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GUI-based interface makes programming robots as easy as stacking bricks

by Vince Long

In our last last issue (Spring 2008) we looked at the evolution of Lego-based robotics from the Dacta and Technic systems to the development of Mindstorms, a self-contained computer allowing autonomous robotic design. The original Mindstorms, the RCX, was a real breakthrough with its infrared link, varied sensors and motors, and its graphical programming language. The latest version, the NXT, continues Lego's commitment to the field with an upgraded, on board computer featuring a graphical display screen and Bluetooth communication. However, the best improvement over the previous system was embracing National Instrument's LabView programming environment. In this article we will look at the build of a common mobile robot, how LabView is used to control motors and sensors, and how basic programming constructs are implement in this application.

There are, of course, an infinite number of building possibilities with Lego, after all, that is one of its primary features. In robot construction the same applies except that we are generally focused on having a robot that can complete a specific task or tasks utilizing its motors and sensors. The standard Lego Lab View software features tutorials that guide the user through construction of a minimalist mobile robot that utilizes some of its features but in the classroom, the mobile bot shown in the optional Robotics Engineering Vol. 1 tutorials is a better design due to its flexibility and compatibility with its tutorials. An experienced Lego builder may wish to chart off on their own, especially if they have a specific function in mind such as a gantry/grabber bot.

The construction techniques required are no different from any other Lego project that includes wheels, axles, and gears. The NXT provides 8 ports for connecting 4 sensors, labeled 1 through 4, and 3 motors, labeled A through C. The cables that connect motors and sensors are similar to a flat telephone cable, though much less flexible, and have a modified RJ-11 modular connector on each end. The Mindstorm kit comes with cables of various lengths. The NXT itself has a USB connector (B-type) for connecting to the host computer.

The first interface which the the user needs to familiarize themselves is the one built in to the NXT itself. This 100 X 64 pixel LCD screen provides access to the stored programs on the built-in computer and to the various system settings. Navigation is accomplished by pressing three of the four buttons on the face of the NXT. Wandering through the menus might take a bit of getting used to, but it is really no different from other hand held devices in use today, such as a cell phone, where many options are accessed using a minimalist external interface.

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The two images above show examples of the NXT interface. Navigation is accomplished by pressing the left and right arrows and selections are made with the center, orage, button.

Through this NXT menu system we can read basic feedback from various sensors, scroll through and activate stored programs, run built-in demonstration programs, set system preferences, and configure the Bluetooth wireless communications. For the latter, the NXT can do a search for local Bluetooth devices, usually other NXTs or Bluetooth-capable computers, but it can poll any Bluetooth device such as a cell phone. Once other devices are found, connection can be activated and passkeys exchanged. The two primary uses for the Bluetooth feature is to allow the transfer of programs from the desktop computer to the NXT, instead of using a USB cable, and to connect to other NXTs for collaborative applications.

The LabView software supplied by Lego has been optimized for the NXT by National Instruments. The full version of LabView is a full-featured automation and simulation tool that comes with a hefty price tag (about $5,000) but our Lego version is tuned specifically for the NXT and its sensors and motors. Windows XP or a Macintosh is the required operating system and 1 gigabyte or more of RAM is suggested as Lab View is fairly bulky. Once launched the software can be configured with profiles that allow users to store their programs separate from one another, although these profiles are not password protected. On a Windows computer, the profiles and programs are actually stored in My Documents in a Lego Creations directory.

The initial user-interface includes access to building and programming tutorials but, as suggested in the optional Robotics Engineering Vol.1 tutorials, it is best to turn those off which then provides a larger programming window. There are also various "palettes," which are shortcuts to the programming icons. The options include the Common, a short list of the most commonly used tools, the Complete, which shows everything, and the Custom, which is user-configurable. In the classroom, we use the Complete palette.

Control Buttons

In the lower-right of the interface is a set of 5 buttons. These allow you to access the NXT for changing its settings or downloading programs to it. Once the NXT is connected,

The panel below provides a desktop view of what is on the NXT

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clicking on the NXT Window button gives you direct access to the NXT, much like a file browser. You can rename the NXT and delete programs, sounds, and images that are stored on it.

To make the robot perform a basic move forward we need to tell it to do the following:

turn on motors B and C
set the duration the motors will be on
turn the motors off

Seems pretty simple but there are a few decisions to make along the way. Let's look at the process.

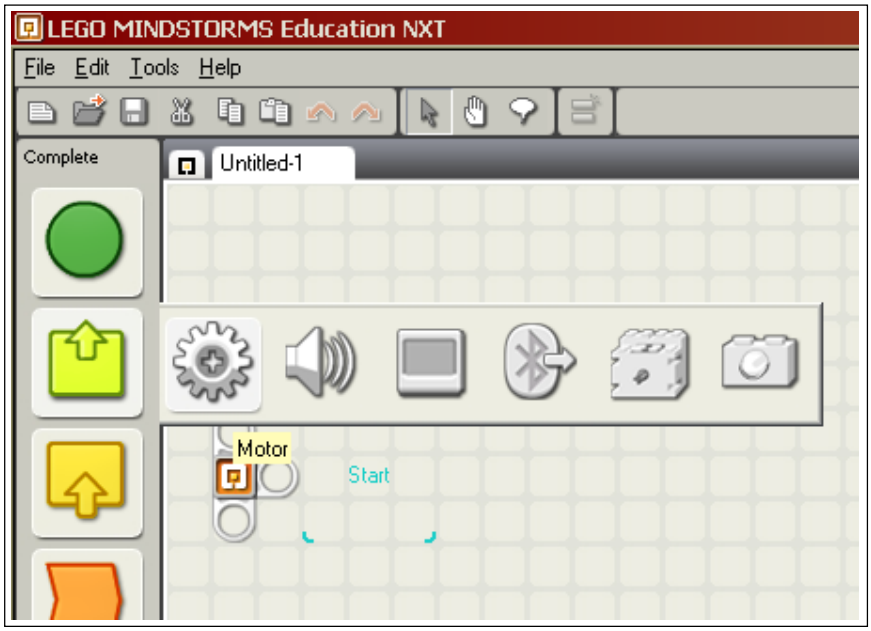

Figure 1

Figure 2

First, drag a Motor Block from the Action menu (Figure 1) in the Complete palette and drop it in the work area (Figure 2). It should anchor on the Sequence Beam. At the bottom of the screen a properties panel will appear (Figure 3). Here we can select which of our 3 motor ports we wish to control, the direction, speed, and other motor-related functions. To get another motor to run, we drag another Motor Block onto the Sequence Beam and set its properties.

Since we have so many ways to control motors we usually set the duration of their operation to "unlimited" and use a different tool to take care of that.

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Figure 3

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From the Flow menu we drag a Wait Block onto the Sequence Beam, placing after the two Motor blocks (Figure 4). The Wait Block can delay the program, allowing the motors to turn, for a specific time period or until an event occurs. The list of events are usually related to sensors. For example, we could set the motors to turn until they have turned a given number of rotations or degrees or until a touch sensor is activated. In the example below, the Wait Block has been set to wait until the motor B's rotation sensor has advanced 360 degrees (Figure 5).

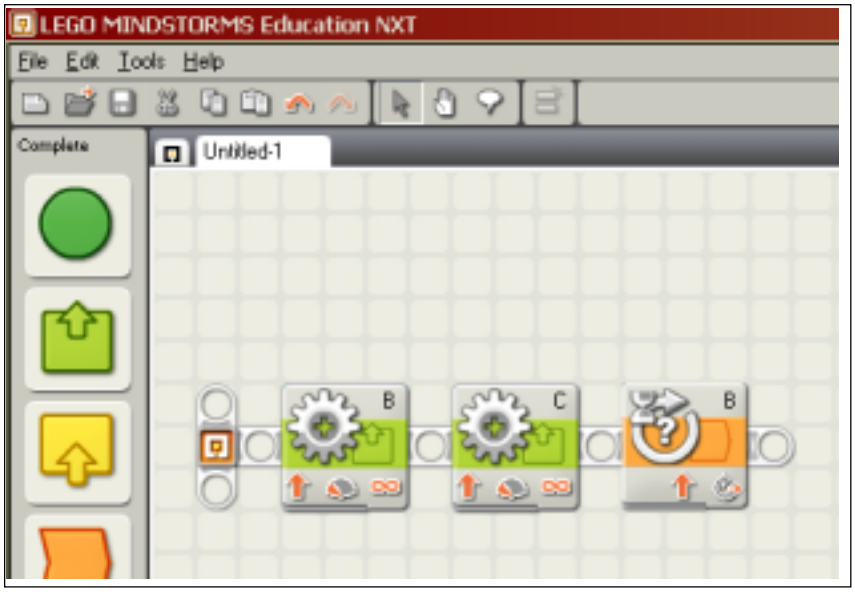
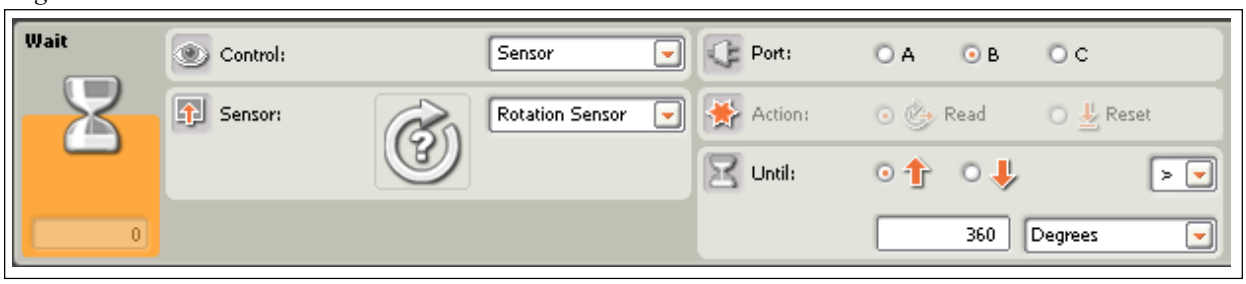


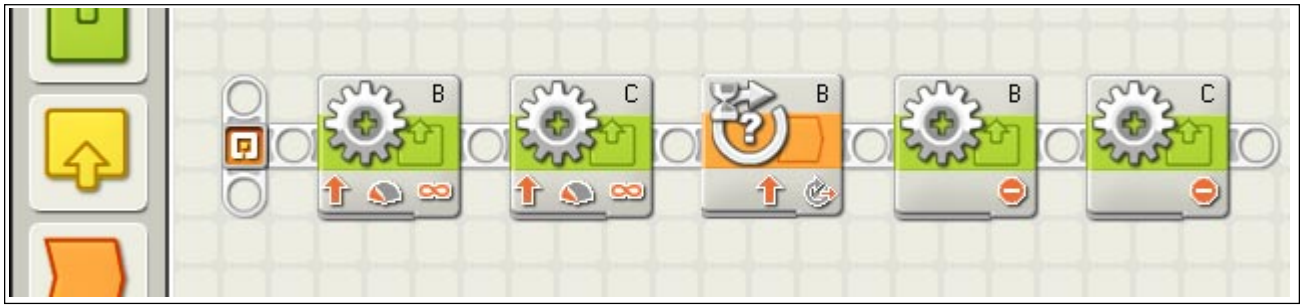
Figure 4

Figure 5



Finally, we drag two more Motor Blocks into the program and set them to turn off the motors (Figure 6).

Figure 6



After we save the program we are ready to download it to the NXT and give it a try. We click on the Download and Run button (Figure 7) and the software will compile the program into an executable form, download it to the NXT, and run it.

Figure 7

While outside the scope of this article to demonstrate the full range of possibilities that the software supports, we can touch on some of the standard constructs that are found in all programming languages. There are variables of text, numeric, and logic types. There are Switches or conditionals, that is, the "if then" construct where if an

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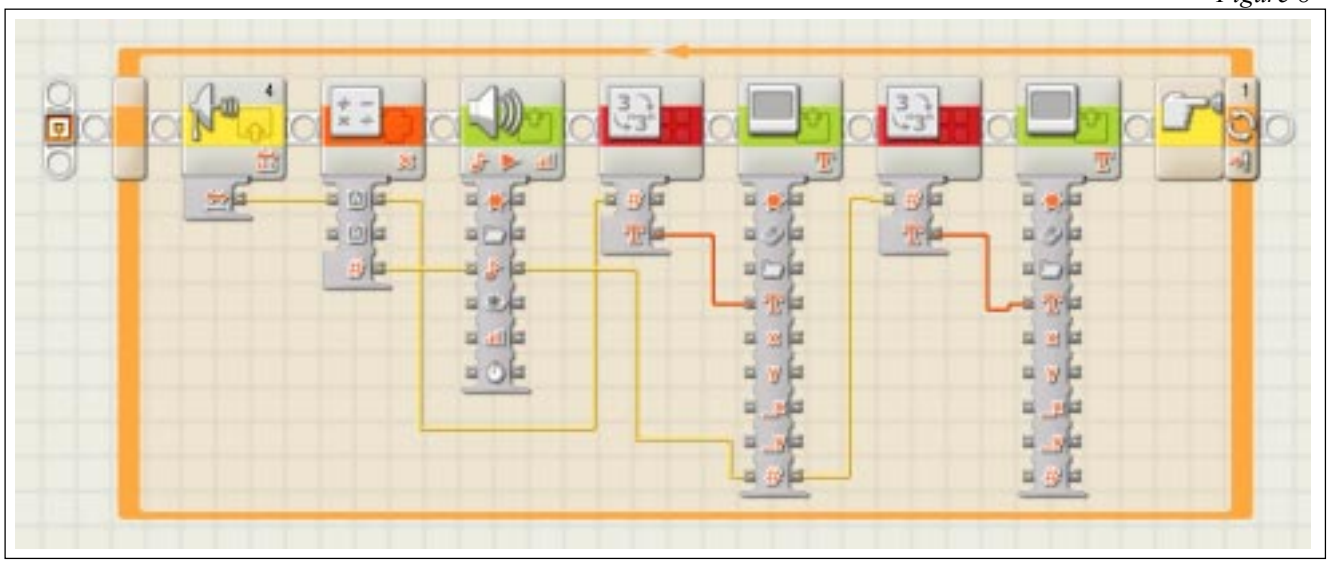
event occurs, the NXT could react to that such as a signal from a sensor or a certain value of a variable. There is a loop function that can cause the program to repeat infinitely or until a specified condition occurs. There is a calculator that can add, subtract, and divide. There are tools to control the output of data to the NXT's LCD panel or to its built-in speaker.

The use of variables uses a unique Lab View technique for passing their values to other parts of the program. All that is necessary is to draw a "wire" from the variable to another variable or a Switch, Loop, or other Block. Tools that translate between variables types are also available.

Here's a sample program that shows the use of wires to pass data between blocks. This program uses the ultra-sonic sensor to measure distance and translates that distance into a tone, the farther away an object is the higher the tone.

As is the nature of both the Lego hardware when coupled with a programming language, the possibilities here are infinite. With the wireless capabilities it is possible to develop applications where individual robots gather data and share it with one another to accomplish a collaborative task.

Figure 8



Mindstorms Resources Online

Lego Mindstorms
mindstorms.lego.com
This is the official Mindstorms site.

Fisrt Lego League
http://www.firstlegoleague.org/
Robotics competition.

NXT Club
http://www.nxtclub.com/
Online forum discussing everything about the NXT.

NXTasy online forum
http://www.nxtasy.org/
Another Mindstorms online community

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