Department of Electronic & Telecommunication Engineering

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Sensor Selection - XtremeV

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1. Motor Encoders

We are planning to use two types of motors in our robot. They are,

- DC Gear Motors
- Servo Motors

Since both the motors need to be controlled accurately, an optical quadrature encoder and an angle position tracking encoder is used in the DC Gear Motors and Servo Motors respectively.

Figure 1.1: Optical Encoder

Encoder for Servo Motor

We are planning to use servo motors for the pick-and-place mechanism. It will require an angle position tracking encoder to control the angle of the servo motors. In the encoder market, we can purchase separate encoder modules which can connect to servo motors externally. The E3 optical kit encoder is an example for such an encoder. Since most of the servo motors have built-in potentiometer encoders, using such kind of servo motors for our robot is more economical. Therefore, we are planning to use Metal Wheel MG995 servo motors that have potentiometers as encoders.

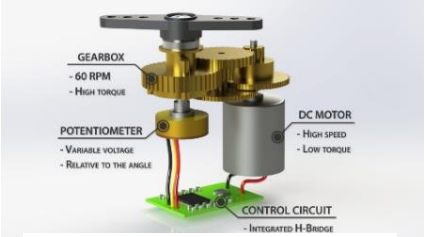

Figure 1.2: Inside Servo Motor

Quadrature Encoder for Gear Motors

We chose the Pololu Gearmotor 25Dx64L which has a Hall effect Quadrature Encoder with a 1632 counts per revolution, as the wheel encoders for the DC Gear Motors. A high-resolution encoder was selected to achieve high controlling accuracy. The Quadrature Encoder is selected to fulfil the requirements for controlling the gear motors, which are to measure the rotational speed and the direction of the motor. The disadvantages of other encoder techniques are as follows,

Incremental Encoder (Not Quadrature)	It cannot measure the rotational direction of the motor
Absolute Encoder	The additional feature of precisely measuring the rotated angle is not required for our application

Even though optical encoders offer higher accuracy compared to magnetic encoders in clean, and quiet environments, their performance significantly drop in environments with oil, dirt, and moisture. Similarly, their performance is affected by shock and vibration as well. On the contrary, the Hall effect encoders copes very well with shock and vibration while being unaffected by the ingress of oil, dirt, and moisture. Moreover, the hall effect encoders are compact and cost-effective, which makes them ideal for our application.

Figure 1.3: Pololu Gear motor

2. Distance Sensor

HC-SR05 ultrasonic sensor has been chosen as the distance sensor for the maze navigation task in our robot. Three sensors are mounted on top of the robot to identify the obstacles around it. Ultrasonic sensors use the concept of time of flight to calculate the distance to an obstacle. It measures the time between transmitted and received signal and calculate distance using speed of sound in the air. There are two popular sensors in the ultrasonic sensor category. The HC-SR05 has been chosen over HC-SR04 due to its higher precision and the availability of the 3-pin mode operation. HC-SR05 sensor equipped with five pins, one each for VCC, Trigger, Echo, Out and Ground. It has a measurement range of 2cm to 450cm. One drawback of ultrasonic sensor is that its transmitted signals get distorted around complex objects.

Figure 2.1: HC SR05 Module

Following is a comparison between alternatives available for ultrasonic sensors.

Ultrasonic	Sharp-IR	LIDAR	VCSEL
Low range	Low range	High range	Low range
Low frequency data retrieval	Low frequency data retrieval	High frequency data retrieval	High frequency data retrieval
Less Cost	Moderate Cost	High Cost	High Cost
Multiple interface options	Analog output	UART/ I2C	I2C interface only
Low resolution	High resolution	High resolution	High resolution

Table 2.1: Comparison between distance sensors

Figure 2.2: Sharp IR

Figure 2.3: LIDAR Sensor

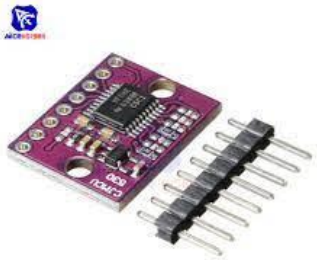

Figure 2.4: VCSEL Sensor

3. IR Sensor Array

In this device, there are several IR sensors connected in series. There can be 5 sensors, 7 sensors or 8 sensors. This device used for the line following task. It's easy to place and drive the robot in the middle of the line with this array.

Suitable IR Sensor arrays for the project are,

1. **Pololu QTR 8-bit Line Hunter Sensor Array Module for Arduino (MD0601)**
   This IR array has 8 TCRT5000 IR sensors. It is a good sensor for line-following robots. It is very precise and easy to handle as well. The sensor outputs are digital I/O-compatible signals that can be read as a timed high pulse. Moreover, there are LEDs for each sensor for indication.

   Operating voltage: - 3.3V - 5V
   Operating current: - 100mA
   Price: - Rs.2950.00

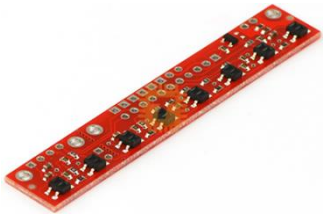

Figure 3.1: Pololu QTR IR Module

2. **Reflective Sensor Array Raykha S8**
   This is the local version of the above sensor array. It is made in Sri Lanka, and it is as good as Pololu IR sensors but not that expensive. Each IR sensor has its own Digital I/O measurable output, variable analogue voltage output and an LED for indication purposes.

   Supply Voltage: - 5V
   Supply current: - max 200mA
   Price: - Rs.1290.00

Figure 3.2: Raykha S8 reflective sensor array

Comparison between Pololu and Rekha IR sensor arrays are as follows,

Pololu IR array	**Rekha IR array**
Expensive	Cheaper than Pololu
Have a built-in library	Don't have built-in libraries
More precise values	Accuracy is a bit lower than Pololu
Both can give digital as well as analog outputs	

Table 3.1: Comparison between Pololu and Rekha IR sensor arrays

4. IR Array or Camera

We are planning to use the camera for colour detection, object detection and obstacle detection. We have an idea to use the same camera module to accomplish the line following task as well. However, since we are unsure about the suitability of that approach, we are planning to experiment and decide. If it works, we won't need an IR array for the line following task. Therefore, it would decrease the budget of the project.

Camera Module Selection

We planned to do following tasks using the Raspberry Pi camera,

1. Dotted Line Following
2. Object Detection
3. Colour Detection

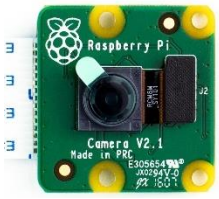

Figure 4.1: Raspberry Pi Camera V2.1

Available Camera modules

1. **Raspberry Pi Camera V2.1 (Original) (8MP)**
   Capture Resolution: 1080p
   Special Feature: Time Lapse
   Price: Rs.6250.00

Figure 4.2: Banana Pi Camera Module

2. **Banana Pi Camera Module (5MP)**
   Capture Resolution: 1080p
   Price: Rs.5500.00

3. **Raspberry Pi Camera V1 (5MP)**
   Capture Resolution: 1080p
   Price: Rs.1490.00

Figure 4.3: Raspberry Pi Camera V1Module

4. **Raspberry Pi NoIR Camera Module V2 (8MP)**
   Official Night vision camera for RPi
   Capture Resolution: 1080p
   Special Feature: Time Lapse, Night Vision
   Price: Rs.7250.00

Figure 4.3 Raspberry Pi NoIR Camera Module

We decided to use Raspberry Pi Camera V1 (5MP) module because its cost effective and capable of performing all the desired tasks. Since we are planning to use the Raspberry Pi camera in multiple occasions, native compatibility with the Raspberry Pi board is a huge advantage and it would allow efficient use of board's resources. Furthermore, the availability of this camera module in the local market (Tronic.lk) is another advantage.

5. References

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