Long-Range Sensor Trade Study for Micromouse Robot

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1. Introduction

1.1. The Micromouse Competition

The Micromouse competition is one in which each team creates a small robot which attempts to find its way autonomously to the center of a 256-cell maze. The maze is composed of 18 cm unit squares with a semi-random configuration of walls. The contest is popular among engineering students in many different areas of the world and is sponsored in the United States by the Institute of Electrical and Electronics Engineers.

1.2. Purpose of the Sensor Study

Sensors are critical components of any Micromouse robot. Of particular interest to the 2010 Ohio University Micromouse team is a sensor that can detect the presence of maze walls at a relatively long range – between 10 and 100 cm forward of the robot. A sensor with this range will enhance the Micromouse robot's ability to navigate the maze. Several sensor technologies exist that are reasonably small, lightweight, and use relatively little power. Sensors that do not blatantly violate these qualitative requirements will be considered in this study; the sensor that best meets all considered criteria will be recommended for use in the design.

2. Methods

2.1. Research on Available Sensors

All sensor options were selected from the inventory of Acroname, an online supplier of parts commonly used in robotics applications. Other online suppliers such as Mouser Electronics and Digi-Key were found to have a similarly diverse selection of sensors. Acroname provides access to each sensor's datasheet; the information in these datasheets was used to determine how well an individual sensor meets the following criteria.

2.2. Criteria for Evaluation

Each sensor was evaluated on how well it meets four weighted criteria. Initially, power consumption, weight, and size were considerations; however, all options were found to have such similar size, weight, and power usage characteristics that these variables were not included in the study. The significant criteria are as follows:

Category	Weight
Range (wall detection from 10 cm to at least 100 cm)	1.9
Precision (prefer narrow beam width)	1.7
Ease of Implementation (easily-interfaced sensor output, 5 VDC input voltage, minimal supporting electronics)	1.3
Cost (less than approximately $30 per sensor)	1.0

The extent to which a sensor meets a given requirement is quantified using a point system, defined as follows:

- 2 Points: Sensor clearly satisfies the given criterion
- 1 Point: Sensor partially satisfies the given criterion
- 0 Points: Sensor in no way satisfies the given criterion

The final recommendation favors the sensor with the highest weighted point score. The total is computed for each sensor option as the weighted sum of that option's four point awards.

3. Sensor Options

3.1. Infrared Distance Sensors

Four sensors were considered that use an infrared light-emitting diode with a collector which measures the angle of returning infrared light; this angle is used to compute a distance measurement which is then output on a single wire as an analog voltage. The following models, all made by Sharp Electronics Corp., were considered:

	Model Number	Basic Specifications
1	R301-GP2Y0A21YK	Range: 10 – 80 cm; Current: 33 mA at 5 VDC; $12.50
2	R144-GP2Y0A02YK	Range: 20 – 150 cm; Current: 33 mA at 5 VDC; $12.50
3	R302-GP2Y0A700K0F	Range: 100 – 550 cm; Current: 30 mA at 5 VDC; $19.50

3.2. Ultrasonic Distance Sensors

Five sensors were considered that use the travel time of directional ultrasonic pulses of sound to compute a distance measurement; this measurement is output as an electrical signal from the sensor. The following models, all made by Devantech., were considered (data can be found on the Acroname site):

	Model Number	Basic Specifications
4	R145-SRF08	Range: 3 – 600 cm; Current: 15 mA at 5 VDC; $64.00
5	R287-SRF02	Range: 15 – 600 cm; Current: 4 mA at 5 VDC; $24.50
6	R254-SRF235	Range: 10 – 100 cm; Current: 15 mA at 5 VDC; $142.00
7	R322-SRF01	Range: 0 – 600 cm; Current: 25 mA at 5 VDC; $36.00
8	R271-SRF05	Range: 3 – 400 cm; Current: 15 mA at 5 VDC; $29.50

4. Evaluation of Options by Criterion

4.1. Range

	Score	Reasoning
1	1	80 cm maximum range is slightly below required 100 cm range
2	2	Sensor range fits range requirement well
3	1	Range may be too large to be useful for maze navigation
4	2	Sensor range fits range requirement well
5	2	Sensor range fits range requirement well
6	2	Sensor range fits range requirement well
7	2	Sensor range fits range requirement well
8	2	Sensor range fits range requirement well

4.2. Precision

	Score	Reasoning
1	1	12 cm beam width at 40 cm range, may be too large
2	2	Narrow beam spread well-suited to maze navigation
3	0	100 cm minimum effective range is too large
4	1	45° beam spread may be too large for maze navigation
5	0	60° beam width too large for maze navigation
6	2	15° beam width is well-suited to maze navigation
7	1	45° beam width may be too large for maze navigation
8	0	60° beam spread too large for maze navigation

4.3. Ease of Implementation

	Score	Reasoning
1	1	Non-linear output vs. sensed distance; need free A/D converter
2	1	Same as Option 1
3	1	Same as Option 1
4	2	Uses standard IIC bus for output, non-sync echo (frees processor)
5	2	Standard IIC and serial interface, automatic calibration
6	2	IIC interface, automatic calibration
7	2	Digital serial output (frees A/D converter on processor), auto-calibration
8	2	IIC interface, automatic calibration

4.4. Cost

	Score	Reasoning
1	2	Cost is relatively small within scope of budget
2	2	Cost is relatively small within scope of budget
3	2	Cost is relatively small within scope of budget
4	1	Price is relatively large, sensor may be unaffordable in scope of budget
5	2	Cost is relatively small within scope of budget
6	0	Price is very large within scope of project budget
7	1	Price is relatively large, sensor may be unaffordable in scope of budget
8	2	Cost is relatively small within scope of budget

5. Conclusions

The weighted totals for each option (1 through 8) are as follows:

Option Number	Weighted Score	Option Number	Weighted Score
1	6.9	5	7.4
2	10.5	6	9.8
3	5.2	7	9.1
4	9.1	8	8.4

6. Recommendation

The sensor model with the highest weighted point score – Option 2, the Sharp GP2Y0A02YK infrared rangefinder – should be used in the Micromouse design.

7. References

IEEE Region 2 Micromouse Competition Rules:

http://www.ieee.uc.edu/main/files/sac2007/mm_rules.pdf

Acroname Sensor Inventory:

http://www.acroname.com/robotics/parts/c_Sensors.html