EN2532 Robot Design and Competition

Sensor Selections

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Abstract

This report explains about the sensors that can be used for each task of the robot competition with reasoning we have selected one appropriate sensor. While selecting the sensor we made our decision by considering its accuracy, suitability for the task, availability, cost and ease of use.

Line detection

Raykha S8 Sensor Module

Raykha S8 is line follower sensor based on TCRT5000 IR sensors. It provides eight channels of measurements with separate digital and analog outputs. It has relatively good resolution, consumes considerably less power and is a product of the local electronics shop called Aptinex.

Alternatives for line following

Image-recognition options
It is possible to detect the line with camera module like OV7670 with the image recognition libraries of Arduino environment. The main disadvantages in using this method are the need of lot of training time for the image recognition process and uncertainty of output against changing light conditions. Furthermore, image-processing task would require high processing powers, which would push the ATMEGA 2560 to its limits, resulting in high response times.

Separate TCRT5000 Modules arranged in an array
Connections would require more screws and take a larger space that could be saved by the module.

Making a sensor module from scratch
A custom-built sensor module would allow us to place our sensors at desired positions and customize the shape and space required. However, given the condition in the country, a shortage in electronic components in the local market is expected and with the safety risk of importing PCBs and sensors, we opted for a pre-built sensor module with sufficient resolution and channels.

Wall detection

VL530LX Time of flight sensor

This sensor uses the time of flight principle to find the distances with the working range of 3mm-2m. It is precise and has a high resolution which can be useful in following the wall effectively. It uses the I2C interface which allows connecting as many sensors as needed. Unlike ultrasonic sensors cone of detection is very small which allows the use of multiple sensors in a small area.

It is decided to use this sensor to measure the distance to the wall, detect the box, detecting pillars and gates

Alternatives for distance measurement

HC-SR04 ultrasonic sensors can be used to measure distances but using multiple sensors will cause issues and to use

this sensor robot speed must be reduced. Speed of sound changes with temperature and humidity so it has to calibrated at the time of use.

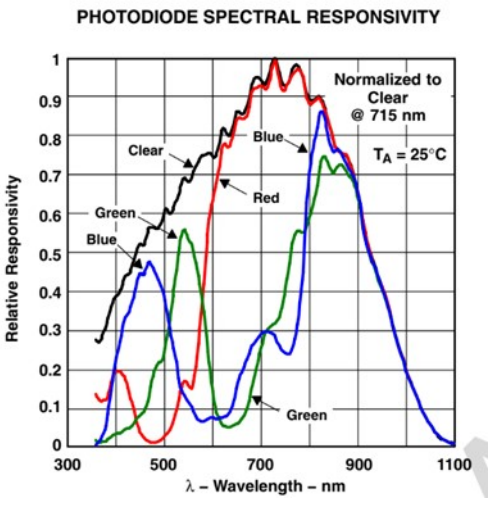
Another possible alternative is SHARP GP2Y0A21YK0F which is a position sensing device. This sensor is nonlinear and provides an analog output. This sensor is larger compared to the VL530LX sensor and around the same cost. So VL530LX is a better choice for this purpose.

Color detection

TCS 3200 colour sensing module

One of the available colour sensing modules in Colombo, Price is Rs. 720. Attached with 4 illuminating white LEDs. Therefore, acting as an active opto-sensor module.

Easily interfaced with MCUs and contains libraries for operation (Ex: Arduino libraries). Interfacing with the MCU is through I2C protocols. Need 7 pin connections from the connecting MCU. (4 digital output control pins, and one PWM input, VCC and GND).



Spectral characteristic shows clear separation for red in terms of relative response, although Green and Blue have closer values. Average 5V supply is needed, I_{DD} range is 1.4-2mA, recommended to operate at less than 80°C.

Performance is affected by:

- Ambient IR- solution would be to take a reading at ambient light level and use it as a filter before final reading.

- Humidity and shelf life- recommended to be stored at less than 90% humidity and to use before 12 months of shelf life.

We concluded that these limitations can be overcome and that the given task can be achieved.

Alternatives for color detection

There are other TCS series sensors, the TCS 34725 is a higher and version with an in-built IR filter (making it more accurate), but at more than double the cost, and not available in Sri Lanka.

The TCS 230 is the same price, available locally, but a smaller number of Photo diodes at detection (4x4 compared to the 8x8). Thus, given the option, the TCS 3200 is better in precision and accuracy.

Apart from TCS series, the ISL series is in the market, but the ISL29125 (which has comparable features to the TCS 3200) does not contain an illuminating mechanism. (It is a passive opto-sensor). Furthermore, it is at double the cost (around Rs 1600) and not in stock in Colombo, most probably needs to be shipped. However, the performance curve shows an equal relative response for the three colours, with the blue colour more separated and the red colour less distinguishable compared to the TCS model.

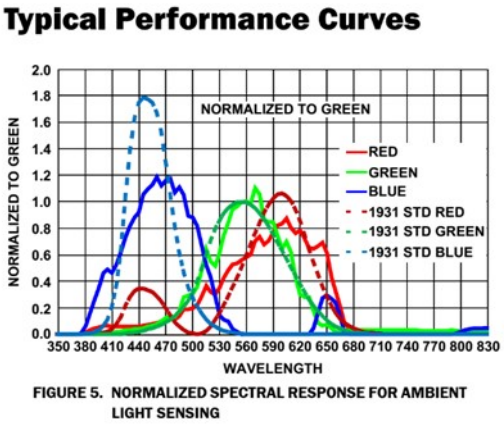


FIGURE 5. NORMALIZED SPECTRAL RESPONSE FOR AMBIENT LIGHT SENSING

There is also the option of building a colour sensor mechanism from opto-sensors from scratch, but we felt the desired result can be obtained from a more compact module, so that the trade off of the cost of the TCS module in return for the compact nature ,and reliability was worth.

Ramp navigation

mpu6050 Gyroscope

This sensor include 3 axes accelerometer and a 3 axes gyroscope and convert all the readings to digital . This can measure the angular velocity along all 3 axes. It uses MEMS(Micro Electro Mechanical System – with variable capacitors) technology and the Coriolis Effect for measuring and supports I2C communication technique up to 400kHz and SPI technique up to 20MHz. We just need to integrate along one axis to detect the ramp. As an additional support, we can find the direction robot is heading to. So we can double check our path in circle navigation.

- Tri-Axis angular rate sensor (gyro) with a sensitivity up to 131 LSBs/dps and a full-scale range of $\pm 250, \pm 500, \pm 1000$, and $\pm 2000 dps$
- Tri-Axis accelerometer with a programmable full scale range of $\pm 2g, \pm 4g, \pm 8g$ and $\pm 16g$
- Wide extended operating temperature range (-40° C to 85° C)

Alternatives for ramp navigation

LYPR540AH
The LYPR540AH is a three axis yaw, pitch and roll analog gyroscope featuring three separate analog output channels. LYPR540AH provides amplified (± 400 dps full scale) and not amplified (1600 dps full scale) outputs for each sensible axis available at the same time through dedicated pins, and is capable of detecting rates with a -3 dB bandwidth up to 140 Hz.
Range : -400 to 400 dps
Sensitivity : 3.2 mV/dps
ITG 3200
This is a gyroscope uses for professional work. It is a single chip including followings in it.

- Digital-output X-, Y-, and Z-Axis angular rate sensors (gyros) on one integrated circuit with a sensitivity of 14.375 LSBs per °/sec and a full-scale range of $\pm 2000°/sec$
- Three integrated 16-bit ADCs provide simultaneous sampling of gyros
- Cost is High

Summary

The following sensors are selected and finalised for each task

Task	Selected Sensor
Line following	Raykha S8
Distance measurement	VL530LX TOF
Color Detection	TCS3200
Ramp navigation	mpu6050 gyroscope