An introduction to Robotics with LEGO® MINDSTORMS (XVI)

US vs. IR Sensor Comparison

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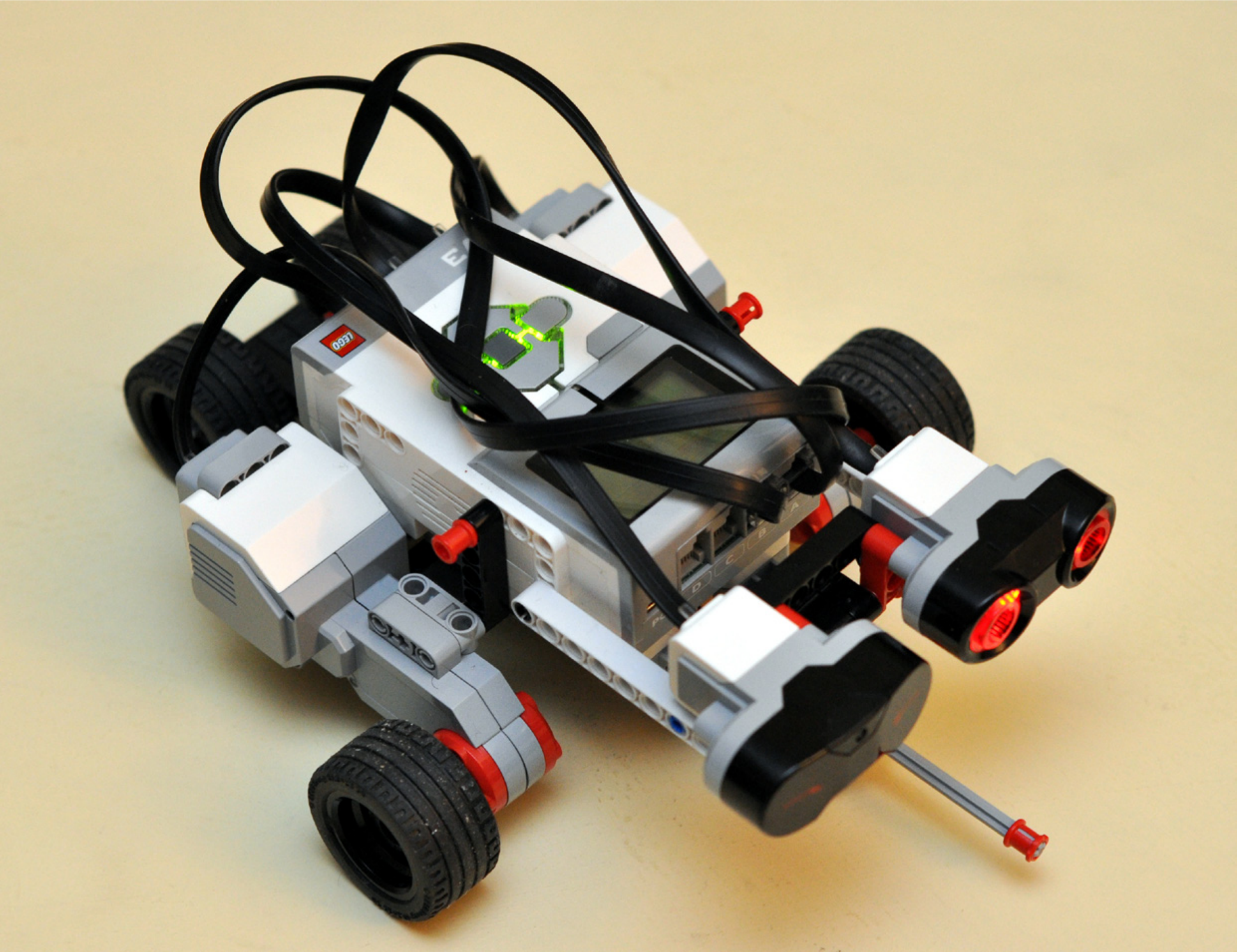
The Retail edition of the LEGO® MINDSTORMS EV3 contains an infra-red distance sensor while the Education version has an ultrasound sensor. Both allow you to measure distance, but each of them has its peculiarities.

Since it is always good to know how sensors work before starting to use any of them, I have run some tests to see how each one of them responds.

To this end I have collected data in a file on the EV3 itself, which I have then transferred to a computer to open it in a spread sheet to create graphs in order to make interpreting the data easier.

The process for saving data to a file is very similar in EV3-G when compared to NXT-G. I published another article on how to do this in HBM 017, so I will not explain it on this occasion.



Ultrasound sensor

This sensor allows you to measure the distance to an object in front of it. It gives a reading in centimetres or inches and has a maximum range of 255 cm. It emits a sound that is inaudible to people and measures the time it takes for this sound to bounce back. With this data it can calculate the distance to the object. Other ultrasound sensors or objects that the sound can bounce off of can generate interference in the readings.
Infra-red sensor

The infra-red sensor emits infra-red light (invisible to the human eye) and measure distance based on the light that is reflected. This sensor doesn't give readings in centimetres, but offers a relative value between 0 and 100, 0 being near and 100 far.

The value can change depending on the colour, roughness and other characteristics of the surface of the object.

The robot

I built a basic robot that cannot turn, just move forwards and backwards. To determine their behaviour when closing in on a wall that is perpendicular to the sensors I mounted the sensor in parallel, making it easier to compare readings.

The robot also has a touch sensor to detect the moment it touches the wall.

The program

I used the retail version of EV3-G to record the data. Contrary to the Education version, it does not include any specific tool to record data systematically, so it was necessary to develop a program that could do this. But before doing anything you need to define what exactly it is you want the program to do.

- The robot advances in a straight line at a uniform speed until it touches the wall.

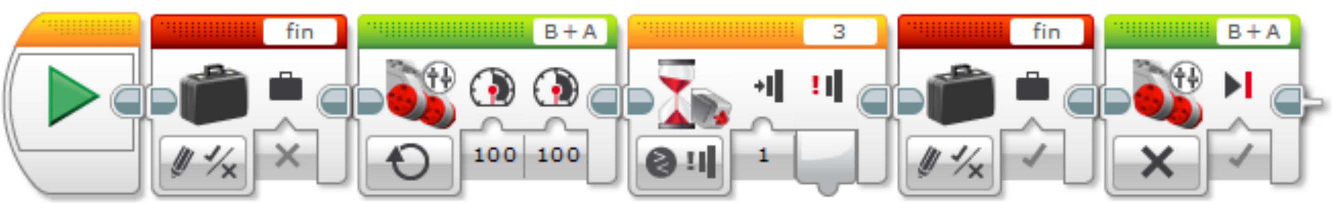
- While the robot advances it reads the data from the infra-red and ultrasound sensors every 0.05 seconds and records the values in a file.

- At the moment the robot hits the wall data registration is finished, the program exits and the robot stops.

EV3-G allows you to create programs with multiple threads that are executed simultaneously. You simply need to use more than one Start block, just like I did in this case.

The program consists of two threads. The reason for doing things this way is that the robot needs to be monitoring the touch sensor while recording the readings from the ultrasound and infra-red sensors.

The first thread is in charge of the movement of the robot and monitoring the touch sensor so it will stop as soon as it touches the wall. In order to tell the second thread to stop registering data and to close the file a variable named fin (end) is used.



The second thread registers the readings from both sensors until the robot touches the wall (when the value of fin turns to true), and then it closes the file and exits the program.

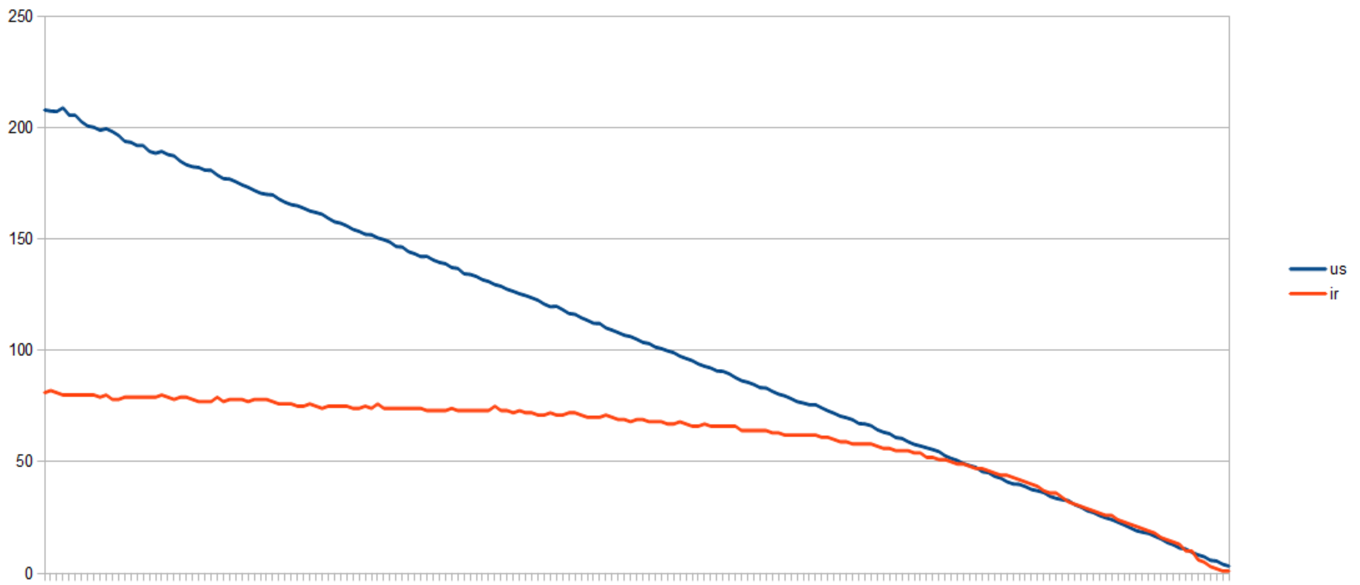
Data collection

For this experiment the robot was placed at an initial distance of 2 m from the obstacle so that it would travel towards it at a right angle. The material of the obstacle is variable while the floor is made of wood.

Results

Case 1

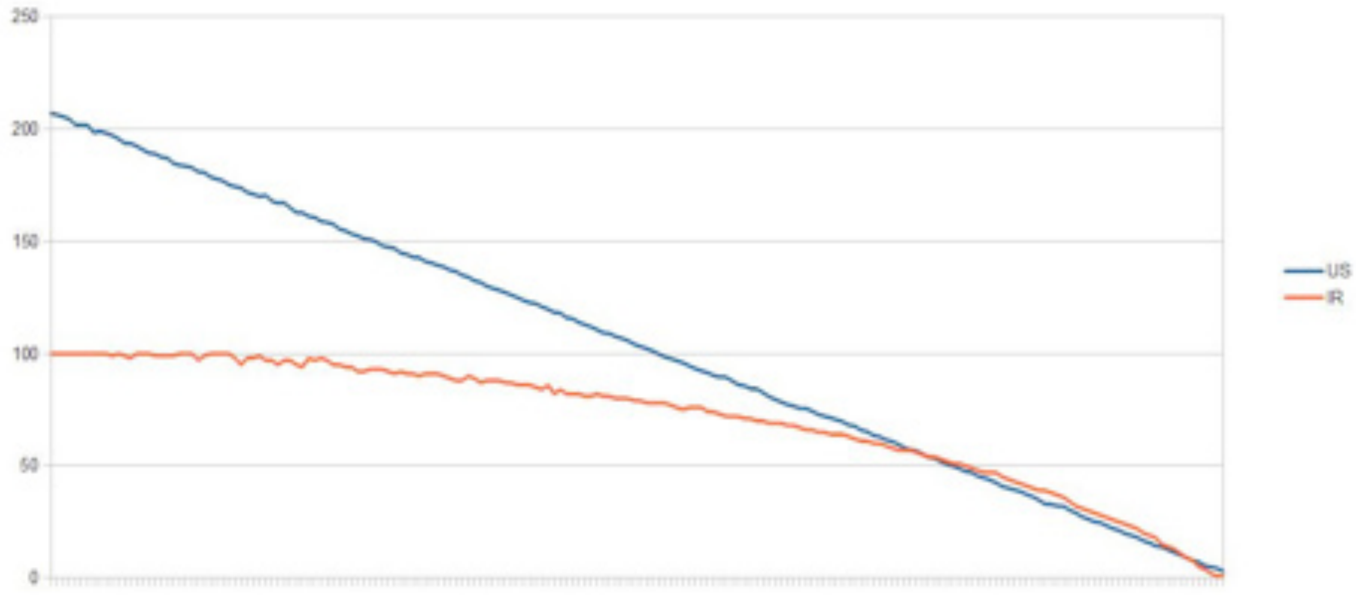
In the first test I placed a laminated wooden board with white melamine against the wall for the robot to “see”.
I ran the program with different power levels for the motors, but this has had no impact on the results. The results shown in the image correspond to a test with motor power at 50%.



The first surprise when opening the files on the computer was that although the robot was at 2m from the obstacle when it started the initial readings never indicate anything over 85cm. This has been a constant in all the tests which has led me to believe that the floor affects the readings of the sensor. And it does: with the lower part of the infra-red sensor at 6 cm from the floor the distance it measures is always less than 85.

I modified the robot to elevate the sensor and place it at 15cm from the floor. From this moment on the highest readings start at 100 as can be seen in the next image.

On the other hand, you can see that under 50cm the readings from both sensors are very similar, although the ultrasound sensor is the only one that gives a reading that is directly proportional to the distance.

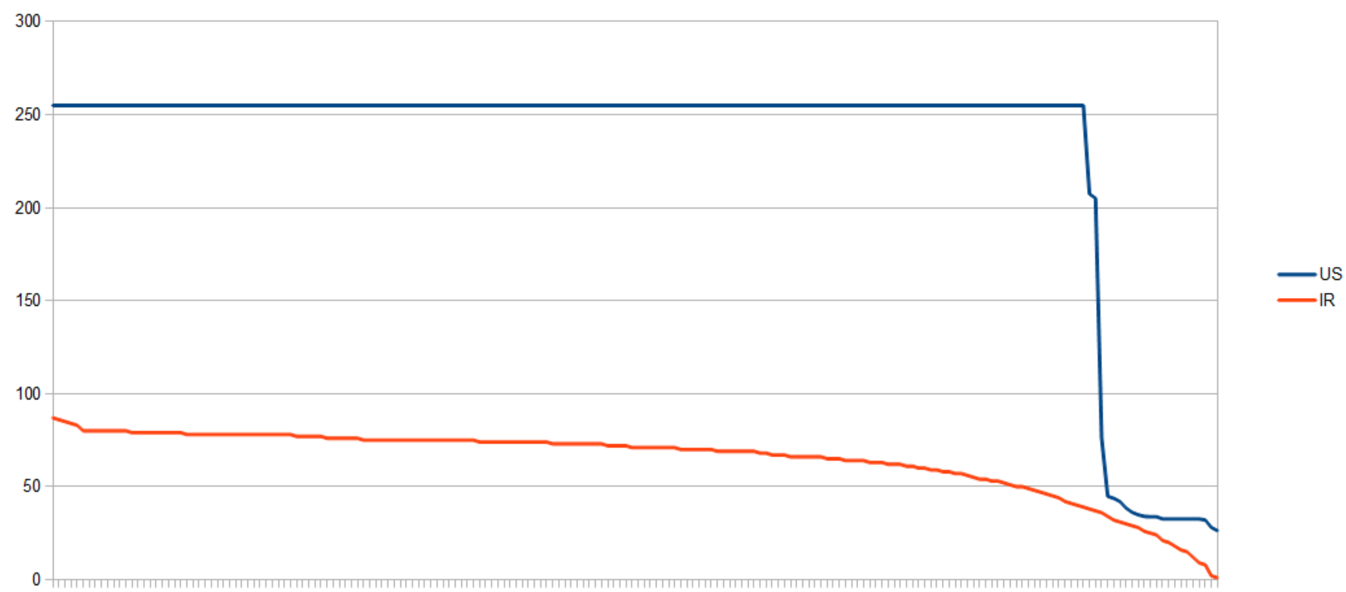


Case 2

Two years ago I had the opportunity to collaborate with LEGO® and Ericsson in an exhibition at the Mobile World Congress. The object was to give a fun demonstration of the Internet of Things. Among other things we built a robot that collected socks from the floor and placed them in baskets depending on their colour.

After building the robot, with only the picking mechanism to be adapted for picking up socks it was time to programming and testing. At first glance, finding the socks with the ultrasound sensor seemed like an easy task, but it wasn't. It's behaviour was completely unexpected and after doing some testes we realised that the sensor didn't "see" the socks; the material they were made of didn't reflect the ultrasounds in the same way as other materials do so it was impossible to locate them. After studying and testing several alternatives and in view of the limited time we ended up putting the socks in small transparent plastic bags so the sensor could see them.

So I decided to do a test with socks. I have piled up some socks and, after placing the robot at 2 meters distance again, repeated the test. You can see the results in the following graph.

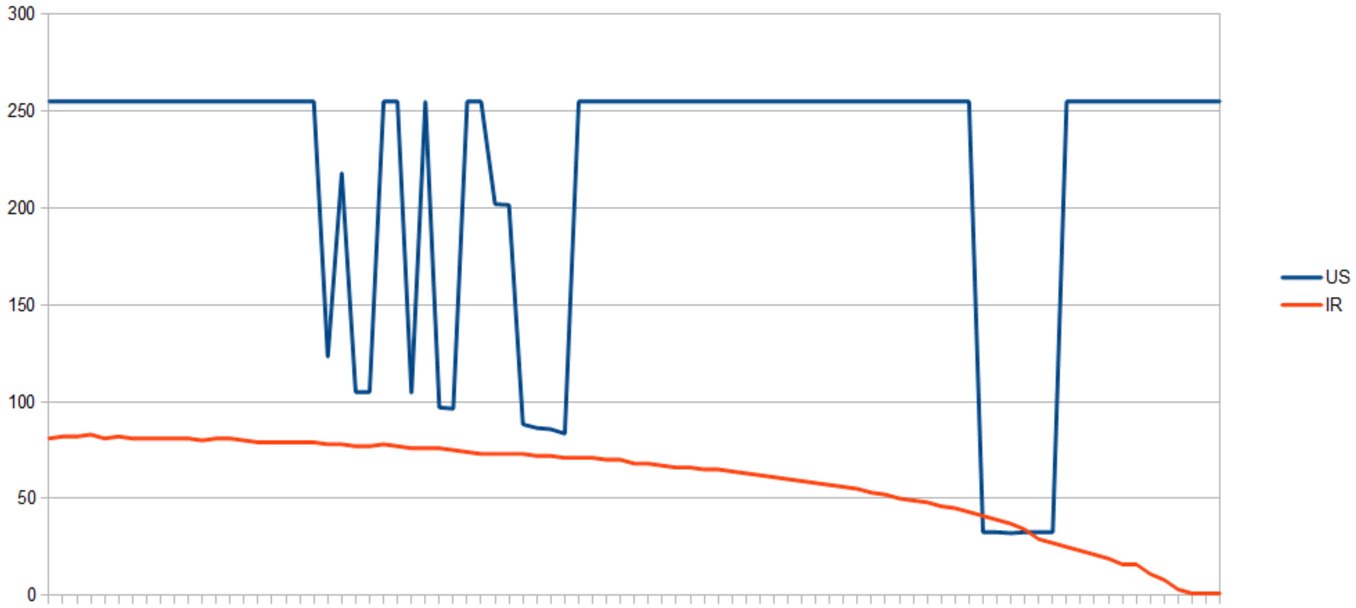


As you can see in this case the infra-red sensor is the clear winner sin the ultrasound sensor doesn't produce any reliable readings. I did another test using a box covered with a sweater and while the results were different the ultrasound sensor again did not offer any reliable results.

Case 3

The third situation I wanted to test is when a robot approaches a wall at an angle of approximately 45º. I have run several tests with varying results, but all of them had something in common: the readings from the infra-red sensor are more predictable than those of the ultrasound sensor.

The following graph shows the results of some of these tests. The results of the ultrasound sensor may be due in part to the rebounding of the sound on surrounding objects.



Conclusions.

- When using the infra-red sensor you need to keep in mind that if it is close to the floor the readings will never be over 85.

- At a distance of under 50cm the readings from both sensors are very similar, although only the ultrasound sensor readings reduce lineally as it approaches the object.

- When approaching a wall from an oblique angle the infra-red sensor provides better readings, while the ultrasound sensor is unpredictable.

- The material of the objects that need to be detected may affect the readings.

- If you wish to get readings at distances over 50cm you will have to use the ultrasound sensor.

- Always test the response of the sensors when using the robot in a new context.

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