Design and Control of a Lego Unicycle

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Abstract

Your abstract.

Contents

1 Author's note

2 Introduction

Your introduction goes here! Some examples of commonly used commands and features are listed below, to help you get started. If you have a question, please use the help menu ("?") on the top bar to search for help or ask us a question.

3 Construction

3.1 Ev3

The EV3 is the third generation of Lego Mindstorms platforms, the specification of this platform can be seen in the table 1. Furthermore some options for programming platforms are listed in the table 2. Lastly can a picture of the EV3 also be seen in figure 1

Processor	ARM9
OS	Linux- based
Sensor ports	4 , analog, digital (up to 460.8 Kbit/sec)
Motor port	4, with encoders
SD- card	Micro SD- Card Reader, (up to 32 GB)

Table 1: Specifications for the EV3 platform found at [3].

Programing platforms
Lejos (extension of JAVA)
RobotC (similar to C)
NCX (similar to C)

Table 2: Some of the optional programing platforms for the EV3.

Figure 1: Shows how the hardware platform EV3 looks like which was used in the project.

3.2   Sensors

3.2.1   HighTechinic Gyro Sensor

The Gyro sensor gives the rate of change in x, y and z orientation in radians per second. More specified details about the sensor can be seen in the table 3. The first row shows how long time it takes for our program to fetch a sample, second row shows how accurate the sensor is given by specification by the manufacturer and the last line shows the update time of the sensor also given by the manufacturer.

In nature all gyroscopes has a drift and offset, both are unwanted. The drift means that the rate of change will increase with time even though the sensor is stationary as can been observed in the figure 3. Secondly the offset is the property that give a constant value although the sensor is stationary. How we dealt with these problems will be explained in later sections. Lastly can we see the gyro sensor in figure 2.

Refresh time in program	10 ms (average)
Accuracy	±1 degree [5]
Update of value	300 times / second [5]

Table 3: Specifications for the gyro under the name NXT Gyro Sensor (NGY1044).

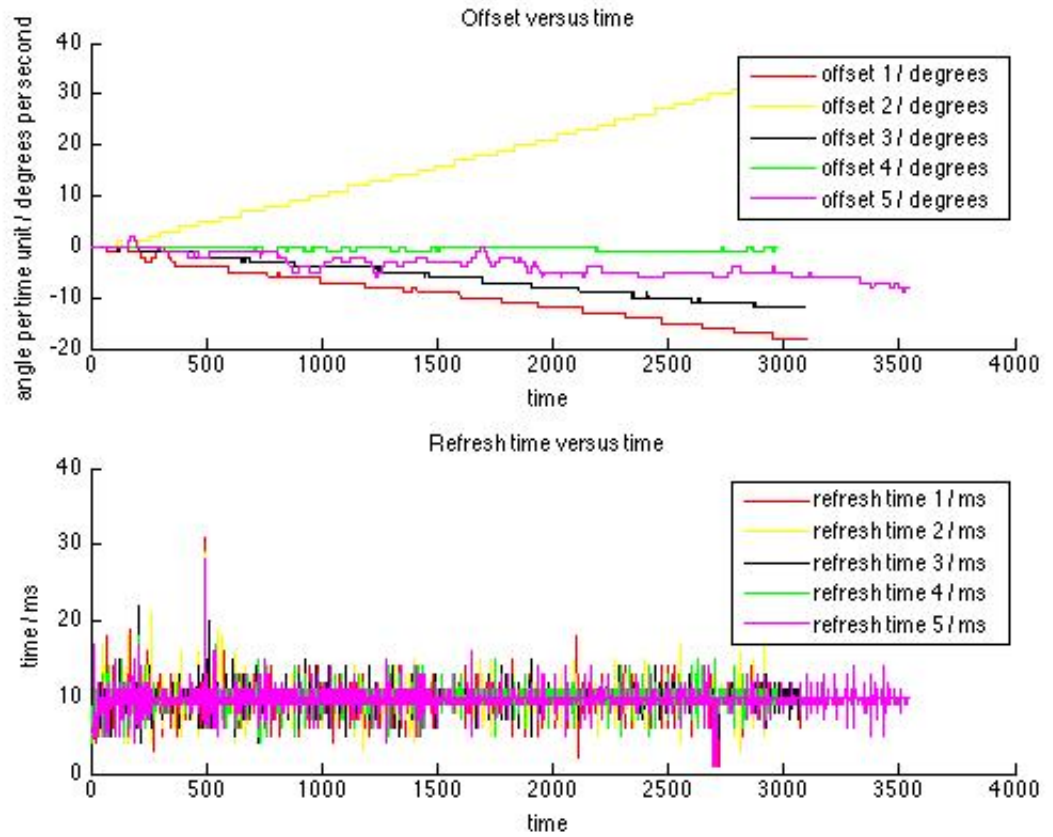Figure 2: Shows the gyro sensor which was used in the project.

Figure 3: Shows the gyro sensor's offsets and refresh times when beeing stationary.

3.2.2   HighTechinic Accelerometer Sensor

The accelerometer measure acceleration in x, y and z direction relative to the sensors specified directions given by the manufacturer. The specifications of the accelerometer can be seen in the table 4 which shows the the time for it to give a sample to our program respectively number of times the sensor can update a value. On the other hand this sensor also comes with unwanted properties which is that the value is (very) noise however when it is not noise it gives reasonable good data. We can also see how this sensor looks like in the figure 4 and the refresh time for a longer of time can be seen in the figure 5

Refresh time in program	20 ms (average)
Update of value	100 times / second [4]

Table 4: Specifications for the accelerometer under the name NXT Acceleration (NAC1040).

4

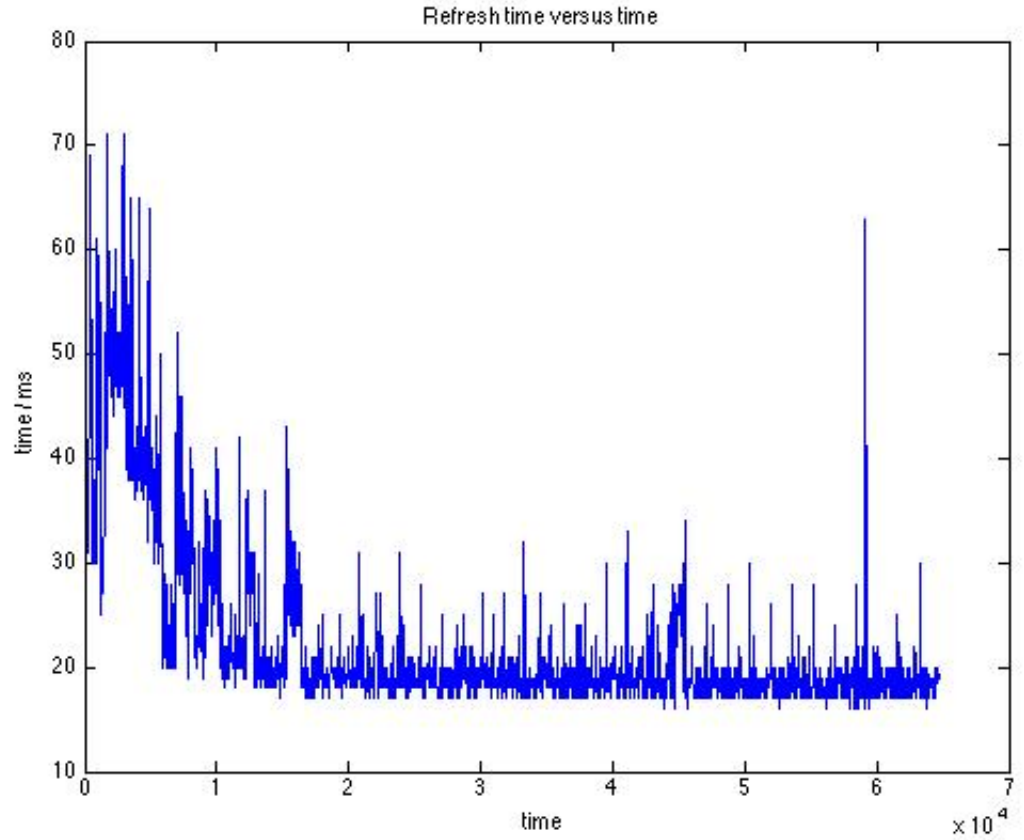Figure 4: Shows the accelerometer sensor which was used in the project.

Figure 5: Shows the accelerometer sensor refresh time.

3.2.3 AbsoluteIMU-ACG

The AbsoluteIMU-ACG can gives gyro, accelerometer and compass data but in this project we are only interested in the gyro and the accelerometer therefor we will only discuss those measurements. As discussed previously gives the gyro part the rate of change in x,y and z. The accelerometer part measures the gravity in the x,y and z direction. The interesting part of this sensor is the refresh time versus the previous sensors and the update time can be seen in the figure 6. With this sensor one can also choose to have a smoothing filter for the

accelerometer part of the IMU, downside is that this will increase the refresh time of the sensor. Therefor we did two measurements, one with sensitivity 0 and one with sensitivity 4 (figure 7).
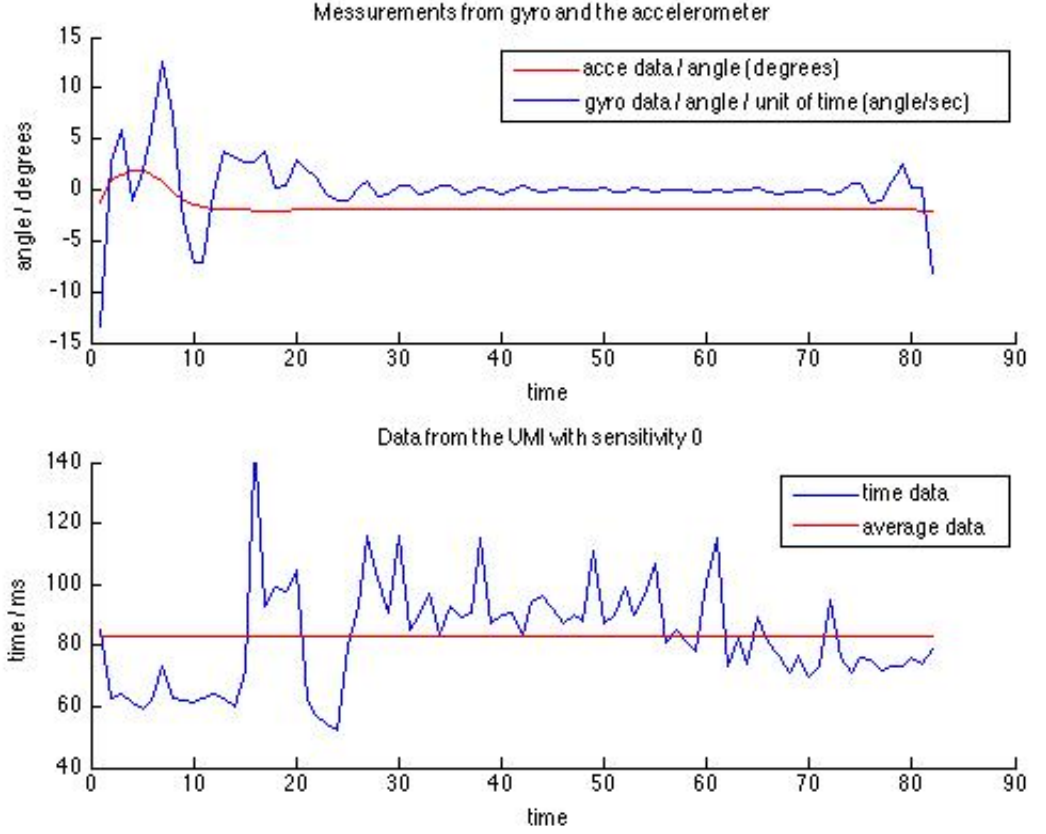

Figure 6: Shows the important properties of the IMU sensor with sensitivity 0.

Refresh time in program	83 ms (average)
Update of value	100 times / second [1]

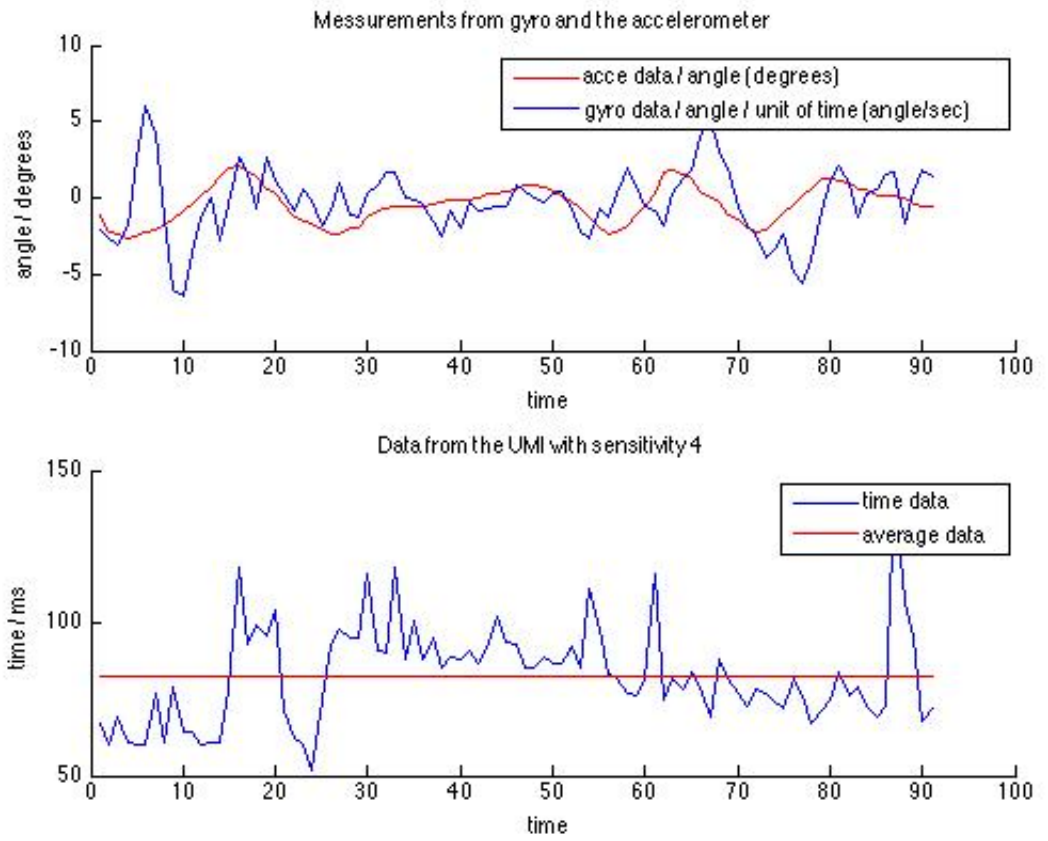Table 5: Specifications for the IMU-ACG sensor.

Figure 7: Shows the important properties of the IMU sensor with sensitivity 4.

3.3 Reaction wheel

3.4 Motors

3.4.1 EV3 Large Servo Motor

This is one of the strongest motors there is for LEGO and the specifications for this motor can be seen in the table 6. One experiment was done to get the connection between the torque and the power which is the parameter that control the PWM that goes to the motor. The power goes from -100 to 100. The result can be seen in the figure 8.
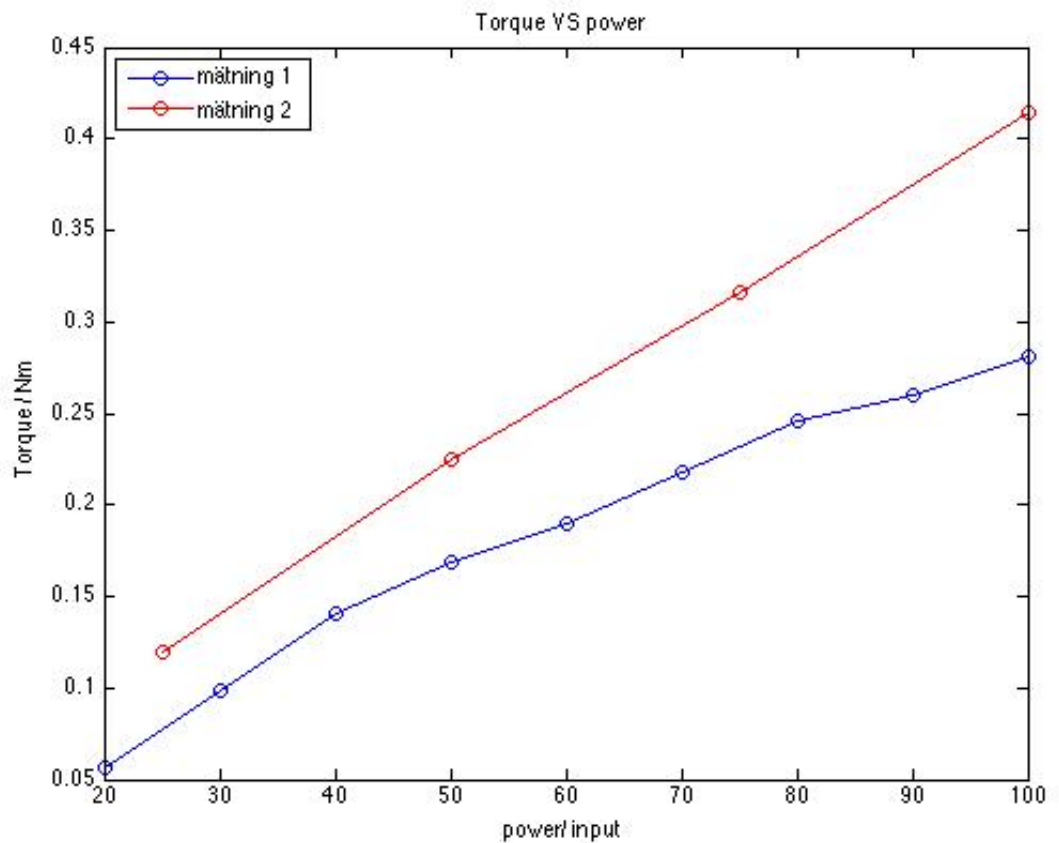

Figure 8: Shows the relation between the power and the torque of the motor.

RPM	160 - 170 [2]
Running torque	20 N/cm [2]
Stall torque	40 N/cm [2]

Table 6: Specifications for the EV3 large motor server.

4   Modeling

5   Implementation

6   Results

7   Discussion and Conclusion

References

[1] Absolute imu sensor. `http://www.mindsensors.com/index.php?module=pagemaster&PAGE_user_op=view_page&PAGE_id=158`.

[2] Ev3 large servo motor. `http://shop.lego.com/en-US/EV3-Large-Servo-Motor-45502?fromListing=listing`.

[3] Ev3 platform specifications. `http://botbench.com/blog/2013/01/08/comparing-the-nxt-and-ev3-bricks/`.

[4] Nxt acce. `https://www.hitechnic.com/cgi-bin/commerce.cgi?preadd=action&key=NAC1040`.

[5] Nxt gyro sensor. `https://www.hitechnic.com/cgi-bin/commerce.cgi?preadd=action&key=NGY1044`.