A Critical Review on Obstacle Detection Methods

Aaron WEDRAL[1*]

1(Höhere Technische Bundes Lehr- und Versuchsanstalt Wiener Neustadt, Abteilung Informatik Secondary Technical College Wiener Neustadt, Department for Computer Science)

*Corresponding author E-mail: i11097@student.htlwrn.ac.at

Abstract

This publication gives a critical review on obstacle detection [4] possibilities that are currently available for use in the Botball event. It will cover the basics on how to use them as well as whether you should use them.
First each sensor will be presented and explained. Afterwards the advantages and disadvantages will be highlighted and the best applications will be shown.
This review could function as an in-depth guide on obstacle detection methods for future robotic teams that want to take part in the Botball challenge.

Introduction

Just as you start working as a robotic team and get to a point where you need to construct and program more and more complex robots you need to think about one important topic: how will the robot detect the obstacles and objects in his path?
The first question you should ask yourself in this matter is which objects you need to detect and at what distance they need to be detected. These have to be the main criteria which influence the choice of sensors.
Obstacle sensors all have their pros and cons. You could for instance use an "ET"-Sensor for obstacle detection which will do a great job with big obstacles but has problems with smaller objects and at close distances (less than five cm).
The point this is leading to is before deciding on a way of obstacle detection you have to inform yourself on the details of the available sensors and to decide according to the task this sensor has to fulfill.
With this intro we can jump right into our concept.

Concept

To start this off we will have a look at the different approaches of detecting obstacles. First a short description will be given. The next step is going to be how and when to use the specific approach. Last but not least the complications that can occur while working with an approach in bad or even optimal environment will be covered.

Overview:

- Introduction
- Approaches
    - Description
    - Application
    - Complications

1 Analog Sensors

1.1 ET-Sensor

Description

This sensor's name originates from the shape of the sensor resembling a famous movie Extra Terrestrial. This sensor works by sending out a modulated frequency IR beam and measures the intensity of the reflected light. With knowledge of the distance between sender and receiver the angle can be calculated. With this angle it triangulates [2] the distance to an object. According to the data specification this information is not explicit.
Because of the modulated frequency, this sensor is less susceptible to error due to changing lighting conditions [1].
It has a straight field of view in the shape that is best comparable to a line.

Application

Most of the time you will use the ET-sensor for detection because it is the easiest way to use and the most reliable sensor when it comes to detecting box shaped objects. Because of its straight field of view it returns fairly correct values when facing a flat object however facing a round or rough surface these values will not be as reliable but still useable.

The ET sensor should only be used in an interval of 5-50 cm because only in this range you get data that you can rely on.
It should be mentioned that the sensor returns his highest value at 5 cm and descends with both closer and further distance which can lead to interesting bugs if the sensor is not mounted to only get as close as 5 cm to an object. This is shown in the picture below.

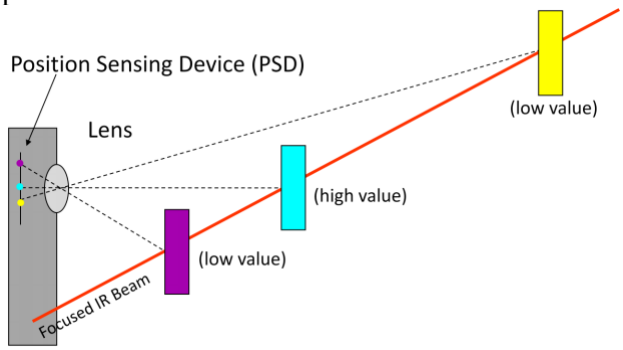

Figure 1: Sensor Value Graphic [1]

An example is that the robot ignores an object because it drives too fast and the responding limit is set too close to the value of 5 cm.
It also is not recommendable to use this sensor in close quarters because of the possibility of mistaking the wall with the obstacle which can also cause fatal errors if not intended.

1.2 Top Hat Sensors

Description

'The "Top Hat" sensor gets its name from the shape of the sensor. This sensor is really a short range reflectance sensor. There is an IR emitter and an IR collector in this sensor. The IR emitter sends out IR light and the IR collector measures how much is reflected back' [1].
The Top Hat Sensors are a group of two sensors, one large and one small top hat sensor.
The main difference between these two is the fact that the large one has a 3 mm higher range and that the large top hat sensor is less error-prone than the small one.

Application

The top hat sensors can only be used for obstacle detection of close objects because of their short (13 or 15 mm) range. This requires the robot which uses the top hat sensors to either move very slowly or to have no problem with bumping into most of the objects before detecting them.
Another problem comes into play with differently colored obstacles because of the way these sensors work. A close white object results in the same values as a further away black object.
That is the reason why you should only use them for mono colored objects.

The best use of the top hat sensors in obstacle detection is for obstacles that the robot can drive over (or should avoid driving over). The problem is that this method is also very error-prone.
This leads to my conclusion of keeping these sensors as black line detectors on white ground (or reversed).
A good advice for everyone using a top hat sensor is that whenever you doubt a small top hat sensor being enough test for errors and even if it only occurs once in 5 times use the large one instead.

2 Digital Sensors

Digital sensors only have two states either on (1) or off (0).
This way you cannot have problems with misinterpretation of values. Either they are activated or they are not. But **if** they get activated is another story.

2.1 Touch Sensors

Description

There are two kinds of touch sensors included in the Botball kit: the touch sensors and the lever sensor. These are both used for rather similar operations that include touching the objects they want to detect.

2.1.1 Touch Sensors

'The touch sensor is a mechanical switch. Pressing the switch brings two contacts together completing the circuit.' [1]

2.1.2 Lever Sensor

The lever sensor is a button that gets activated by a metal plate which is connected to the sensor construct.
When the button is pressed the contacts get together and the circuit is completed.

Application

These can only be used if you want to detect objects that you bump into as you have to apply quite a pressure to activate the touch sensors which means that most lightweight objects will not be able to trigger the touch sensor.
The lever sensor can be used rather similar but has the advantage that it requires less force to activate hence it does not have to withstand the object so that the robot can put pressure into a sidearm. This way you do not have to worry about breaking the sensor or having to back up a little before making your path around the object to avoid the aforementioned problem of breaking the construct.

The best use for the touch sensor is to detect walls because they will always apply enough pressure to activate the sensor if you collide with it.

The best uses for the lever sensor are

- to detect objects beside of the robot that cause errors in your pathing,
- to assist driving around obstacles of unknown size as you can rearrange your robot if you encounter the object or
- to detect objects that you might drive over (like pencils).

Implementation

This information was gathered over years by testing a lot and trying out new methods for greater success at the RoboCup competition. For the Botball workshop this information can be used for the seeding strategy planning and for the robot construction.
In the strategy [5] it is used to determine if it is possible to detect an object that is necessary for the strategy to work and if it has to be detected otherwise.
A good example is the detection of the plastic pipes. Since the robot cannot detect it from afar consistently with any sensor a touch sensor has to be used. To decide which touch sensor to use the surroundings of the robot as well as the circumstances under which the sensor has to detect have to be considered. Because the object which has to be detected has a round surface and a touch sensor would most likely glide off the surface and from time to time will not detect properly.
After thinking all this through the conclusion is to use a lever sensor over a simple touch sensor to detect a pipe.
The next step is the construction. After the decision of the sensor is made a suitable mount on the robot has to be designed.
Since this varies extremely even if one only compares two robots this paper is only able to give vague guidance in this matter.
The most important aspects of the placing should be reliability, stability and space consumption in this order.
Concerning reliability the sensor has to return correct results in at least 95 percent of the time.
When working on stability the pressure the sensor will face has to be kept in mind to build a construct powerful enough to withstand this force.
Space consumption is important since most of the times a construction for fulfilling a task with this information is to be mounted near the sensor as well.

Results/Conclusion

This paper results in a list of best practices [3] for obstacle detection methods.
One of these could sound like ‘Use the ET sensor unless it requires other specific detection or when the detection is completed in close quarters’.
After reading this paper one has a better understanding of the sensors and usage of the sensors that are allowed for the Botball competition.
This paper shall work as a guide for new teams and shall help them overcome problems other teams had before them. It shall ensure that mistakes will not unnecessarily be repeated.

Acknowledgements

The author would like to thank Dr. Michael Stifter for his support and shared knowledge during the time of creation for this article; Thomas Jakli for constant support and help in creation and refinement of this paper.

References

[1] Official Sensor Documentation [Online] (http://www.cs.uml.edu/~holly/teaching/91450/spring2015/Sensor_and_Motor_Manual_BB2011.pdf) quoted: 30.03.2015

[2] Paper about Triangulation [Online] (http://www.sciencedirect.com/science/article/pii/S1077314297905476) quoted: 02.04.2015

[3] BRICS – Best practices in robotics [Online] (http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5756905&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5756905) quoted: 02.04.2015

[4] Real-time obstacle avoidance for fast mobile robots (http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=44033&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D44033) quoted: 03.04.2015

[5] Goals, strategy development, and task performance: some limits on the efficacy of goal setting. (http://psycnet.apa.org/journals/apl/74/1/24/) quoted: 04.04.2015