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**Integrating Project
(ACHA4008) - Assignment**

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Date

Table of Contents

Table of Contents.....	2
Abstract.....	3
1. Introduction.....	4
2. Research.....	5 - 7
2.1 Hardware.....	5 - 6
2.2 Software.....	7
3. Planning and Designing.....	8 - 9
3.1 Criteria Specification.....	8
3.2 Iterative Design.....	9
4. Assessment of Success.....	10
4.1 Success Criteria.....	10
4.2 Evaluation.....	10
5. Reflection.....	11
References.....	12
Appendices.....	13

Abstract

1. Introduction

As the subject of robotics continue to become more mainstream in day to day life its prevalence is continuing to be felt across all sectors. Robotics continue to drive advancements in society as they can be utilised to perform tasks that are otherwise impossible to conduct solely by humans, the most famous of these tasks being extra-terrestrial exploration by NASA.

LEGO, a worldwide toy manufacturer famous for their unique educative approach, has begun to adopt the use of robotics through the introduction of LEGO Spike, a specialised set of robotics equipment designed to to introduce and educate people about robotics at an early age. Lego Spike has the potential to excel in its intended goal as it introduces students to concepts like programming, logic, engineering, physics and maths as robotics is an applied science meaning it is made of several different subjects working together.

Furthermore, as robotics is an applied science, it requires specialists from the branching subjects collaborating to achieve the desired goal. By encouraging students to engage in teamwork during early development years they will gain key skills in communication, organisation, workload delegation, specialisation and efficiency management which are transferable skills allowing the students to have a higher chance of successfully adapting to future careers where the aforementioned skills are vital.

In the following project, the Lego Spike Robot has been assigned the task of navigating a series of obstacles set in front of it, first starting with travelling along a set line, circumventing a barrier along said line, before traversing through a maze structure until the goal is reached.

2. Research

2.1 Hardware

The Lego Spike project has its own dedicated set of equipment that enables students to engage in multiple disciplines but the students must first analyse the equipment to understand what the function of each component is and how to utilise them.



A publicly available pdf from LEGO (1) and contained in every set is the above overview spreadsheet that lists all of the components within and the quantity of each. For robotics hardware we can see that the set contains:

1x Hub: According to video tutorials related to Spike on the LEGO Education website (2), the hub is a small (rechargeable) battery operated device credited as 'The heart of creative builds'. The hub's base has a 5x5 customisable colour matrix for visual indication of use, a speaker that provide audio feedback, 6 axis gyroscope so that the hub can detect its current orientation, stores up to 20 programs from the LEGO Spike software via Bluetooth or micro USB connection, and 6 peripheral ports where the sensors can be plugged into for operation.

1x Large Motor and 2x Medium Motors: Referring back to the tutorial videos (2), LEGO Spike comes with three rotating motors, the two medium sized motors are compactly designed for small hub builds and lower loads therefore they can rotate at a faster rate. The large motor on the other hand has been designed for larger models providing a higher level of torque and power.

The Spike Prime sensors video on the website showcases the following three sensors.

1x distance sensor: The distance sensor is a device that utilises ultrasound to detect surfaces up to 200cm away with +/- 1cm accuracy.

1x Force Sensor: The force sensor is a button like device that registers up to 10 newtons of pressing force, doubling as a touch sensor.

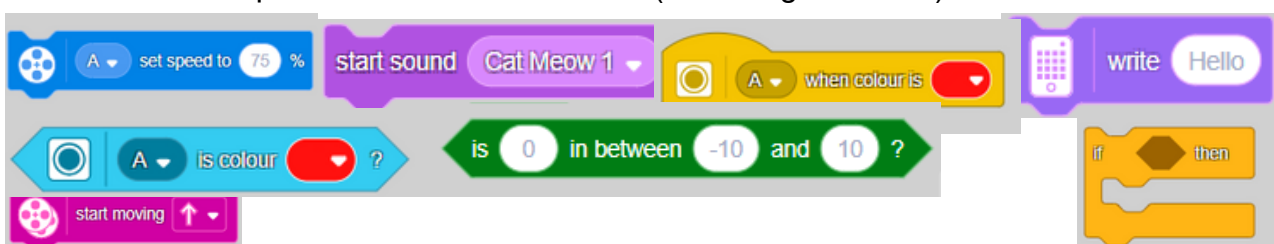
1x Colour Sensor: The colour sensor can detect 8 distinguishable colours and also measures the degree of reflected light from its built in flashlight.

2.2 Software

LEGO Spike's hardware components cannot function without a computer program stored within the hub. Alongside the physical set LEGO has released a free to use software application (3) that is compatible with the hardware. This software provides students with the ability to create programs for Spike in python or a suite of pre-coded icon blocks that are beginner friendly. The blocks suite is broken down into a series of sections for easy navigation. They are:

- **Motors:** This section is where the motors can be programmed a set speed, the duration of motor rotation and whether they should start or stop.
- **Movement:** This section provides options to set which ports the motors are plugged into, when to stop or start movement, movement duration and/or distance for and direction of movement
- **Light:** This set of blocks is where the colour matrix can be programmed to display a custom image for visual indication of progress, text messages and pixel brightness
- **Sound:** Custom sounds, volume, and sound duration can be set here
- **Events:** The first of two major program sections, events is where program execution start conditions are scripted and whether the condition is user inputted or a detection from one of the available sensors
- **Control:** The second major section, controls are where loops and if-else condition statements are programmed giving LEGO Spike a series of conditions to follow and decide the best course of action based on the inputted scripts
- **Sensors:** In this section, the parameters of the prime sensors can be defined with distance, rotation, colour detection and light (as discussed in 2.1)
- **Operators:** The operators section is where extra functions can be embedded into control including the use of mathematics
- **Variables:** Variables is where users can introduce their own value and functions leading to an expanded variety of operations with the LEGO Spike robot.

Below is an example block from each section (excluding variables):



3. Planning and Designing

3.1 Criteria Specification

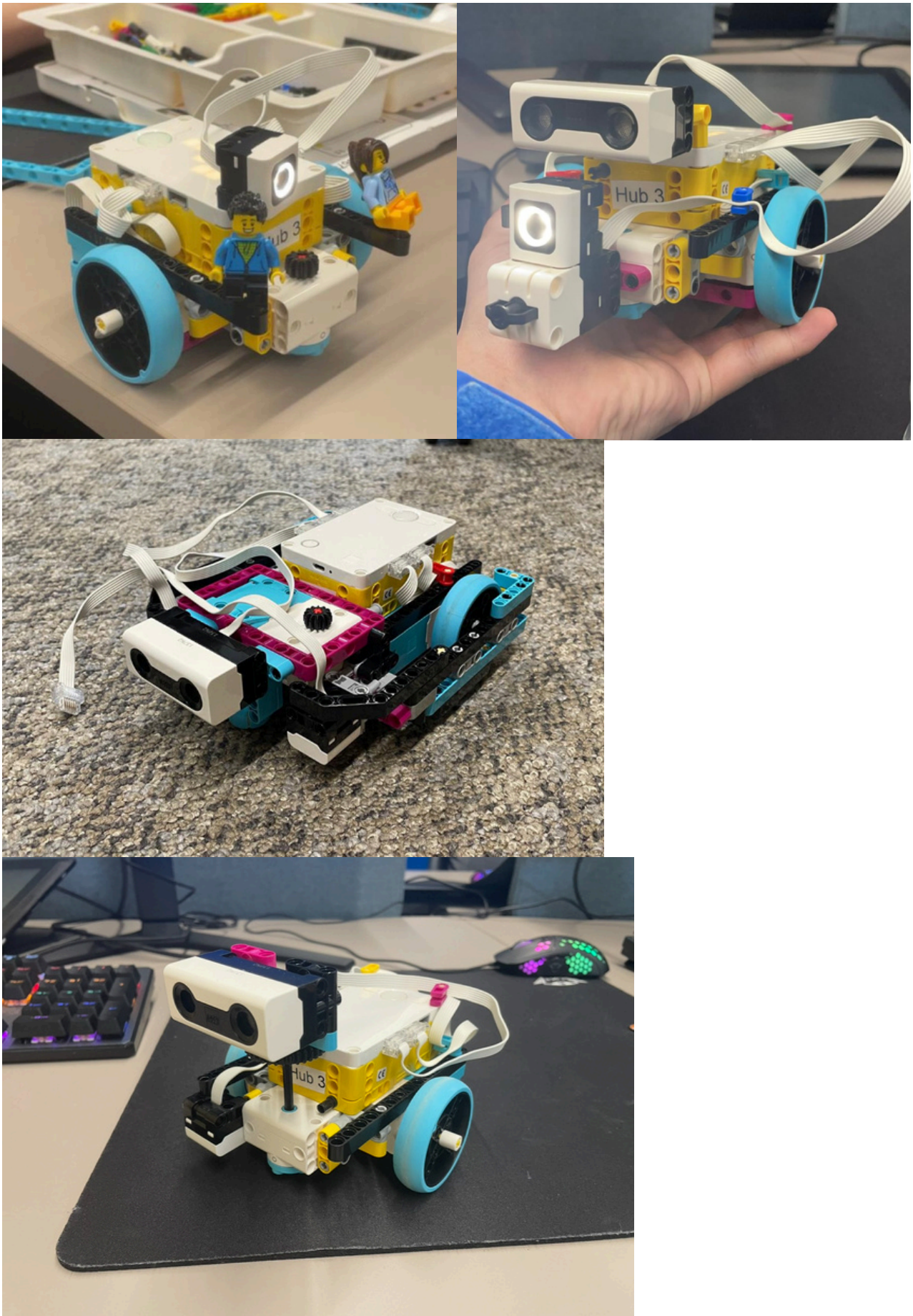
Now that the LEGO Spike kit has been studied in detail we can get to work on how to solve the problem provided in the assignment brief. As stated in the introduction the LEGO Spike robot has been given the task of solving a series of obstacles. Below is a decomposition table explaining each stage and the criteria required to pass:

Section	Pass criteria	Components
0: Movement	The robot must be able to move forwards, backwards and rotate 360*	2x medium motors 1x large motor
A: Following a set line	The robot must accurately follow a provided line by detecting colour	1x Colour sensor
B: Bypassing an obstacle	The robot must be able to move around a detected obstacle at a distance without colliding into it	1x distance sensor
C: Navigating a maze	The robot must be able to smoothly navigate through a provided maze until it detects a finishing line	

The task at hand has been decomposed into 3 distinct parts being:

- Section: This column provides section titles and a corresponding sequential letter
- Pass Criteria: This column provides a brief description of what the robot must do in order to be considered a completion of each section
- Components: This column lists the minimum hardware requirements needed in order to successfully complete the designated section and the tasks that follow it

3.2 Iterative Design



4. Assessment of Success

4.1 Success Criteria

As outlined in 3.1 the robot has a set criteria in order to pass the assessment, on top of this we also need to analyse the success of the program and the structure of the robot. As shown in the final iteration in 3.2 The robot has been given a frontal design so that the distance and colour sensors will detect items in front and can respond accordingly.

The program needs to be able to follow a series of conditions in response to the puzzles initiating varying programs activating the sensors and motors.

4.2 Evaluation

After completion of the demo there were a number of successful and failing factors. In section A the robot has successfully traced the provided line but does not move straight and instead wiggles along the line until the distance condition is met.

During section B the robot successfully detected the obstacle and moved itself around perfectly according to program script. Section C proved stressful as the robot did not align itself upon maze entry leading to inconsistencies between the real world and program script leading to the robot moving off track causing frequent collisions with the maze terrain. However, the distance sensor and large motor did perform as intended and rotated to check for an open pathway leading to successful navigation of the maze.

In future, if the base program included an ability for the robot to self align then it is possible that there would have been no side tracking and therefore no maze collisions.

5. Reflection

After completion of the project there is a variety that can be given deep thoughts on. I've developed an improved ability to analyse robotic components and gain an understanding in their individual functions. Furthermore, I've developed an entry level skill set in structural engineering as its important to make sure the LEGO Spike build is solid.

Throughout the project there was difficulties in the programming as the icon blocks are known to have inaccuracies for degree of rotation functions. On top of this, a limited time frame and limited access to the LEGO Spike resources have hampered effects to refine and improve the designs of both the program and the robot build. The compact design of the robot has been achieved however I felt that the cable management could've been vastly altered. Should a project involving LEGO Spike be done again in future I would take steps to ensure that the physical design is optimised early on as it gives way for more time to be delegated to programming and testing.

References

1. https://assets.education.lego.com/v3/assets/blt293eea581807678a/blt28cad37f1f002fd3/5f8801b982eaa522ca601c89/le_spike_prime_element_overview.pdf
2. <https://education.lego.com/en-gb/product-resources/spike-prime/teacher-resources/video-tutorials/>
3. <https://spike.legoeducation.com/prime/lobby/>

Appendices

