FUNDAMENTALS AND DIRECTIVES TO BUILD A ROBOT WITH LMEEC TECHNOLOGY PART VIII: ORGANIC SENSORS

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ABSTRACT

It describes the eighth set of Fundamentals and Directives to build a Robot with a set of LMEEC (Logical - Mechanical - Electrical Electronical and Control) technology, in this part it will be described the use sensors. Although this might seem pretty basic, even any student, any teacher or any professional with previous robot building experience might find useful information regarding the general method of building a robot, it take step by step the LMEEC technology that are used to build a robot.

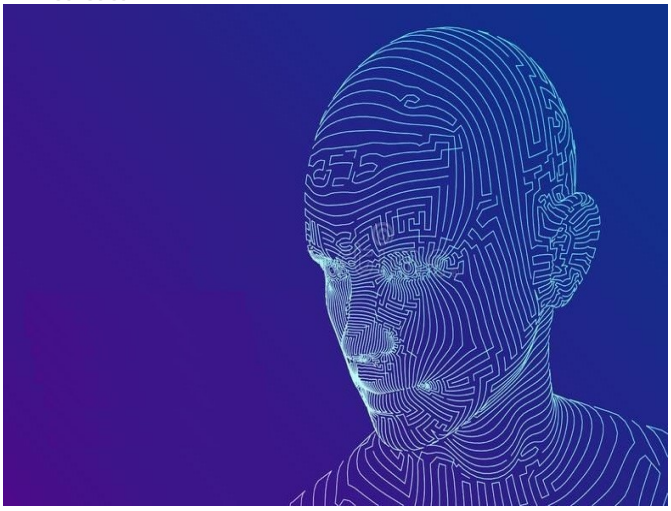
INTRODUCTION

Communications World has been changing dramatically with the ocurence of the world wide web in 1993 finally a good part of the population could access a global data network that for a long time was the exclusive use of Universities and of the Department of Defense of the United States of America **[1]**. This approach to this network of networks known as the Internet, brought many advantages, being one of the most important to shorten distances, allowed network users to access a large amount of information and also place the information within reach of the rest of users and this became a tool for everyday use in the office and at home. Internet enabled tasks that years ago would take days or hours in a few minutes giving rise to new ideas **[2]**. The possibility of remote control and maintenance operations was seen using the internet and this will be the focus of this project, which takes as a starting point the possibility and scope of using the internet as an easily accessible means to allow control and the maintenance of electronic devices **[3]**. With a simple browser it has a complete and real-time view of the state of an industrial plant, a farm or the security system of a home, and this can be controlled from anywhere in the world that has an internet connection available **[4]**. This is how the new concept called Internet of Things (IoT) was born, as we are entering an era in which the internet has the potential to dramatically improve the lives of everyone on our planet **[5]**. From curing diseases, to understanding climate change, improving the way of doing business, or making every day more enjoyable. As more things, people, and data connect, the power of the internet (which is essentially a network of networks) grows exponentially.

VIII. Organic Sensors. Robots use a variety of different electromechanical sensors to explore and understand their environment and themselves. Emulating a living creature's senses is currently very difficult, so IEEE Researchers and IEEE Developers have resorted to alternatives to biological senses. What Robots can not sense and the people can. Robots can "see" but have a hard time understanding what they are looking at. Using a camera, a Robot may be able to pick up an image made up of millions of pixels but without significant programming, it would not know what any of those pixels meant. Distance sensors would indicate the distance to an object, but would not stop a Robot from bumping into it.

IEEE Researchers and companies are experimenting with a variety of different approaches to permit a Robot to not only "see" but "understand" what it is looking at. It will take a long time before a Robot is able to differentiate between objects placed before it on a table, especially if they do not appear to be exactly the same as what is in its database of objects. The Robots have a really hard time tasting and smelling. A human may be able to tell you "this tastes sweet" or "this smells bad" whereas a Robot would need to analyze the chemical composition and then look up the substance in a database to determine if humans have marked the taste as being "sweet" or the smell as being "bad".

There has not been much demand for a Robot that can taste or smell, so not much effort has been put into creating the appropriate sensors. Humans have nerve endings throughout their skin and as such, we know when we have touched an object or when something has touched us. The Robots are equipped with buttons or simple contacts placed in strategic locations (for example on a front bumper) to determine if it has come into contact with an object. Robot pets may have contact or force sensors placed in their head, feet and back, but if you try to touch an area where there is no sensor, the Robot has no way of knowing it has been touched and will not react.



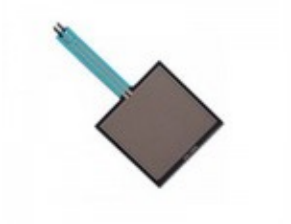
Although a Robot cannot tell you if a substance tastes good or if an odour smells bad, the steps involved in analyzing the chemical composition can give it far more information than a normal human could about its properties. A Robot, equipped with a carbon monoxide sensor, would be able to detect carbon monoxide gas which is otherwise colorless, odorless to humans. A Robot would also be able to tell you the PH level of a substance to determine if it is acidic or basic and much, much more. People use a pair of eyes to get a very good sense of depth, though for many, accurately gauging distance is not easy. A human might tell you "the tree looks to be about 50 feet away", but a robot, equipped with the right distance sensors, can tell "the tree is 43.1 feet away". Additionally, Robots can not only sense but give accurate values of a variety of environmental factors that humans are otherwise unaware of or incapable of sensing. For example, a robot can tell you the precise angular or linear acceleration it is subjected to, while most humans would only tell you "I'm turning", or "I'm moving". A human can tell you based on experience if they think an object will be hot or cold without actually touching it, whereas a thermal camera can provide a 2D thermal image of whatever is in front of it. Although humans have five main senses, robots can have an almost infinite number of different sensors. The sensors that the Robots need. So, what types of sensors are available and which ones Robots need. It needs to first ask the porpouse "What does the robot need to measure?" and refer to the appropriate category below. There is a good chance what you have in mind will not fall "nicely" into one of these categories, so try to break it down into its basic elements.

Contact

Push button / Contact switch

Switches, buttons, and contact sensors are used to detect physical contact between objects and are not just restricted to humans pushing buttons; bumpers on a robot can be equipped with momentary push buttons, and "whiskers" (just like a Pet) can be used to sense multiple distances. **Advantages**: very low cost, easy to integrate, reliable. **Disadvantages**: single distance measurement

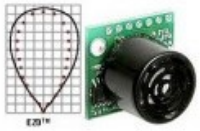
Pressure sensor



Unlike a push button which offers one of two possible readings (ON or OFF), a pressure sensor produces an output proportional to the force that is being applied to it. **Advantages**: allows gauging how much force is being applied. **Disadvantages**: can be imprecise and are more difficult to use than simple switches.

Distance

Ultrasonic Range Finders



Ultrasonic range finders use acoustics to measure the time between when a signal is sent versus when its echo is received back. Ultrasonic range finders can measure a range of distances, but are used specifically in air and are affected by the reflectivity of different materials. Advantages: medium range (several meters) measurement. Disadvantages: surfaces and environmental factors can affect the readings.

Infrared

Infrared light, which as we saw is used in communication, can also be used to measure distance. Some infrared sensors measure one specific distance while others provide an output proportional to the distance to an object. Advantages: low cost, fairly reliable and accurate. Disadvantages: closer range than ultrasonic.

Laser

Lasers are used when high accuracy, or long distances (or both) are required when measuring the range to an object. Scanning laser rangefinders use spinning lasers to get a two dimensional scan of the distances to objects Advantages: very accurate, very long range. Disadvantages: much costlier than regular infrared or ultrasonic sensors.

Encoders

Optical encoders use mini infrared transmitter/receiver pairs and send signals when the infrared beam is broken by a specifically designed spinning disk (mounted to a rotating shaft). The number of times the beam is broken corresponds to the total angle travelled by a wheel. Knowing the radius of the wheel, you can determine the total distance travelled by that wheel. Two encoders give you a relative distance in two dimensions.

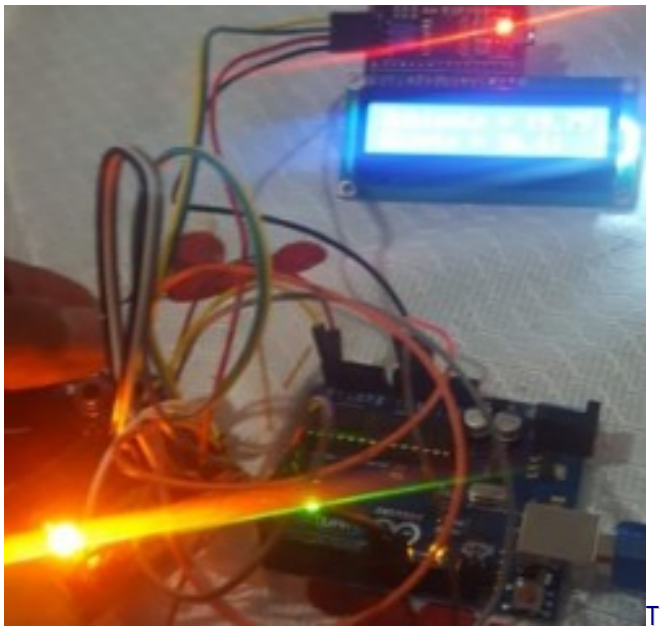
Advantages: assuming there is no slip, the displacement is absolute. Often comes installed on the rear shaft of a motor.

High Performance Sensors but allow the user to vary many of the communication parameters involved. These modules have a specific footprint (layout) and are only produced by certain companies. Their main advantage is that they provide a very robust easy to set up link and take care of all of the communication protocol details. Many Robot builders choose to make semi-autonomous Robots with RF capability since it allows the Robot to be as autonomous as possible, provide feedback to a user and still give the user some control over some of its functions should the need arise. Advantages: **A**. Considerable distances possible. **B**. Setup can be straightforward. **C**. Omni directional (impeded but not entirely blocked by walls and obstructions). Disadvantages: **A**. Very low data rate (simple commands only). **B**. Pay attention to the transmission frequencies – they can be shared. Bluetooth. This is a form of RF and follows specific protocols for sending and receiving data. Normal Bluetooth range is often limited to about 10m though it does have the advantage of allowing users to control their Robot via Bluetooth-enabled devices such as cell-phones, PDAs and laptops (though custom programming may be required to create an interface). Just like RF, Bluetooth offers two-way communication. Advantages: **A**. Controllable from any Bluetooth enabled device (usually additional programming is necessary) such as a Smartphone, laptop, desktop. **B**. Higher data rates possible. C. Omnidirectional (does not need line of sight and can travel a little through walls). Disadvantages: **A**. Devices need to be "paired". **B**. Distance is usually about 10m (without obstructions). WiFi. WiFi is now an option for Robots; being able to control a Robot wirelessly via the internet presents some significant advantages (and some drawbacks) to wireless control. In order to set up a WiFi Robot, you need a wireless router connected to the internet and a WiFi unit on the Robot itself. For the Robot, you can also use a device that is TCP/IP enabled with a wireless router. Advantages: **A**. Controllable from anywhere in the world so long as it is within range of a wireless router. **B**. High data rates possible. Disadvantages. **A**. Added programming required. **B**. Maximum range is usually determined by the choice of wireless router. GPRS and Cellular. Another wireless technology that was originally developed for human to human communication, the cell phone, is now being used to control Robots. Since cellular frequencies are regulated, incorporating a cellular module on a Robot usually requires added patience for programming as well as an understanding of the cellular network system and the regulations. Advantages: **A**. Robot can be controlled anywhere it has a cellular signal. **B**. Direct satellite connection is possible. Disadvantages: **A**. Setup and configuration can be complex, not recommended for beginners. **B**. Each network has its own requirements or restrictions. **C**. Cellular service is not free; usually the more data you transmit and receive. Autonomous System. System not yet well setup for Robotics use. The next step is to use the microcontroller in your Robot to its full potential and program it to react to input from its sensors. Autonomous control can come in various forms: pre-programmed with no feedback from the environment, limited sensor feedback and finally complex sensor feedback. True "autonomous control" involves a variety of sensors and code to allow the Robot to determine by itself the best action to be taken in any given situation. The most complex methods of control currently implemented on autonomous Robots are visual and auditory commands. For visual control, a Robot looks to a human or an object in order to get its commands. Getting a Robot to turn to the left by showing a piece of paper with arrow pointing left is a lot harder to accomplish than one might initially suspect. An auditory command such as "turn left" also requires quite a bit of programming.

All of our used assembly robots go through a rigorous reconditioning process, but can cost up to 50% less than a new one. Our robotic integrations throughout the Universidad Tecnológica de Nezahualcóyotl to Universidad Autónoma Metropolitana Iztapalapa , Instituto Tecnológico de Iztapalapa and Instituto Politécnico Nacional Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional Unidad Oaxaca, speak to our excellent workmanship, and technical advance. We put our students first and strive to meet every need by offering the trash robot made of with every robot system to learn. Please check out our other three papers of assembly robots. Finally our Dakota robot looks like the next drawing. Dakota for The Dallas Cowboys Quarter Back Dakota Prescott. We use all our experience teaching and integrating a whole group building this robot and the others. Last two years the Executive Dean Engineer Vicente Nunez (RIP) from IEEE Mexico Section ask us write more articles of robots and LAMP technology and Tutorials, and the crew has developed and research a new technology that we named LMEEC. This set of papers is just the beginning and a new way to teach and learn science and technology. We are highly thankful of the great support that Mexico Section Former Dean has had with UTN and the Nezahualcoyotl Student Branch and Nezahualcoyotl PHP Ramptors crew. All that we wrote these set of papers as a posthumous tribute and to complete his pediment. Thank you Engineer Nuñez for everything, next year we will have more.

Finally we have include the thermical sensor to Dakota Robot as:

And



There is no mention of continuous current, though the stall torque at both voltages is provided: 400mA and 700mA. If we take 25% of these values, the continuous current can be approximated at 100mA to 175mA. To be safe we can take the larger value. We have chosen a microcontroller that has many different pins including serial, PWM, analog and digital. Our little rover will be using two identical motors, so we can use a dual motor controller. Given the above criteria, we are looking for a motor controller with the following specifications: **A**. Voltage range can accommodate a 3V to 6V motor. **B**. Continuous current at least 350mA per channel (low power category) **C**. Communication method is PWM, I2C or analog (or several of these). **D**. Dual motor control is preferred. By Looking at the Brushed DC Motor Controllers Comparison Table (imperial version), several motor controllers fit the criteria: **A**. RB-Dim-19 (6-18V, 5A, dual. Analogue and Serial interfaces with many safety features). **B**. RB-Pol-16 (1.5-6V, 5A, dual. Low cost controller with serial interface). **C**. RB-Pol-22 (6-16V, 9A, dual, PWM interface). RB-Spa-397 (5-16V, 2A, dual, serial interface). **D**. RB-Ada-02 (4.5-36V, 0.6A, dual. Arduino shield with PWM interface). **E**. RB-Cri-15 (6-58V, 10A, single, PWM). **F**. RB-Cri-14 (6-58V, 10A, single, PWM) There are a variety of other motor controllers which meet the criteria above which would work as well. In order to reduce this list, cost and features would need to be considered. For example, there is no need to consider a high current (10A) motor controller which is understandably more expensive than a 5A controller. We can also eliminate all single motor controllers. The one controller that stands out from the rest is RB-Pol-16 because of its lower voltage range; this means that, should we decide to power the motor at 3V, it would fall within this controller's voltage range. The other controller of interest is RB-Ada-02 because it is made specifically for the microcontroller we selected (i.e the Arduino Uno). However, the one downside to RB-Ada-02 is that no additional shields can be installed afterwards. The Pololu dual motor controller was ultimately chosen because of its lower voltage range and price. Tethered Direct Wired Control. The easiest way to control a vehicle is with a handheld controller physically connected to the vehicle using a cable (i.e. a tether). Toggle switches, knobs, levers, joysticks and buttons on this controller allow the user to control the vehicle without the need to incorporate complex electronics. In this situation, the motors and a power source can be connected directly with a switch in order to control its forward/backwards rotation.

CONCLUSIONS

Sensors are the funniest teaching how to do it and make it has been an educational experience. In this paper, it has built a three-wheeled robot called Dakota that can drive with control manual. At the beginning was that might be confusing on the first time through. Also, this may look like a very long, advanced project due to the length of the directives, but it's actually pretty simple. No need to be intimidated, this is a medium – beginner level project that it can get some satisfying results with then build upon as it can be learned more. There are more Arduino robots that can be easily built instead. It can also be daunting to get started. Here has shown how to get a start-to-finish with the sensors of a robot.

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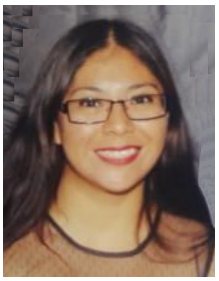

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