

Lego Mindstorms Intergrating Project

by Richard Warwick

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Lego Mindstorms project

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Introduction

"Lego Mindstorm EV3" is an application for windows or Mac OS that allows a user to program a Lego robot through USB, Bluetooth or via Wi-Fi. The EV3 robot can also be programmed using Python. Mindstorm EV3 uses a "brick" that has 8 ports, 4 for motor controls and 4 for sensors. The mindstorm pack used for this project was the educational EV3 core set. In this task the practicality of the EV3 Mindstorm robot will be displayed by completing a set of 3 tasks. This assignment was to be completed in groups of 3. In this team were Richard Warwick (1809026), Paul Newman (1805494) and Ross Shaddick (1803900). First of all the team set out to build a robot, after a small discussion it was decided that a tank would be a good option for this task as the team wanted to be different to the other teams. The tank consisted of the Lego brick, with two tank treads attached to a motor each. A frame was then built around the brick using the Lego components supplied in order for the sensors to be added to the robot. With the robot complete the next step was to discuss the challenges that the task laid out. These challenges are stage 1, stage 1.1 and stage 2. Stage 1 is to use a sensor to follow a guidance tape that is laid out along the floor. Stage 1.1 was to navigate a blockage that is on the route of the guidance tape. The final stage of the task sees the team using an ultra-sonic sensor to navigate a maze. The following report will document the teams' progress and also see how any problems were overcome whilst completing the task.



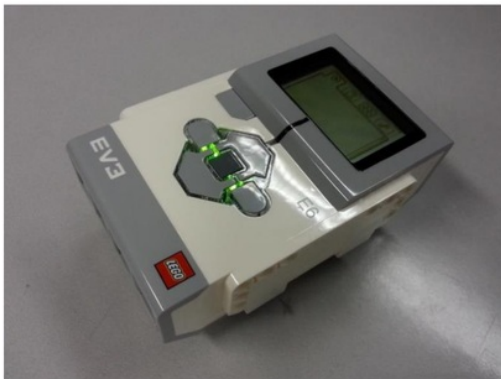
[2]

Research

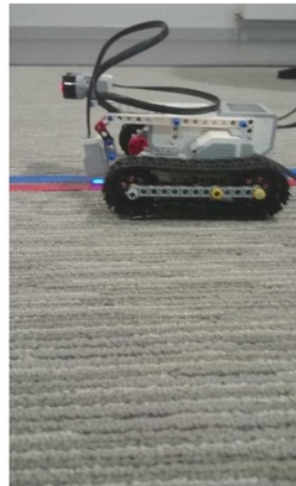
In order to solve the 3 challenges and complete this task the team had to get familiar with Lego Mindstorms EV3 programming application. In order to do this the team downloaded a PDF [3] with the basics of the programming using the mindstorm application. Pages 8 and 9 are the ultrasonic and colour sensor. After reading the pdf and checking the mindstorm EV3 application the team realised that they did not have the ultra-sonic sensor on the system needed to complete this task. It was then downloaded off the UWTSD moodle site. Page 20 shows how the motors work and how positive and negative numbers will rotate the tracks clockwise and anti-clockwise. As the team chose to build a tank the information on how the tank motors work was found on page 22 of the pdf document.

Building the Robot

The first step in the project was to construct a robot that was capable of completing the tasks outlined in the introduction. The Lego Mindstorm EV3 educational core set came complete with a programmable brick (shown below Fig.2) that would be the brains of the robot. The EV3 brick works by storing pre-programmed data via an SD card. Besides this the EV3 brick can also be programmed by USB data input. It also has Wi-Fi and Bluetooth capabilities. In order to be able to navigate the route set out by the task the brick has to have wheels or tracks attached to it. The team of students decided to build a tank to complete the course. The reason for this was better traction on the carpet and also the fact that with tracks rather than wheels it would move at a slower pace, making it easier to navigate the maze in part 2 of the task. After agreeing that a tank would be more suitable for the task, the team started building the robot by attaching two large motors to the side of the brick. The next step was to attach the tank tracks to the motors. With the tracks and motors in place the Ultrasonic sensor and the colour sensor were then placed accordingly in order to be able to detect the colour of the line for part 1, and to navigate the maize. (This is pictured below alongside the EV3 brick Fig.2).



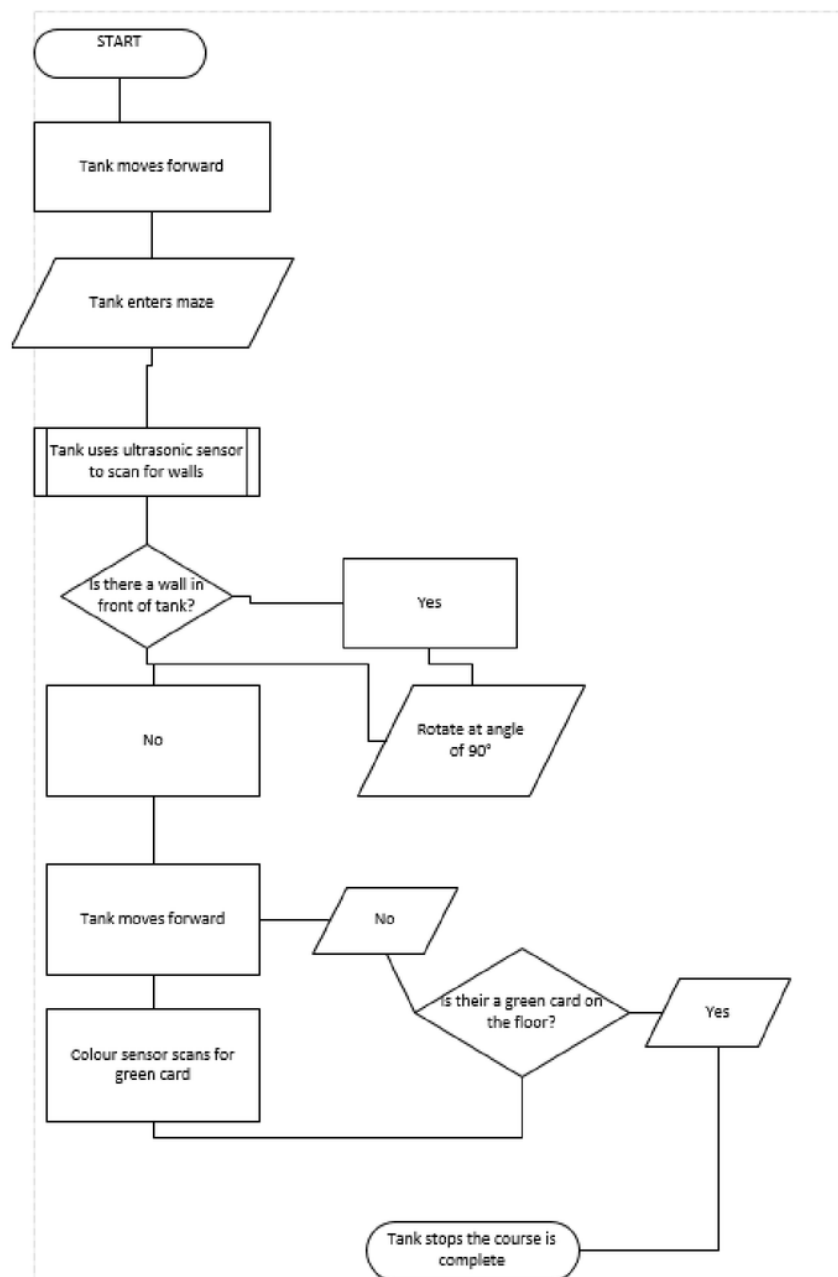
[4]



With the robot functional it was time for a test run to see if the tank tracks were an appropriate choice for the task. In order to complete the task a two stage route was outlined on the floor. This consisted of a red and blue line on paper that meandered before going into a maze. In order to complete this the brick was plugged into a computer to download the program so it could run the script of code to use the sensor and determine an outcome depending on the data read. Lego Mindstorm EV3 windows application was used in order to program the brick.

Flowchart

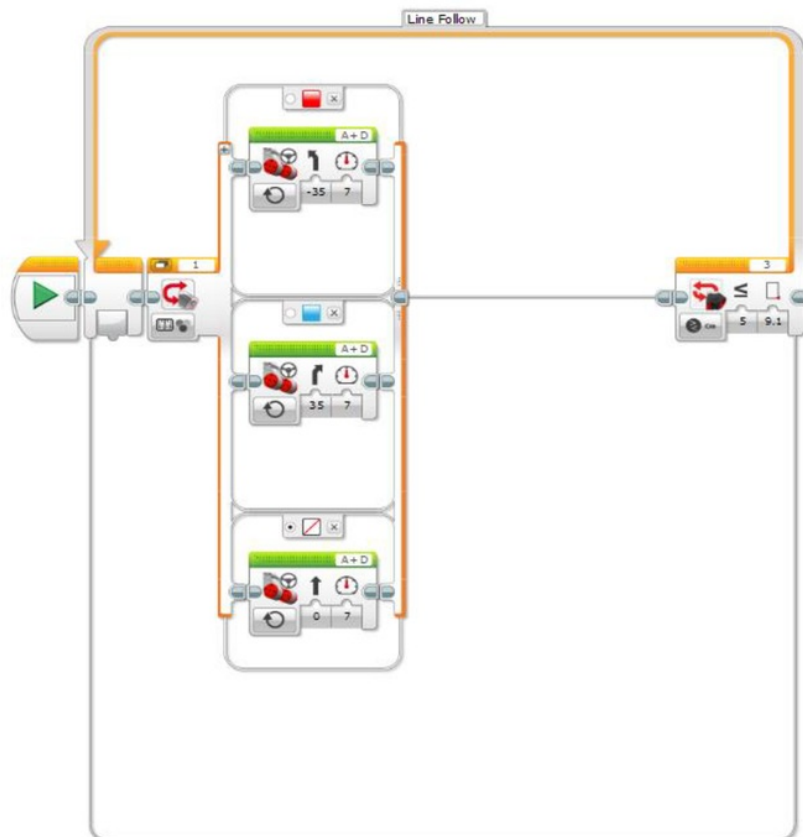
Here is a flowchart to show the decision making plan and process for the maze navigation



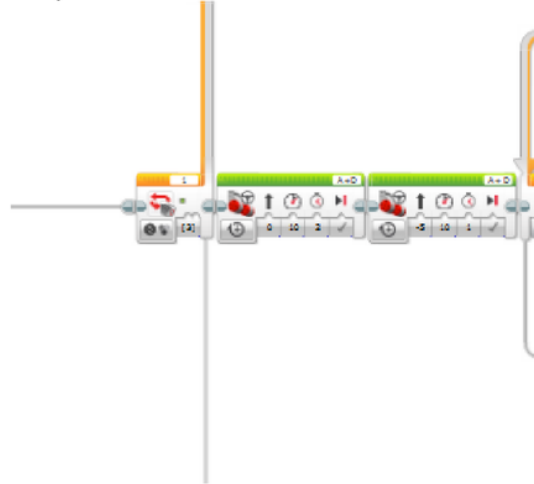
Programming the Robot

Line follow stage 1

The robot was programmed using the Lego Mindstorm EV3 windows application. Shown below is a diagram of the line follow sequence. The line follow works within a loop by using a colour sensor to detect a line on the floor. The code was programmed so that if it detected a red line it would turn right, and if it detected a blue line it would turn left. This meant that the robot would follow the line as outlined in the task brief. There was one slight problem. The tracks that the robot were running on tearing up the paper, so in order to still complete the task the team had a dilemma on their hands. One option would be to rebuild the robot. An easier option was chosen to lay down red and blue tape on the floor in order for the robot to follow the lines on the carpet instead of the paper. This was done as shown below with a wire connecting the brick to the sensors. Colour sensor in port 1, Ultrasonic sensor in port 3. The sensor was coded to pick up 3 colours in the first loop. Red, Blue and White. If it sensed red it had to turn right, if it sensed blue it would turn left and if it sensed white, it would move forward. Ross Shaddick (1803900) took the lead on this section of the task.



At the end of the line follow sequence the robot would have to stop following the line as it was at the end of the lines laid out on the floor. For the robot to recognise this a green card was placed on the floor. When the colour sensor sensed green it was to drive straight forward. This told the robot to move out of the first line follow sequence and into the next sequence. This meant that Part 1 of the task was complete.



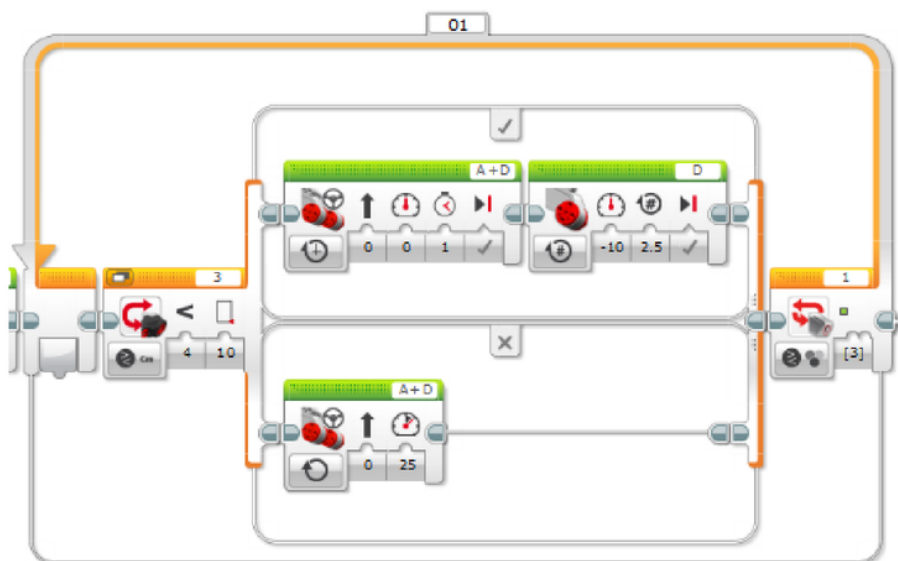
Blockage on route stage 1.1

The next part of the task was part 1.1. Paul took the lead on this stage of the task. Paul set about building a swinging arm on the Lego robot that was attached to a large motor. So that when it came to the blockage in the route, the robot would be able to swing the arm and hit it out of the way. Allowing the robot to carry on route and enter the maze. Below is the large motor that was used to turn the swinging arm. That is operated after the ultrasonic sensor senses an object in the robots path. Once the sensor detects an object in its path the swinging arm will turn at a power of 100 for 1 rotation. Clearing the object out of its way. Paul Newman (1805494) took the lead on this part of the task.



Navigating the maze stage 2

With stage 1.1 complete, the team moved on to the next stage in the assignment. Stage 2 was to program the robot to manoeuvre the maze using an ultrasonic sensor. In order for the robot to navigate the maze Richard Warwick (1809026) took lead on programming this part of the task. As shown below the robot was programmed to use the ultrasonic sensor to scan as it moves forward. If an object is 10cm in front of it the robot would turn. In order to do this one motor that controls track D will rotate backwards, this moves the robot in reverse at an angle of 90° . After moving backwards the robot will then move forward navigating the maze whilst scanning the path in front of it using the ultrasonic sensor. The colour sensor used earlier on in stages 1 and 1.1 of the task was also used within the maze navigation. As soon as the colour sensor detects a green card, the navigation is over and it has successfully worked its way through the maze. The robot will stop. At this point the task is complete. During the execution of this task the team had a couple of issues. One of the motors that operated the left side track of the tank was faulty. At this stage of the task the team had to reconstruct the robot. Another issue also came up with the swinging arm from stage 1.1 interfering with the colour sensor due to the wire connecting the sensor being in the path of the swinging arm. This problem was easily solved using insulation tape. The third and final problem in order to complete the task was the degree of rotations for the left motor of the tank which can be seen below in control of port D. Originally the rotations were at 2, but the robot wasn't able to complete the maze due to one of the corners catching at this degree of rotation. With a bit of trial and error Richard concluded that 2.5 rotations would be sufficient in order to rotate the robot 90° . The final part of stage 2 was to scan a green piece of card, the robot did this. Due to a low battery it was decided by Richard that the tone was to be taken off at the end of the sequence. It was also taken out of the programming code to avoid any confusion.



Conclusion

After completing the task with all three challenges successfully completed it is now time to analyse the results of the task. In hindsight there are a number of things that could have been done differently on each task. First of all, stage 1 of the task in the outline states that the robot should navigate a circular section. Looking back at the task I can see that the team did not do this. The reason for not having a circular section was that the tank would not manoeuvre correctly on the paper course, the tracks would rip the paper up. If this assignment was to be done again it may be a better choice to opt for wheels over tank tracks as the tracks required a far wider turning circle than the wheeled alternatives. Another problem in task 1 was that the lights in the classroom were reflecting off the tape on the floor, this made it hard for the sensor to work efficiently. If this experiment was to be carried out again the problem of light interference with the sensor could be solved by constructing a cover around the sensor in order to prevent the lights on the ceiling interfering with the colour sensor. That would increase the productivity and accuracy of the sensor.

Stage 1.1 of the task required that one the route the robot should follow the line and then negotiate a blockage in the route. The team did this by hitting the blockage out of the way with a swinging arm, but the robot did not leave the line in order to complete this part of the task. It simply just knocked the obstacle out of the way. If the task was completed again the team could manoeuvre around the blockage in order to stay true to the task description.

The final part of the task in which I completed with relative success and even and the challenges were completed with a fair degree of success using the tools available. There were a few challenges to overcome whilst completing task 2. Most of these challenges were to do with the manoeuvrability of the robot. Attempting to manoeuvre a robot around a maize in the form of a tank provided several problems with the turning circle of the robot. A wheeled alternative would offer far more versatility and would be more efficient in completing the task. The smaller turning circle of a wheeled robot makes it easier to code and program.

In conclusion the task was a success, but the practicality of a tank tread based robot definitely came under a lot of scrutiny whilst completing this task.

References

- [1] University of Wales Trinity Saint David Logo (UWTSD, 2019)
- [2] https://proimage.images-bn.com/pimages/0673419193054_p0_v1_s550x406.jpg [Accessed April-2019]
- [3] https://stemrobotics.cs.pdx.edu/sites/default/files/Lego%20Robot%20-%202013EV3Programming_0.pdf [Accessed 2019]
- [4]"Lego Mindstorms EV3", *En.wikipedia.org*, 2019. [Online]. Available: https://en.wikipedia.org/wiki/Lego_Mindstorms_EV3#/media/File:Lego_Mindstorms_EV3_brick.jpg. [Accessed: Apr- 2019].

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GRADEMARK REPORT

FINAL GRADE

57 / 100

GENERAL COMMENTS

Instructor

Report (60%) over all 53

Introduction - 3 /5

limited reference list. there is in text citation but it was not done correctly in most cases. good introduction.

Background research - 8/15

there is evidence of research informed arguments in the document but it is limited in most cases.

Project plan -7 /10

project planing was clear but again was limited and lacked core information.

Design Process - 25/40

the report included a decent information on the design the quality of the flowchart can be improved. and it was very simple. you could have had at least another one for the obstetrical. you could have used pseudo code to help explaining the code blocks.

Evaluation and Results - 10/30

evaluation and conclusion was combined in one section. there was a brief evaluation of the results but not the over all outcome.

Demo (40%) - 62% Overall

Technical knowledge/skill - 12/20

Analytical and problem-solving skills - 12/20

Quality of result - 38/60

Line is being followed, but there are no bends in the line which is a more difficult process. There should be at least one left hand and one right hand bend to demonstrate the skill of turning. Obstacle is cleared, Transition line to maze is made successfully. Maze is followed but you are dependent on the quality of the turn to maintain precise position - you could have a side sensor to mitigate collisions with the wall, particularly if the maze was in a different configuration.

Overall mark for module: 57%

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