practical applications were able to be visualized

Results

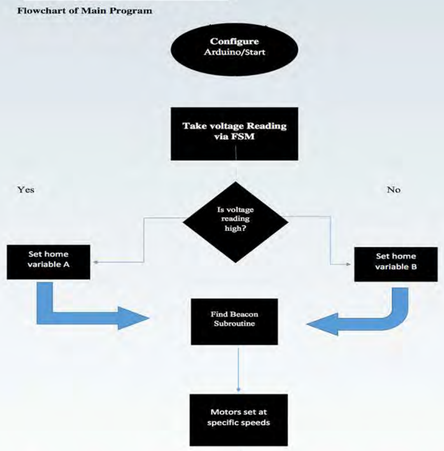
Robot Enemy Target Light Locating/Obstacle Avoidance Subsystem

Goal: Identify the Conceptual Design with the Highest Probability of winning the robot competition (45 sec. to extinguish both target lights)

		Four Alternative Designs							
		Ant Arms		270		Straw		Claws	
Number of Bumpers		2 Bumpers		2 Bumpers		2 Bumpers		2 Bumpers	
Shape of Bumpers		Pincer-Shaped		Rounded-270		Backwards U-shaped		Pointy - Front Split	
Placement of Bumper Switches		Bumpers		Bumpers		Bumpers		On Body	
Number of Target Light Sensors		2: 1Lt, 1Rt		2: 1Lt, 1Rt 3 in. above roof		3: Lt, 1Rt, 1Middle 3 in. above roof		3: 2Front, 1Rear 3 in. above roof	
Height of Beacon Sensor		On Roof							
Any other parameter you think is important				Non-curved beacon lis					
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score
Teams chose own acceptance criteria									
competitions)	5	7	35	7	35	5	25	5	25
Doesn't confuse the navigation light with target lights	15	5	75	5	75	8	120	5	75
Minimal impact on software complexity	15	7	105	7	105	5	75	5	75
Crosses from Friendly to Enemy Territory in 15 seconds	10	6	60	4	40	9	90	4	40
seconds	25	6	150	6	150	8	200	5	125
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	6	120	6	120	8	160	5	100
Doesn't cross back to friendly territory after crossing into enemy territory	10	7	70	7	70	5	50	3	30
Total Percentage =	100%		615		595		720		470

Conceptual Design

4'x 8' Arena



"The Last Straw"

Flowchart of Main Loop Program

Expermental Design

- An alternative design matrix was used to trade off four conceptual designs and mathematically determine the optimum robot to be built.
- The Arduino Integrated Development Environment was used to program the autonomous robot in the C++ language to execute a variety of functions.
- A Work Breakdown Structure and Gantt Chart was utilized to keep up with the extensive amount of tasks to executed while simultaneously maximizing productivity.
- A flowchart was used as a method of planning the software implementation.
- An arena, 4' x 8' in size, was used to test the autonomous robot's capabilities in a competition.
- A band saw, scroll saw, drill press, and sanding machine were used to construct the mechanical structure of autonomous robot.
- Dropbox was used to effectively share various documents with one another

References/Acknowledgements

Sponsors

National Aeronautics and Space Administration (NASA)

NASA Goddard Space Flight Center (GSFC)

NASA Goddard Institute for Space Studies (GISS)

NASA New York City Research Initiative (NYCRI)

Stevens Institute of Technology (SIT)

Contributors:

Prof. Joseph Miles

Dean Siva Thangam

Mohammad Fardos (Undergraduate)

Sandeep Singh (HSS)