AUTONOMOUS COLOUR SORTER

Technical Report

TEAM 2

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ABSTRACT

This report presents an Autonomous Colour Sorting Robot. It is an example of a simplified solution to waste management. It sorts between 2 colours, black and white and separates them into groups using a mechanical claw. This could be scaled into a machine that is able to collect wate that has been desugared on the floor after falling off a conveyable or alternatively being fed waste on a conveyer belt and sorts it by colour or material, making it a possible solution to waste management.

Glass bottles are an example of a waste material that must be sorted by colour before being recycled. Usually this is done manually using different bins, so we created a system that does this autonomously without the need of human interaction. The efficiency of the waste management process would be significantly improved by using this machine. A robot like this would decreases errors made by humans when recycling making it a more efficient process. This project is a combination of electrical, mechanical, and visual subsystems.

In this report we reflect on the construction, programming and testing of our robot. This report concludes with problems we faced and how we overcame them using the resources we found along the way, peer analyzation, and the help of our lectures.

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1. INTRODUCTION

For this project we were tasked to design and construct a robot that is suitable in solving one of the Sustainable Development Goals (SDG) and utilises Neural Networking. We were given a set of objectives that we had to meet to successfully complete this module. For example, we must consider and raise awareness of ethical issues in engineering. We were supplied with the Makeblock Bot Ultimate 2.0 kit to meet these aims.

The idea settled upon was based off an autonomous waste sorter. After some consideration, we decided this idea might not be feasible due to time constraints and a lack of equipment. Instead, we simplified the idea to an autonomous colour sorter. This allowed us to maintain the core workings of the waste sorter in a simplified way. This project is aligned with the 12th SDG, Responsible Consumption and Production. It improves waste management and resource efficiency by categorising objects based on their colour. This ensure that valuable resources can be recovered and reused instead of being wasted.

This report will focus on the robot's design, its practical application, and its potential environmental benefits which align with the 12th SDG goal.

1.1 Definition of an Embedded System

An Embedded system is a system that works under the combination of both software and hardware to carry out a specific desired task. [1] They provide efficiency, accuracy, and automation. Embedded systems are often used within larger systems and machines.

Embedded systems can work with or without human intervention. They are reliable as they do not frequently change, which makes them very consistent with the tasks they perform. In our case, the hardware is the MakeBlock robot, and the software is the Makeblock coder.

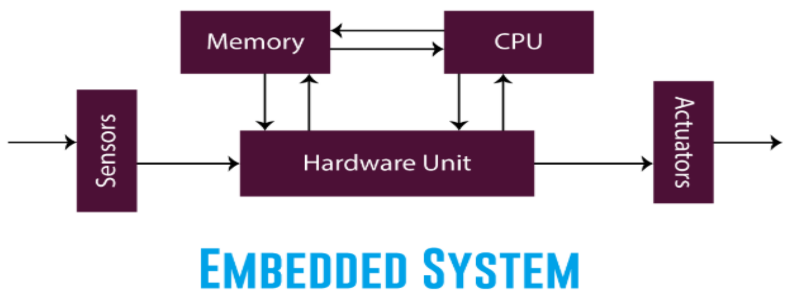


Figure 1 – Example Diagram of an Embedded System

1.2 Definition of Neural Networking

Neural networking is an intelligent program that allows a computer to make independent decisions. [2] It is a branch of machine learning. [3] It uses an algorithm to analyze input data, determine patterns, and produce an output based on an estimate from what it has learned from inputs. It is designed to mimic the human brain. A random number generator is our algorithm. This will generate a number for each colour detected by the sensor and give it coordinates to place it down, this eliminates any mixing of the colours.

A neural network's accuracy will improve over time as it obtains more training through experience. There are three main ways to train a neural network. Supervised learning unsupervised learning, and reinforcement learning.

For our project we were provided a Movidius Neural Compute Stick. This is a deep learning USB plug in device that accelerates the processing rate of the neural network, without sacrificing the accuracy of outputs. [4]

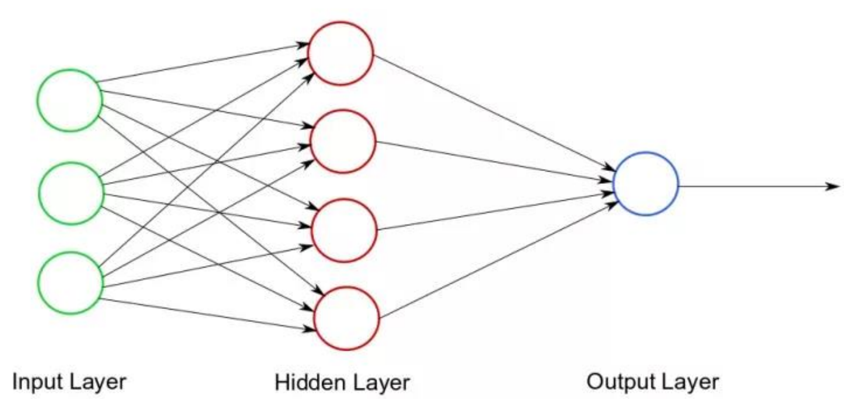


Figure 2 – Example of a Neural Network

1.3 Report Layout

The remainder of this report is structured as follows:

Section 1: An introduction to the project and our main goals, and an outline of how the report will be laid out.

Section 2: An in-depth description of various aspects of the project such as our what a neural network is, parts we used, and how we built and programmed our robot.

Section 3: A walk through of the continuous testing process and improvements we made throughout.

Section 4: A collection of results from our final test.

Section 5: A Literary survey where we outline related examples of our project

Section 6: Our final conclusions.

Section 7: A list of references.

2. MANUFACTURING PROCESS

This section will detail "Components," "Construction of the Robot" and "Programming" of our robot.

2.1 Components

For this project, we were provided with the MakeBlock Ultimate 2.0 Kit. This kit contains different components and materials that gives us the option to choose between 10 different robot models to build. This allowed us to create a robot that suited our needs for our planned project.

The mechanical components we used for our Autonomous Colour Sorter robot are as follows:

- The MakeBlock Robot Gripper – to pick up objects

Figure 3 – MakeBlock Robot Gripper

- 2 Rubber tracks – to allow the robot to move.

Figure 4 – Rubber Tracks

- Plastic gears - to make the robot move

The electronic components we used are as follows:

<u>Me Line Follower V2.2</u> - This module is designed for line following robotics. It has two sensors on the module and each sensor contains two parts – an IR emitting LED and an IR sensitive phototransistor. It can output a digital signal to Arduino so the robot can reliably follow a black line on a white background or vice versa. Detecting range: 1~3cm [5]

Figure 5 – Me Line Follower V2.2

<u>MegaPi</u> - It is based on Arduino MEGA 2560 and supports programming with Arduino IDE perfectly. MegaPi can be divided into 6 function area, allowing you to connect with various plug-in modules to drive motors and sensor and to realize wireless communication. MegaPi has strong motor-driving ability which is capable of driving 10 servos or 8 DC motors simultaneously. It is the ideal option for various robotic projects [6]

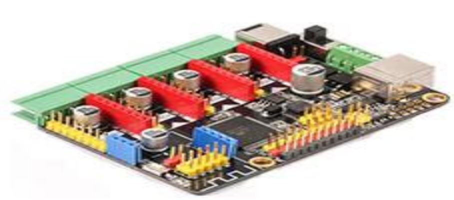


Figure 6 – MegaPi

- Ultrasonic sensor – to allow the robot to detect blocks

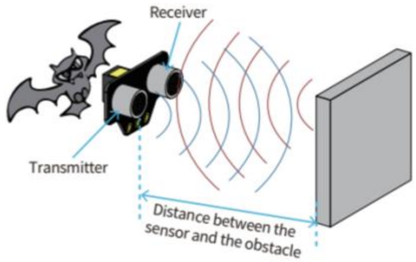


Figure 7 – Ultrasonic sensor

- 2 185rpm DC Encoder motors – for the tracks

Figure 8 – 185rpm DC Encoder motor

- 186rpm DC Encoder motor – for the robotic arm

- Battery pack – to power the motor

2.2 Construction of the Robot

When constructing the robot we opted for an armed tank design. We chose this design as it works best for our project, the small base allows the robot to move swiftly, and the arm attached to the top has good range for picking up the sensed objects.

To do this, we created a frame and attached the tracks to two 9-volt DC Encoder motors with a top speed of 185rmp. We then placed the MegaPi on top of this chassis. When we were testing the sensors on the robot, we decided to mount the ultrasonic sensor onto the front of the chassis. We decided on this as there would be no interference from the robot arm when it was moving up and down and it was in the optimum place.

Finally, we built an extension for the robotic arm, as well as a platform for the battery pack. The arm is connected to a 9-volt DC Encoder motor with a top speed of 86rpm. This would allow the arm to move up and down smoothly. At the end of the arm, we attached the gripper claw to hold objects. The claw is connected to the MegaPi with a wire to allow us to program it.

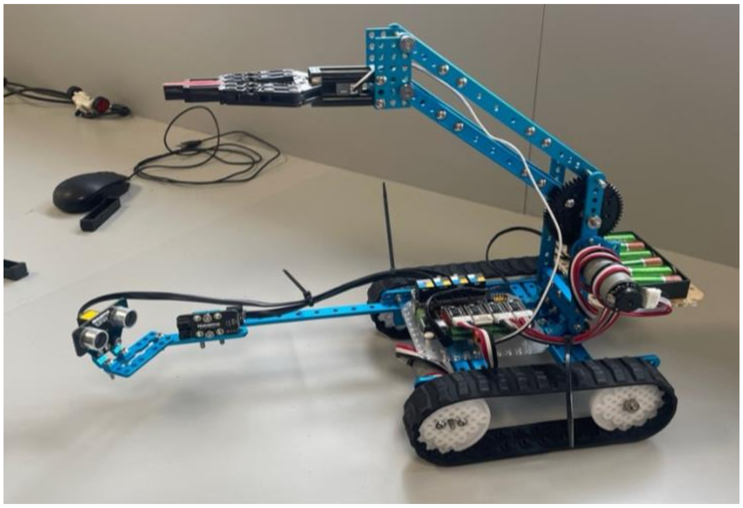


Figure 9 – Final Robot Design

2.3 Programming

Raspberry Pi

The initial plan was to use the Raspberry Pi premium starter kit we were given as our project's computer. However, in the end we decided against using this.

The first step we took with the Raspberry Pi was to get a working camera for the Neural Network to be able to process visuals. We had two options, an aftermarket PIXY camera, or a Logitek USB webcam. We ended up using the USB camera. From there we downloaded the “FSwebcam” package via the terminal [7]. This allowed us to record images with a command, verifying that our camera worked.

Our next task was to download OpenCV onto the Raspberry Pi. This would allow us to run a live stream for the Neural network to recognize objects in real time [8]. This step produced a lot of issues. Having tried many methods of downloading the software, such as with PIP and Sudo apt-get, we kept running into different errors that prevented us from progressing. These errors included runtime errors and wheel errors.

After weeks of trouble shooting, we were still facing problems with the software, and the deadline was approaching, so decided to migrate to a different piece of hardware to carry out the program.

Figure 10 – Raspberry pi

MakeBlock

Makeblock makes creating various kinds of robots simpler using the kit. We were equipped with the mBot Ultimate 2.0, which allowed us to assemble a robot that had functional motors, an ultrasonic sensor, and a gyroscopic sensor. The Ultimate 2.0 is a flagship robot kit Makeblock platform. It contains various mechanical parts and electronic modules, allowing you to build more complicated robots and develop your creativity [9].

We began investigating its possibilities, we started experimenting with various coding techniques on the Makeblock programming tools to see how far we might get in controlling the robot itself.

Figure 11 – MakeBlock kit

3. TESTING

3.1 Testing Accuracy of Ultrasonic Sensor

Investigating the margin of error of the ultrasonic sensor to determine its accuracy.

Equipment: Ultrasonic sensor, LAN cable, Mega Pi board, USB cable, measuring tape, a computer, a flat surface e.g. a wall.

Procedure

Step 1: Connect the ultrasonic sensor to the Mega Pi Board using a LAN cable.
Step 2: Connect the Mega Pi Board to the computer using a USB cable.
Step 3: Open a Scratch file and choose the live mode to see real-time changes.

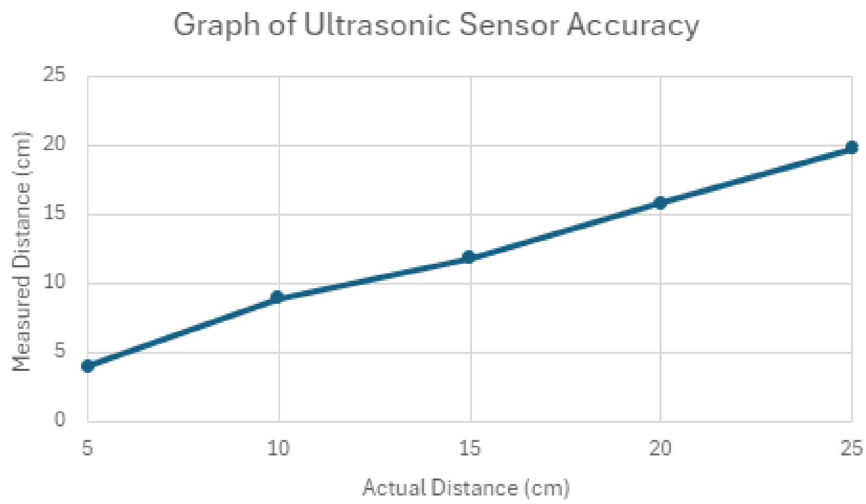
Step 4: Using the measuring tape mark a distance from the wall.

Step 5: Hold the ultrasonic sensor at the marked distance from a wall.
Step 6: Record the distance shown on the screen.
Step 7: Repeat several times.

Results:

Actual Distance (cm)	Measured Distance (cm)
4	3.97
8	8.92
12	11.89
16	15.85
20	19.82

Table 1 – Ultrasonic Sensor Test



Graph 1 – Graph of Ultrasonic Sensor Test

3.2 Testing Distance of Line Follower

Investigating what distance, the line follower can differentiate colours.

Equipment: Me Line Follower, LAN cable, Mega Pi board, measuring tape.

Procedure
Step 1: Connect the Line Follower to the Mega Pi Board using a LAN cable.
Step 2: Hold the Line Follower and place a white object in front of it.
Step 3: Put a measuring tape next to the Line Follower and object to check the distance between them.
Step 4: Slowly move the object towards the Line Follower until the lights at back of the sensor light up. This indicates a colour is detected.
Note: The object should not be black as the lights only turn on when the colour white is detected.

Results:

The Line Follower can detect colour from a distance of 2.5cm.

3.3 Testing Pixy

The Pixy was originally going to be used to detect assorted colours. It would allow us to differentiate between up to 7 colours. The following explains how this is done.

Procedure
Step 1: Plug the Pixy into computer using a USB cable.
Step 2: Open the Pixy Mon app and connect the Pixy.
Step 3: Hold button at the top of Pixy to reset it.
Step 4: Holding up a singular colour in front of the camera.
Step 5: Wait till boxes on the screen are only on that colour.
Step 6: Press button on the back of the Pixy to save that colour as a signature.
Step 7: Repeat to save other colours as signatures.

Results: We were successful in getting the Pixy to identify different colours, however, we were unable to get the Pixy to work with the Megi Pi.

3.4 Discussion of Results

Ultrasonic Sensor: Concluded that this sensor worked well and is very accurate. It is used in this project to detect if an object is present before the Line Follower differentiates the colours. It is programmed to check if an object is within a range of 5 cm, before the claw picks it up.

Line Follower: Although we did not use this component for its intended function, we found an alternative use to suit our needs. However, this meant the range of colours we could detect was limited to black and white. We found from testing that the Line Follower needed to be placed close to the object it is detecting the colour of. We incorporated an extended arm into our robot's design to facilitate this. Now the colour of each object can be detected by the Line Follower before being picked up by the claw.

Pixy: We were eventually able to get the Pixy running and save assorted colours as separate signatures. However, we couldn't figure out how to implement it with our other equipment. Mblock is the software used to programme the Mega Pi Board, but it has no libraries that include the Pixy. Another option was the Raspberry Pi Board, but we also had difficulties getting it to work.

4. ETHICAL CONSIDERATIONS

When starting this project as a group we had to come together to consider the ethical impart our project had on not only the environment but the social impact it would have on society as well. The equipment that was used was provided to us by the college, so the sourcing of the material was out of our hands.

Environmental Impacts

- In the Ultimate MakeBlock kit that was provided it contains aluminium components, which are recyclable. However, to minimise the environmental impact, ensure these materials are properly recycled at the end of the robot's life cycle.
- The electronic components e.g. sensors, motors, and microcontrollers included in the kit can contain rare earth metals or other non-renewable resources. These should be responsibly sourced and recycled to prevent environmental harm.
- The Makeblock kit relies on battery power. To reduce the waste of batteries we used rechargeable batteries. We also assessed the efficiency of the robot's energy consumption to extend battery life and minimize the frequency of recharging or replacement, we did this by switching the robot off when we were not using it and taking out the batteries to limit the power drainage.

Social Impacts

- Improving the efficiency of waste sorting and recycling, the robot can contribute to a cleaner and healthier urban and rural environment. This leads to a better quality of life for people and animals.
- By taking over waste-sorting tasks, the robot can protect workers from exposure to sharp objects, toxic substances, or biohazardous materials commonly found in waste streams. This is a positive impact on the working environments for people and in long term reduces the amount of workplace fatalities and injuries.

4.1 Sustainable Development Goals

For our project, the criteria were that it had to fall under one of the seventeen Sustainable Development Goals. For our Autonomous Waste Sorter, we chose the twelfth goal which is Ensure sustainable consumption and production patterns.

In this goal it says that it wants to achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment [10].

This works for our project as we have created a waste sorting robot that works by without having human intervention which in turn, creates a safer disposal of waste as there is less human contact with chemicals that could be harmful. It would also be faster that a person sorting out the waste making it a better solution in the long term as it will increase the waste disposal time leading to a cleaner environment.

5. LITERARY SURVEY

Here we have a project with the same concept to ours. In the first one it can distinguish between black and white block and separate them and in the second it can distinguish between different colours [11].

In this project an Arduino, Servo motor, and IR Sensor was used. We used this as a Baisis for our project even though it was a lot similar than ours. We used a Me line Follower V2.2 as the colour sensor it has an IR emitting LED and an IR sensitive phototransistor.

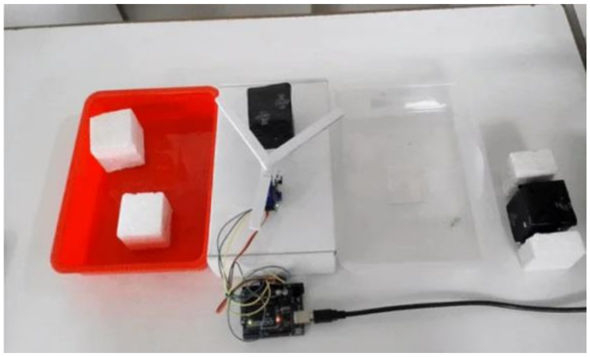


Figure 12 – sample project 1

This example the Lego Mindstorm kit is used to create a colour sorter. Like the example above it relies on a form of a conveyer belt to sort the coloured blocks. This has more movement that the other, so we took that from it and used it as inspiration for the tracks on the robot [12].

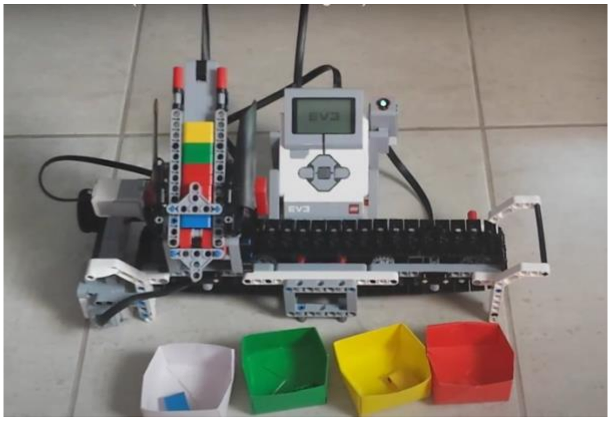


Figure 13– sample project 2

Here we will explain how our project differs from the others.

The main differences between these projects and our project are:

- That we have a mobile robot that is on tracks with a robot gripper arm attached unlike the above samples.
- Our robot can pick up the stationary objects and move them to a separate are by moving on tracks. It has neural networking's that allow the robot to detect where to place the different coloured blocks.

6. CONCLUSIONS

In conclusion, our project went well and over all we were happy with the results. Going into this project we knew it was going to be challenging for us to create an embedded system using a neural network with the timeframe we had been given, so to have a working robot able to complete the task was a productive outcome. During the project we had many changes in the robot, in the components we used, the design of the robot and the coding of it.

Below are some of the positives we took and learned from working in this project:

Communication

During the 12 weeks, we had to complete the project we continuously were updating each other on what each person was completing and what was yet to be done. This was by itself a vital feature to the success of the project as no one was left in the dark about task being completed and nobody was left with too great of a workload.

Learning about Embedded Systems and Neural Networking

The main outcomes of the project were to learn about how to create a neural network and embedded system, these were achieved by each member of the group. We feel that the 12 weeks was a constant learning experience which grew our knowledge on the topic which is a huge benefit to us for the future and was the intension of this PBL module.

Below are some things we could have done that would have accelerated the process further:

Using the right components.

At the beginning we started with a Pixy camera to be able to detect different object, but it was not a success as it detected more than the object in front of it making unreliable at times. We believe that having this information sooner would have been a significant help. We feel that this would have been more efficient to use at the beginning of our project.

Understanding the right components

If we were able to take more time to understand what type of components we would need for the robot to be able to pick up and move with the objects. If we did this, we would have been more efficient in finishing the project. For example, we worked on the Raspberry Pi for most of the time given when it did not end up working for us.

7. REFERENCES

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[11] Black And White Object Sorting Robot

[12] Colour Sorter