Robot Design and Competition
EN-2532
Sensor choice Report

Team Sensorium

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1 Introduction

We are the team sensorium, and we have divided the task into four sub-tasks. Line following, Maze solving, Object challenge, and ping-pong challenge are those. When selecting sensors, our goals were simplicity, accuracy, and low cost. In this report, we have listed the chosen sensors, alternatives, and custom-made sensors.

2 Sensors

2.1 APDS - 9960

The sensor facilitates proximity sensing ($3cm$ to $10cm$ range), Digital Ambient Light Sense (ALS), and Color Sense(RGBC). It is also a low-cost, accurate, and small-size sensor. The slim modular package, $L3.94, W2.36, H1.35mm$, incorporates an IR LED and factory calibrated LED driver for drop-in compatibility with existing footprints.

`https://cdn.sparkfun.com/assets/learn_tutorials/3/2/1/Avago-APDS-9960-datasheet.pdf`

2.2 US-015

This is an ultrasonic distance measuring transducer sensor. The sensor uses the time delta to receive the transmitted ultrasound. It supports from $2cm$ to $4m$ range with a resolution of $0.5mm$. With this specific sensor, we can reduce the detecting angle up to $15°C$.

2.3 OV7670

The camera module has a resolution of 640x480 (VGA) and F1.8 / 6mm lens. Furthermore, the module comes with many useful features like low-light sensing, scaling support, auto flicker detection, etc. It takes a minimum of 7 IO pins for proper communication.

3 Tasks & Sensor Choice

3.1 Line Following

For the line following task, we are planning to design a sensor using a CD4503 multiplexer, 9 LDRs, 8 LEDs, a LM311 comparator and a 74LS90 3-bit counter IC.

3.1.1 Functionality of the sensor planned to design

1. Here 8 LDRs and a strip of 8 LEDs (always on) are placed in parallel.
2. Obtain the readings of the LDRs using the multiplexer with the 3-bit counter IC.
3. Use a 9th LDR to monitor the background colour.
4. Use the comparator to compare the 9th LDR and the multiplexer.
5. Use the output from the comparator to decide the position of the robot relative to the line.

3.1.2 Alternative sensors

- QRD1114 IR reflective line/object sensor and CNY70 reflective optical sensor
- TCRT5000 infrared photoelectric sensor
- QTR-8RC Line Following Reflectance IR Sensor Array

When compared with the sensor that is planned to design, these alternative sensors cost high and use a higher no. of pins in the microcontroller. Therefore, using this sensor designed with LDR-LED pairs can be beneficial.

3.2 Maze Solving

Identifying walls and the obstacles in the robots path is the major requirement, when it comes to maze solving sensors. Sensors' accuracy and the range affect the quality of the whole sensing procedure and maze solving algorithm entirely depends on these sensors. So it is a main need to select most suitable sensor for this task.

3.2.1 Selection

Proximity/distance can be taken from this sensor as munitioned in this document.Considering this sensor can be used for multiple tasks, APDS 9960 found out to be the most suitable sensor.

3.2.2 Alternatives

- **US-015 Ultrasonic Sensor**
  Most popular sensor used for maze wandering.3 of these sensors have to be set in front and two sides to get the proper understanding about walls around the robot. Accuracy is enough and cost is very reasonable. But the only measurement that can take is distance.
- **OV7670 Camera Sensor Module**
  For sensing the maze this is programmably-heavy due to each frame is 640x480x3 bits so even selecting a horizontal stripe (just to roughly see the maze) will come with the price of RAM.
- **IR sensor**
  Can not precisely target an object. Can mistakes happen with complicated walls.
- **ToF sensor**
  Accuracy is more than enough but cost is not acceptable .So cannot spend that amount of money only for a distance measurement.

3.3 Object Challenge

To accomplish this mission, we must have proper sensors for color detection and distance measurements. The algorithm of object and shape detection depends on distance measurements. The firmware will use a servo motor and distance sensor to get polar coordinates of the surrounding area and convert it to a cartesian map. Therefore, having an accurate and narrow distance sensor is a must.

3.3.1 Selection

APDS-9960 proximity detection feature provides distance measurement by photodiode detection of reflected IR energy (sourced by the integrated LED). The drawback of the ultrasonic sensor can be avoided using this sensor. Furthermore, as mentioned in section 2.1, the same sensor can be used to sense color.

3.3.2 Alternatives

- **US-015 Ultrasonic Sensor**
  Since sound waves are spreading with distance, sharp edges cannot be detected. Moreover, this spreading effect can cause inaccurate results due to wall reflections.
- **TCS34725 RGB Colour Recognition Sensor Module**
  This sensor is an appropriate selection for color sensing. But it can only sens color.

3.4 Ping Pong Challenge

3.4.1 Selection

APDS-9960 can give the RGB values directly. Also, it has been used in previous tasks as well. Therefore APDS-9960 is the best option for this task.

3.4.2 Alternatives

- **TCS3200 color sensor**
- **OV7670 camera module**
- **VL53LOX Laser module**
  VL53LOX is very small and therefore is need only very little space compared to others. It uses lasers to measure the distance. But as the datasheet says, it has an 80cm max range when dealing with indoor grey surfaces. But for white surfaces, it can go up to 200+ cms. At the moment both Ultrasonic and VL53LOX sensors seem good for the robot and depending on environmental parameters a one from them has to be chosen.