What Makes a Smart Robot Smart?
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1. Introduction

With the push for smarter and smarter robots, how do you quantify the intelligence of a robot? Is it purely based on the job done or do other aspects need to be taken into account? This paper explores the versatility of a simple robot and compares the performance to a more complex robot.

2. BYO-Bots

What comes to mind when building a smart robot?

Is it a super articulated robot with human level intelligence (or smarter)? My smart robot is a BYO-Bot® [1]. The KISS Institute of Practical Robotics developed and has been selling BYO-Bots. They are reprogrammable behavior based robots. BYO-bots are very simple robots that are able to demonstrate complex behaviors and are very inexpensive. As of the date this paper was written, BYO-Bots are available from http://botballstore.org for $18.

The BYO-Bot is a good robot due to the simplicity of the design and the versatility of the circuit. Even though the BYO-Bot is simple, it can perform as well as a robot controlled by a microcontroller.

3. BEAM

These robots can be classified as a Braitenberg Machines [2], or BEAM robots. BEAM stands for Biology, Electronics, Aesthetics, and Mechanics [3]. BEAM robots are mainly constructed using simple embedded electronics [4] to control the robot. Most modern robots begin with a powerful controller and build the structure to move, but most BEAM robots begin with a simple reflexive motion and build the robot to suit that movement.

The BYO-Bot uses two light sensors and a pair of transistors to control the power applied to the motors. As in most BEAM robots there is not extra structure, the circuit and battery box provide the structure. The BYO-Bot is designed to follow light, or in BEAM terms is a phototrope (meaning light reacting), or more specifically a photovore (meaning light seeking).

4. Reprogramming a BYO-Bot

If the robot is just a circuit with no microcontroller how is it reprogrammable?

A program is a set of instructions for controlling input and output. In robotics the program takes the input from the sensors and determines the output to effectors. Reprogramming a robot is changing the program or instruction set to change output.

The basic configuration is for the BYO-Bot to follow a light source. The light sensors trigger power to the motor on the opposite side of the robot, driving it towards the light. To make the robot avoid light, switch which light sensor controls which motor, or bend the sensors so they point in the opposite directions [5]. By adjusting the angle of the sensors you can also program the BYO-Bot to orbit a light source [6].

5. Following a Line

The BYO-Bot is a reprogrammable robot, but what does that have to do with smart robots?

The BYO-Bot is a simple robot that demonstrates the principle of simple logic making a smart robot. I took this concept one step further by adapting the BYO-Bot to be a line following robot.

I am using the same basic principle as in the original BYO-Bot, but this time instead of measuring ambient light, it is measuring the amount of reflected light to tell the difference between a black line and white background. The wiring is the same except the light sensors have been replaced with IR reflectance sensors and an extra line has to be added to the power out pin to power the IR LED.

The line following robot works extremely well. It will even stop at the end of the line if there is a black perpendicular line. The robot is still reprogrammable, since it will follow a black line, or a white line. You can even vary how smoothly the robot follows the line by varying the placement of the sensors in relation to the line.

6. Twins

I have taken this one step further still. I have inserted the brains of a BYO-Bot into a dead CBC v2 to directly compare this simple robot to a more complex CBC v2 using an Arm processor and requiring software to direct the actions.

I wired the bottom of the sensor port to an operational amplifier that will act like the transistor and proportionally supply power to the motor ports based on how much black the sensors detect. The

operation is the same as the original BYO-Bot, but it operates using 8.4 Volts supplied by the Lithium Polymer battery from the CBC instead of 3 Volts from 2 AA batteries.

Both robots now have the same structure and use the same type of sensors and motors, so the only variable is programming. The BYO-Bot uses proportional control to follow the line. The CBC v2 uses a standard proportional line following program, meaning that the motor speed is proportionally related to how much black the reflectance sensors detect.

Which robot is smarter?

Both robots look the same and each of the robots excels at line following. One robot is using complex hardware and programming, and the other using a simple analog circuit. The CBC robot can be reprogrammed to perform different tasks, however the BEAM robot can be reprogrammed as well.

7. The Ultimate Test

Andrew Howard from JPL indicates that real world interaction determines the intelligence of a robot [7]. It is easy to have a robot run perfectly in a tightly controlled environment, and the true test comes from operating in the real world. I agree with Andrew Howard. The best determination for intelligence is real world application. Now differences begin to develop between the robots. Once the tape or back ground colors are changed, the BEAM robot begins to have difficulties. The CBC based robot can easily fix those problems with a simple code tweak, but the BEAM robot needs to have circuitry added to adapt. While code can be programmed conditionally, changing hardware will require another intelligent being, be it human or robot.

8. Conclusion

The CBC robot and the BEAM robot are both smart robots, but until robots can better mimic human level intelligence most robots will be designed for specific tasks. The BEAM robot is good for use in a stable environment where there is tight environmental control, while the CBC robot is better in situations where the environment is more dynamic.

References

[1] BYO-Bot®. KISS Institute for Practical Robotics. http://botballstore.org, 2010

[2] Braitenberg, Valentino, Vehicles: Experiments in Synthetic Psychology, 1984.

[3] A Bit of background on BEAM. Solarbotics. http://www.solarbotics.net/library.html, 2010.

[4] Braunl, Thomas. Embedded Robotics. Oxford Oxfordshire: Oxford University Press, 2008.

[5] BYO-Bot instructions, 2010.

[6] BYO-Bot instructions, 2010.

[7] *The Intelligent Robot*, 2007, Educational Broadcasting Corporation and California Institute of Technology. http://www.teachersdomain.org/resource/vtl07.la.ws.research.intelrobot/