

# An introduction to Robotics with LEGO® MINDSTORMS (IV)

## How does a robot feel?

*Text and images by Koldo*

The title of this article is a small little joke, although one of the characteristics of a robot is its capacity for collecting information from its surroundings, something that's intimately related with feeling. It is something robots still do quite clumsily, but which is being improved little by little thanks to the sensors they use.

But simply collecting information isn't enough; it needs to be processed and decisions must be taken based on the information. This is something living creatures do instinctively. In the case of robots their programming carries out this task.

### Sensors

Sensors are devices capable of converting the value of a magnitude (of something that can be measured) into an electrical signal which can then be transformed into numerical data.

LEGO® MINDSTORMS and the NXT-G software offer a system with which you don't need to worry about how this works in such a way that the use of more or less sophisticated sensors is available to every type of user.

Version 1.0 of the LEGO MINDSTORMS NXT set contained 4 sensors: sound, light, ultrasound (to measure distance) and touch. In version 2.0 some changes have been made and it contains the following: a colour sensor which can also be used as a light sensor, two touch sensors and an ultrasound sensor. Soon it will be possible to buy the colour sensor separately.

But this is not the end of the available sensor options for a LEGO MINDSTORMS robot; with the NXT, LEGO opened up the market so other companies could offer complements to its system. As a result, at this moment there is a considerable number of available sensors for the NXT.

In this article I will present some of the options that are available to anyone who want to extend the sensor system of their robots.

### Manufacturers

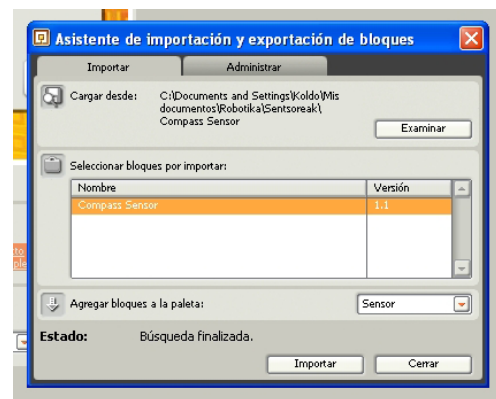
The largest part of available options is made by two companies: Hitechnic and Mindsensors. The first of these offers LEGO certified sensors with an external appearance that is similar to the original ones, while the second has an interesting assortment aimed at more advanced users. Both offer the necessary software to be able to use the sensors with the NXT (NXT-G programming blocks and drivers for other languages).

The software

In order to use a new sensor with NXT-G you need to have the corresponding programming block. This block can be

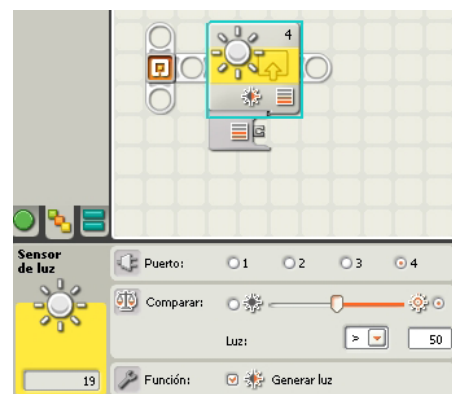
downloaded from the official website or the manufacturer and needs to be installed into NXT-G. After downloading the block we need to follow the following steps:

1. Open NXT-G
2. Open Tools > Block Import and Export Wizard
3. Use Browse to go to the folder you downloaded and extracted the block to
4. Select what palette e want the block to appear in (in our case Sensor)
5. Click on the name of the sensor and then on the Import button



From now on we will be able to use the block just like any other. An interesting strategy to follow before buying a new sensor is downloading the block and installing it to see what options it gives you.

If during programming we need to know what value a sensor will give in a specific situation - level of brightness, readings from an accelerometer - we can use the option View on the NXT itself or connect the NXT to the computer and use NXT-G create a new program with the block for this sensor. To the left of the configuration panel of this block we will see the value of the sensor as can be seen in the image.



## Accelerometer

In physics, acceleration is a magnitude that represents the change in speed of an object. It's what we perceive when we are on a bus that starts to drive or stops and it is what gives us the feeling our stomach will come out of our mouth when we go on a roller coaster ride. So when something starts moving, when it changes direction or when it stops there is acceleration.

In order to measure acceleration you can use an accelerometer, a device that is ever more present in a variety of applications: Wii controls, mobile phones with rotating screens... They are capable of detecting vertical direction, more or less sudden movements, and transform the signal to generate different behaviours.

The accelerometers available for the NXT measure the acceleration they are subjected to in any direction in space, that is to say in three axis, x, y and z.

We can use an acceleration sensor in different ways but I will mention two uses in this article.



### Detecting and measuring a slope

If we keep an accelerometer that measures three axis still in a horizontal plane, the readings it gives for two of the three axis will be 0 while the value that corresponds to the acceleration of gravity will be  $g=9,8/s^2$ . These values will not change as long as the sensor doesn't move. If we tilt the sensor, at least one of the values will start to increase while the value that corresponds to the acceleration of gravity will go down. In this way the robot is able to detect whether it is on a level plane or on a slope.

### Building a Wii-like remote

Building a Wii-like remote to control a vehicle is an interesting project. This can be done using two NXTs and establishing a bluetooth communication between them or building a vehicle with PF motors and controlling it by means of an IR signal.

Whatever the case, we need to define a way to transmit our commands to the remote control. Traditionally this has been done in remote controlled vehicles and videogames by means of levers and buttons, but the appearance of the Wii-remote has changed our expectations of what a remote control can do: it should be able to detect and measure the movements of a hand and convert these readings into commands.

In order to build such a remote control the only thing we need is a NXT, an accelerometer and a cable to connect both.

## The compass

The compass is a sensor that helps with navigation, as it allows the robot to know which way it is facing. This sensor uses the magnetic field of the Earth to determine its heading.

This can cause some problems in the use of the sensor as both metal masses and motors can affect these readings. To avoid problems it is best to place the sensor as far away from the motors as possible, preferably in an elevated position.

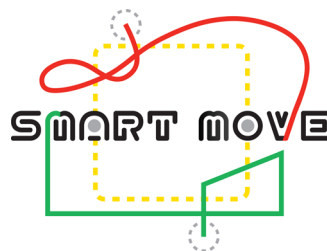
A classical project for this sensor is to build a robot that can turn itself and place it on a rotating surface, or turntable. When the surface is turned the robot will turn itself to maintain its original position.

## Sensors for education

One of the fields where LEGO® MINDSTORMS is used is different areas of education. Among these is the scientific area for which LEGO can be an excellent tool for systematic data collection in various experiments. This data can then be analysed using the NXT-G Education software, thanks to its system of data registering and processing.

Currently there are two companies that provide technology for data collection and analysis: Vernier and DCP Microdevelopments. These companies provide an adapter which allows the use of their sensors with the NXT. Some of the magnitudes that can be measured with them are the following: force, difference in potential, gas pressure, pH, conductivity...

FINAL NOTE: you can find more complete information and all the links in the Lrobotikas wiki (<http://wiki.lrobotikas.net>) #



You can find everything about the final results of the FLL at Barcelona here:

[http://www.firstLEGOleague.es/index.php?option=com\\_content&view=article&id=84&Itemid=100096](http://www.firstLEGOleague.es/index.php?option=com_content&view=article&id=84&Itemid=100096)



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