Sonny Side Up

Mars Rover Project

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Project Members:

- **Black Belt -** Jared
- **Green Belt -** Anish, Peter, Quinton, Mrinal
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- **Champion -** Professor Starr

Abstract:
This project involves the development, building, and operation of a prototype Mars Rover. The rover is designed to navigate a course that simulates the terrain found on Mars. This course includes traversing level ground and features a 45° incline. The success of the prototype is determined by its ability to follow the designated path and traverse the incline. This document provides details about the methods used in creating the rover, discusses challenges encountered during its development, and presents the results of testing. These results showcase the capabilities of the prototype and highlight its applications in exploring extraterrestrial environments.

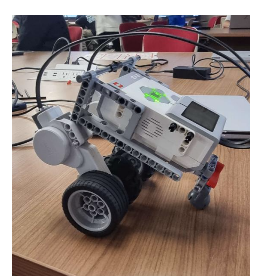
Intro:
The main goal of this project is to create an EV3 rover. This environment includes challenges such as staying within designated lines, climbing steep 45-degree inclines, and moving in a square pattern. The following sections provide an account of the steps taken starting from the design concept all the way to the practical implementation and testing phase of the rover. This comprehensive process results in a prototype ready to accomplish its predefined objectives.

The rover uses code written in the MicroPython programming language to dynamically self-correct its course. The rover's code is uploaded to the EV3 brick and gives the rover specific instructions.

Six Sigma is a program designed to increase quality and efficiency in a system. Six Sigma defines eight dimensions of quality, and uses an iterative process to increase those aspects of a process. Originally created by Mikel Harry at Motorola, the Six Sigma process has been used in industry for over 40 years.

Method:

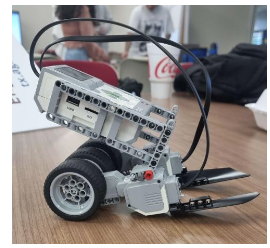
Initial Design:



The rover was initially assembled with two motors affixed to the front to drive the wheels and a ball bearing mounted at the rear for support. This configuration was tested on an inclined ramp; however, the ball bearing failed to provide sufficient traction to ascend the ramp. This rover was hard-coded for a specific course, following individual commands such as “travel 2 meters forward”

Second Iteration:

To address the traction issue, two additional motors, along with wheels, were integrated into the front of the rover. This addition provided the needed force to scale the ramp successfully, but the cost of the extra motors exceeded the budget constraints and proved extremely difficult to program.

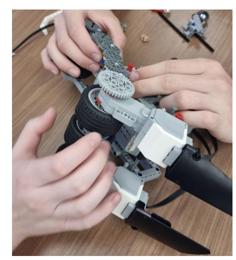


Third Iteration:

The design reverted to the original two-motor setup. To improve the rover's guidance without a significant cost increase, two black plastic fins were installed at the front. These fins served as guides to facilitate the rover's climb up the ramp.

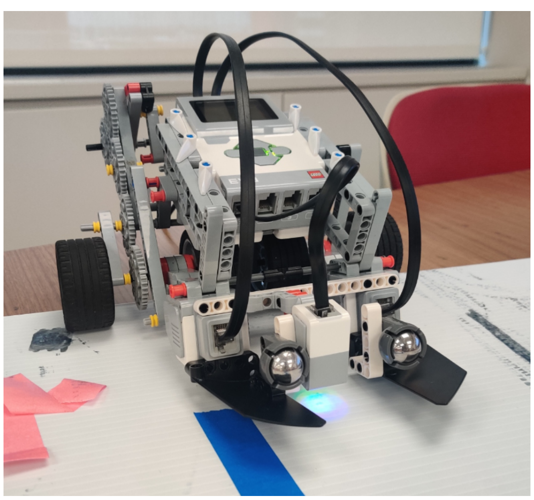
Fourth Iteration:

Despite the guidance improvement, the rover still lacked the necessary power for the ascent. A third wheel was added to the rear, and a makeshift connection using a rubber band was employed to link this new wheel to the front motor. This prototype proved the concept, despite the rubber band not being an official building material and causing issues with steering.



Fifth Iteration:

The rubber band was replaced with gears provided in the kit to mimic the successful prototype. Although the rover was now capable of climbing the ramp, issues with drift and turning precision were observed during maneuvers. At this point hard-coding was abandoned due to previously stated issues and general lack of precision.



Final Iteration:

Weights were added to the front guides to help set the rover back down on two wheels after scaling the incline. This helps with turning purposes as the rear wheel was attached to the same motor as one of the front wheels.To refine the turning capabilities, a light sensor was incorporated into the rover's design. The sensor allowed for more precise navigation and improved the rover's ability to complete the designated course with accurate turns. The color sensor was integrated into the programming aspect of the rover.

In each iteration, the logic and variables used in the programming of the rover were modified to accommodate the physical changes in design. The improvements in traction, power, and navigation were documented and informed in the subsequent iterations.

Results and Analysis:

The final iteration of the robot was far more successful than the first iteration. The robot was able to traverse nearly any flat terrain without issue using a blue painter's tape as a guide line. Additionally, there was significant improvement traversing the 45 degree inclines. However, issues with the inclines were repeatedly present. Despite repeated attempts and configurations, the robot was not able to consistently traverse the ramp successfully. The EV3 brick and motors are not powerful or precise enough to consistently scale a 45 degree incline. Additionally, the rover slides uncontrollably down the opposite 45 degree incline.

The rover was incredibly consistent on flat surfaces, but its performance varied wildly when traversing inclined surfaces. In the future, this inconsistency could be solved by stronger and more precise equipment, a design more able to follow lines up slopes, and/or a more gently inclined slope. Despite the inconsistencies encountered both on and between the ramps, the rover successfully completed the yellow course after minor adjustments to navigate the proper angles after each incline and decline, showcasing its adaptability in overcoming these challenges.

Dimension of Quality	Description
Performance	The rover's performance improved, moving more easily through the green and yellow courses.
Features	The rover gained new features, including steering skids, a gear system, and a color sensor.
Aesthetic Appeal	The robot's aesthetic appeal improved, moving from a kind of blocky shape to a more appealing streamlined shape.
Conformance	The rover's workmanship improved as it was constructed with increasing levels of skill and prowess.
Reliability	The rover became more reliable, staying within the courses more accurately and more consistently.
Durability	The rover became more durable, and it's possible to repair individual parts rather than reconstructing the entire robot.
Serviceability	The rover is innately serviceable, as it is possible to partially deconstruct it to replace batteries or other parts.
Perceived Quality	The rover's brand image improved with the project name and logo.

Python Program Planning:

The first step is to import a variety of modules related to the EV3 Brick, including:
from pybricks.hubs import EV3Brick
from pybricks.ev3devices import Motor
from pybricks.parameters import Port
from pybricks.robotics import DriveBase
from pybricks.ev3devices import ColorSensor
from pybricks.parameters import Color

Next, the variables are initialized:
ev3 = EV3 Brick
left_motor = Motor plugged in to Port B
right_motor = Motor plugged in to Port C
robot = Drive base program using left_motor and right_motor
sensor = Sensor plugged in to Port 1

Next, the settings are initialized, including top speed and acceleration.

Finally, a while loop with an if-elif-else statement is initiated: if the color sensor reads blue, the vehicle veers left; if the sensor reads yellow, the speed and power are increased for ramp ascent; otherwise, the vehicle veers right.

Conclusion:

In conclusion, the Six Sigma process was a success. The rover improved in all eight of the Six Sigma Dimensions of Quality. During each step of the process, the rover was assessed in terms of the five steps of the Six Sigma process: define, measure, analyze, improve, and control. Although the final rover was not perfect, each step was a significant improvement over the previous step and the rover reached the highest possible state of excellence with the given time and materials.

Resources & Appendix:

1. References/Bibliography:

“Getting Started with LEGO® MINDSTORMS Education EV3 MicroPython —

Ev3-Micropython 2.0.0 Documentation.” *Pybricks.com*,

pybricks.com/ev3-micropython/index.html.

2. Schematics and Diagrams:
- Initial Prototype Drawing (reload if you receive an error)

3. Materials List:

- Total Cost: $2,735,850
- Materials List (reload if you receive an error)

4. Software and Code:

- MicroPython is a programming language that's sourced and based on Python 3. It has been specifically developed to run on microcontrollers such as the EV3. The logic of the rover was programmed using MicroPython taking advantage of its syntax and libraries, for integrating sensors and enabling movement.
- Final Code w/ Comments
- Green Course Code
- Yellow Course Code (Hard Coded)
- Yellow Course Code (Sensor)

5. Videos:

- Final Video
- Individual Videos

6. Contributors:

- Mrinal Rebello
- Anish Yakkanti
- Peter Hansen
- Jared Grimes
- Quinton Bowling