CS190: Robotics **09/03/09**

Lab A: Moving around

Introduction

The goal of this lab is to familiarize you with the NXT robotics kits and software. It is assumed that you have watched the "NXT Introduction" and "Editor Introduction" tutorials at http://www.ortop.org/NXT_Tutorial/html/essentials.html (you may have watched these via another URL). You will learn how the motors, the integrated rotation sensors, and the bump sensor work.

This lab is **due by 11:59pm on Thursday 9/10**. You work is strictly governed by the Math/CS SPCA: http://www.mathcs.emory.edu/SPCA/. In particular your work must be exclusively your own and you may not collaborate with any other group or consult any resource other than those indicated below. Violations of this policy will be referred to the Emory Honor Council.

You will be given a portion of the class period to work on the lab; however, most of you will not finish during this time. If you do not finish, you will have to sign up for time to use the NXT equipment at the front desk of the Math/CS Computer Lab in E308 (see http://www.mathcs.emory.edu/computinglab.php for hours). If a particular time slot is not full then the remaining space is available on a first come first serve basis; only one slot at at time may be obtained in this way. The attendant at the front desk will give you the NXT robot assigned to your group for the current lab. Note that your group is **fully responsible for any damage or loss** to the NXT kit while it is checked out to you.

In order to receive full credit for this lab, you must answer each question below and turn in each programming task. Files will be turned in a folder called **labA** on the **L:** drive. Each group will pick one member on whose account's **L:** drive the group's files will be turned in. More instructions for are available in the "class" section of our resources page:

http://www.mathcs.emory.edu/~cs190000/resources.html.

I prefer that you electronically turn in your answers to the lab questions in a filed called "answers"; acceptable formats include plain text ("answers.txt"), rich text ("answers.rtf"), PDF ("answers.pdf"), and Microsoft Word ("answers.doc"). Please let me know if there is some other format you prefer.

A summary of the files you are expected to turn in appears at the end of this lab. This lab has been adapted from National Instruments' Lego NXT labs.

LEGO® MINDSTORMS® NXT Lab A

This lab session is an introduction to the use of motors and rotational sensors for the Lego Mindstorm NXT. The first few parts of this exercise will introduce the use of the Move blocks to perform motion. The last part is a task to move the robot along a specific path.

Lab Summary

A. Use the Lego Mindstorm NXT software to monitor the rotational sensors of the motors
B. Create a program to move the robot forward, backward, left, and right
C. Use what you have learned to create your own program that makes the robot move in a specified pattern

Software

- Lego Mindstorm NXT

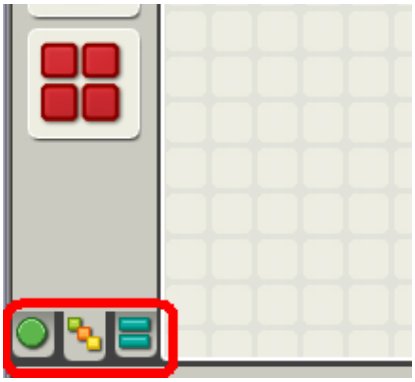
Hardware

- Lego Mindstorm NXT Tribot

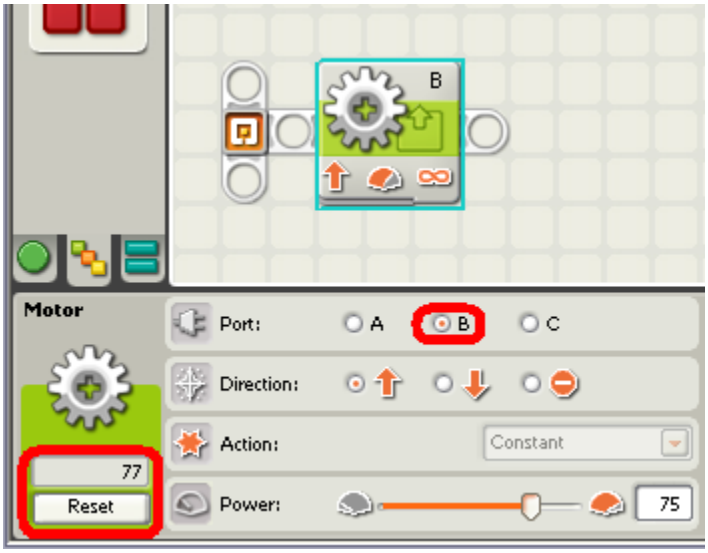
Part A: Monitoring the Rotational Sensors of the Motor

1. Open the Mindstorm NXT software on your computer
2. Go to **File >> New** to create a new project
3. Press the orange, square **Enter** button on the Mindstorm NXT Tribot to turn the robot on
4. Using a USB Cable, connect the Tribot to a USB port on your computer
5. Detect the Robot by clicking on the **NXT Window** button on the lower right of the screen as shown here:

6. A connection dialog window will open. Click on the **Scan** button to detect the robot that is connected to the PC. The name of your robot should appear in the list on the left side of the dialog box.
7. Click on your robot, and then click **Connect.** Detailed information about your robot including battery life, free storage space on the NXT block, and the version of the firmware installed should appear on the right side. This indicates that the software is now connected to the Tribot.
8. Click on the **Memory** tab at the top of this dialog window. This display describes what programs are currently loaded onto the NXT block.
9. Close the dialog box, and navigate to the **Complete** palette found at the bottom of the palette bar on the left side of the NXT interface shown in the following image:



10. Place a **Motor** block found in the Action sub palette
11. Click on a Motor block. The following configuration section should appear at the bottom of the NXT software interface:



Whenever the software is connected to Tribot, the numeric indicator shown at the bottom left corner of the configuration window should appear to have a white background. This means that whatever value is shown in the indicator is the value that the Tribot currently has for that particular sensor.

12. Select a port that is connected to one of the wheels on the Tribot, and try rolling the Tribot forward on the table. The number shown in the indicator should change.

    There are rotational sensors installed for each motor on the Tribot called *encoders*. These devices send a pulse to the NXT block on the Tribot whenever they detect a small change in the rotation of the wheel. These pulses can be counted and used to report what the particular motor is currently doing.

    This information can also be obtained directly from the NXT brick as follows.

    i. From the main menu start at the **My Files** icon.

    ii. Press the right arrow button two times and select the **View** option by pressing the orange button. If you make a mistake you can usually use the dark grey button to return to the previous menu.

    iii. Press the left arrow button four times and select the **Motor degrees** option.

    iv. Select a motor port, for example **Port B**, on the next menu. You will be presented with a box which displays the rotational sensor value. Manually rotate each of the wheels to find the one that corresponds to Port B.

Questions:

a) What happens to the sensor value as the corresponding wheel is rotated?

b) What happens when the wheel is rotated backwards?

c) What happens if the encoder reading falls below zero?

d) Approximately how many ticks equal one whole revolution of the wheel?

e) Does the number reset to zero when a whole rotation is complete? If not, then what happens to the number?

f) What range of values do you expect the sensor to display? Why? Test your hypothesis by spinning the wheel until either (i) your hypothesis is conclusively verified or refuted, or (ii) your grow tired or old.

g) How can the rotational sensor value be used to measure the distance the Tribot has traveled? Give a formula that gives an estimate of the distance traveled in terms of the variable **r,** which represents the current value of the rotation sensor. You may assume that the sensor starts at a value of 0.

h) Does your above formula always give the distance traveled? If not, under what cirucmstances might it fail?

Part B: Command the Tribot to Move

This part of the exercise will command the Tribot to move forward, backward, left, and right. It will also introduce the use of Profiles in the LEGO Mindstorm software so that you can save your work easier.

Create a new profile:

1. Select **Edit >> Manage Profiles** from the menu bar at the top of the window
2. Click **Create**, type in your name for the profile, then click **Close** to create the new profile. Whenever you return to the NXT lab, you can select this profile to revert back to all of your settings.
3. Select your profile in the **User Profile** drop-down box

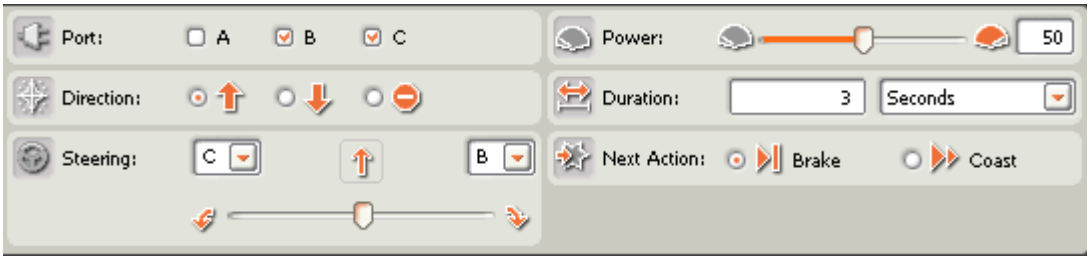
Move the Tribot:

1. Select **File >> New**, or **Ctrl–N** on the keyboard to create a new program.
2. Select the **Move Block** from the **Common** palette and place it on the sequence beam.

   This block is similar to the Motor block. However, it has the ability to command multiple motors to move.

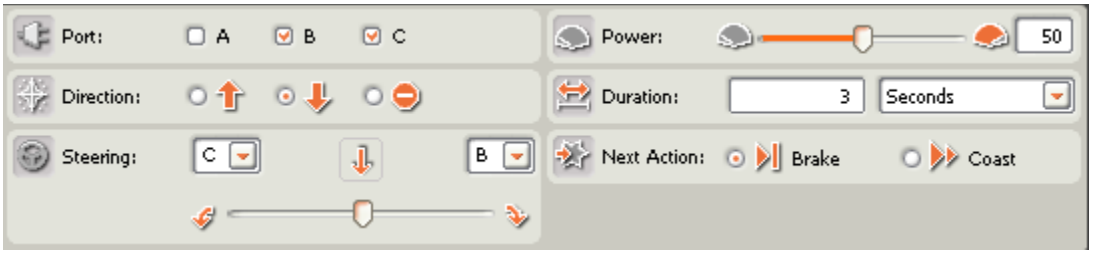
For more information on how to use this block along with any others, click on the **More Help** link shown in the lower right corner of the NXT software program to open detailed help about that particular block. Make sure that the block that you wish to get more help on is selected first.

3. Click on the Move Block to bring up the configuration window for it at the bottom of the software window. Configure this block as shown:



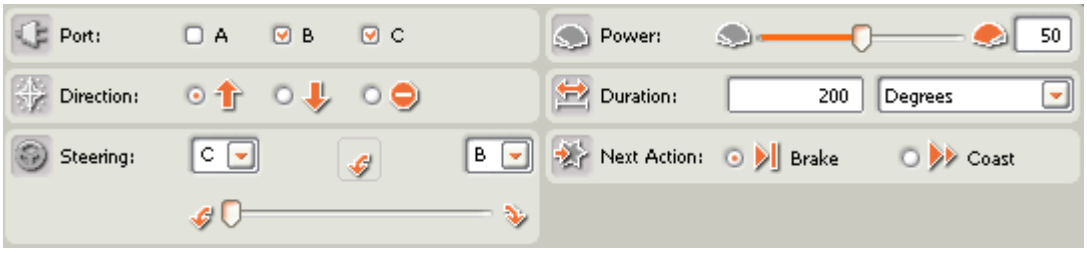
This configuration will command the Tribot to move forward for 3 seconds at a power of 50%, and then brake when it reaches its destination. Notice that a power level of 50% was used instead of 100%. In general, it is good practice to specify conservative power values for motors to help conserve battery life on the Tribot. Use stronger power values whenever they are necessary.

4. Place another **Move** Block on the sequence beam, and configure it to move the Tribot backwards as shown:



Once the Tribot completes this block, it should be sitting back at its starting position.

5. Place another **Move** Block that will command the Tribot to turn left by configuring it as shown:

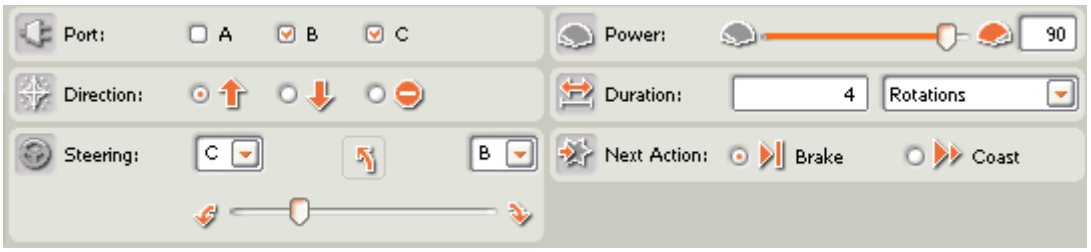


Notice that a duration of 200 degrees is selected instead of seconds.

6. Place and configure another **Move** Block to move the Tribot back to its starting position again.

Tip: You can copy and paste NXT blocks by selecting the objects to copy, and going to **Edit >> Copy**. You can paste by going to **Edit >> Paste**. The pasted blocks will have to be moved back to the sequence beam to become active again. Be careful with copying blocks since the settings for the blocks are also copied.

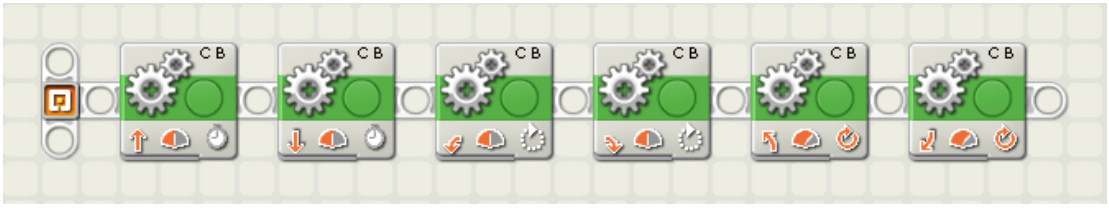
7. Place and configure another **Move** Block that will turn the Tribot at a slightly less angle than the previous left turn as shown:



Note that the Steering slider bar has been moved five spaces left from of center, the duration is set to rotations, and the power has been increased to 90%.

8. Place another **Move** Block, and configure it so that the Tribot moves back to its starting position.

The finished program should look something like the following:



Save your program:

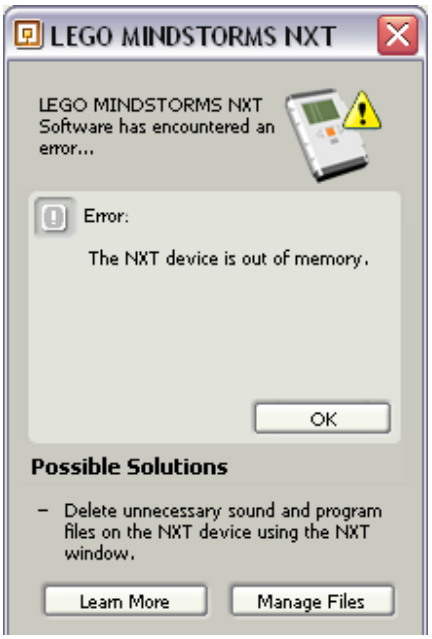
1. Go to **File >> Save As**.
2. Click on the **Browse** button, create a new folder, and name it "Exercise 1."
3. Type "Ex-1b.rbt" as the name of the file, and click OK. You should be taken back to the previous dialog window.
4. Click **Save** to save the program, and close the dialog box.

Download and run your program on the Tribot:

1. With the Tribot connected and powered on, click on the **Download** button found at the lower right corner of the NXT software interface as shown:

This will download the program, along with any other supporting files to the NXT block. If the download completes successfully, you should see the following status window briefly:

If you get a dialog that looks like the following:



This means that the NXT block cannot fit the program that you are trying to download because there too many other files on the NXT block. Click on the **Manage Files** button to go back to the Memory Management dialog window, and delete any unnecessary programs that are residing on the NXT block. Close the dialog, and try downloading again.

2. Once the download completes successfully, disconnect the Tribot from your computer, and place it somewhere on the floor where there are no objects in the way.
3. Run the program on the Tribot by navigating to **My Files >> Software Files**. Select your program, and run it.

There is a battery indicator in the upper right corner of the NXT window that shows the battery life of the robot. Recharge the battery if the indicator shows low battery life to ensure that the Tribot moves reliably.

Questions:

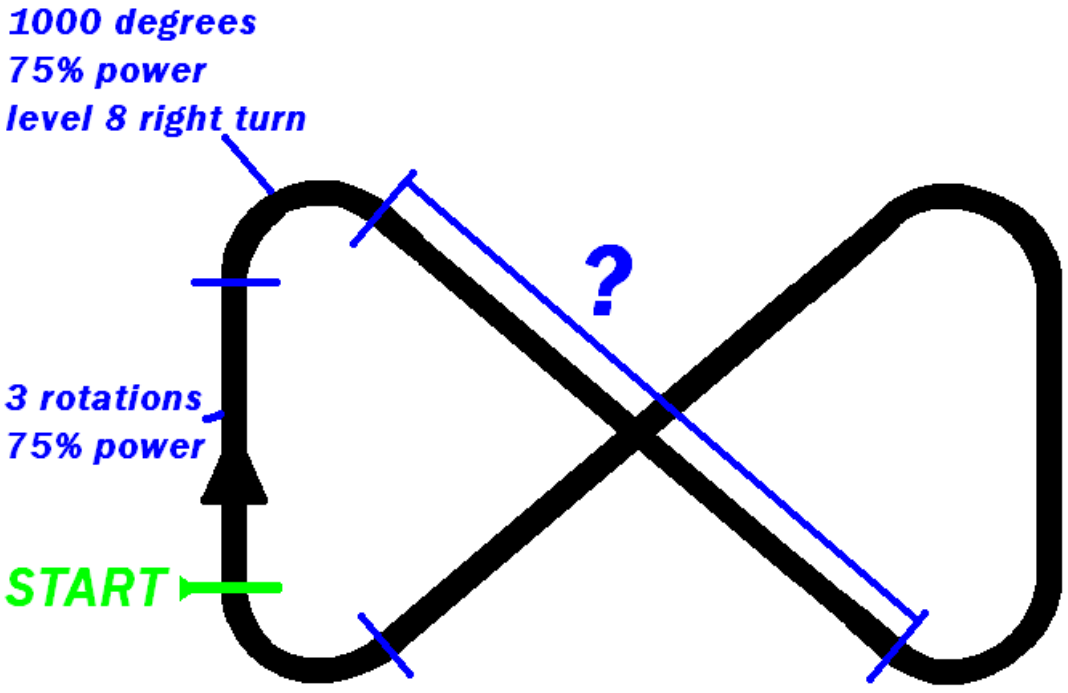
a) The fourth **Move** Block can also return the Tribot to its initial position when the block's direction is chosen to move the Tribot 'backwards.' How do the other block settings need to be changed in this case?

b) Why did the Tribot chassis seem to rotate approximately 90 degrees instead of 200 degrees on the first set of left and right turns? Did any part of the Tribot rotate 200 degrees?

c) Click on each of the **Move** blocks and set the **Next Action** option to **Coast** instead of **Brake**. Now run the program again. How does the behavior of the Tribot change? What is the difference between the **Brake** and **Coast** options?

Part C: (Challenge) Move the Tribot Along a Path

The objective of this challenge is to move the robot in a figure eight pattern as shown in the following image using a series of Move blocks:



The following criteria must be met to pass the challenge:

1) **The robot must start by moving forward 3 rotations at 75% power and immediately and smoothly turning right also at 75% power. You may modify the number of degrees to suit the surface.**
2) **The robot must return to the same location and orientation from where it started.**
3) **Once the program is started on the robot, nothing is allowed to touch the robot until it finishes!**
4) **The robot must travel in a figure eight pattern similar to the one shown in the above diagram**
5) **Each team will have two trials to demonstrate their program. In each trial the Tribot will be started three times from a marked location, and for each run the Tribot's final location and position will be compared against its initial location and orientation. After the first trial, this data can be used to look for systematic errors in the program. After making improvements, each team will be allowed a second trial, also consisting of three runs.**
6) **Extra credit will go to the team whose robot is able to reasonably follow the pattern with the NXT-G program using the fewest number of blocks.**

Good luck!

Turn in the following files:

- **answers.txt** (or **answers.doc**, **answers.pdf**, ...) should contain your answers to questions a)-h) from Part A and questions a)-c) from Part B.
- **eight.rbt** should contain your solution to Part C.
- Optional: I encourage you to play around and experiment with the Tribots. **extra1.rbt, extra2.rbt, ...** should be used to turn in any programs you would like to share and have us evaluate for potential extra credit. Creativity, ingenuity, and effort are the primary criteria used in our evaluation.