Light Theremin - NXT

Overview

Challenge

In this activity, use an NXT brick equipped with two light sensors to emulate a Theremin. One sensor will change pitch as the amount of light sensed changes, and the other sensor will change volume as the amount of light sensed changes. The Theremin is meant to be controlled with the hands, but any object that changes the amount of light that the sensors pick up can be used.

Age Range

12-18

Topics

Light Sensors

Subjects

Math & Science
Music

Programming Themes

Logic
Mathematical Manipulation of Data
Loops

Related Math & Science Concepts

Light and Electromagnetic Waves
Sound Waves

Building and Programming

Materials

- NXT Car
- Light Sensors x 2
- Objects to manipulate sensors with (hands will do!)

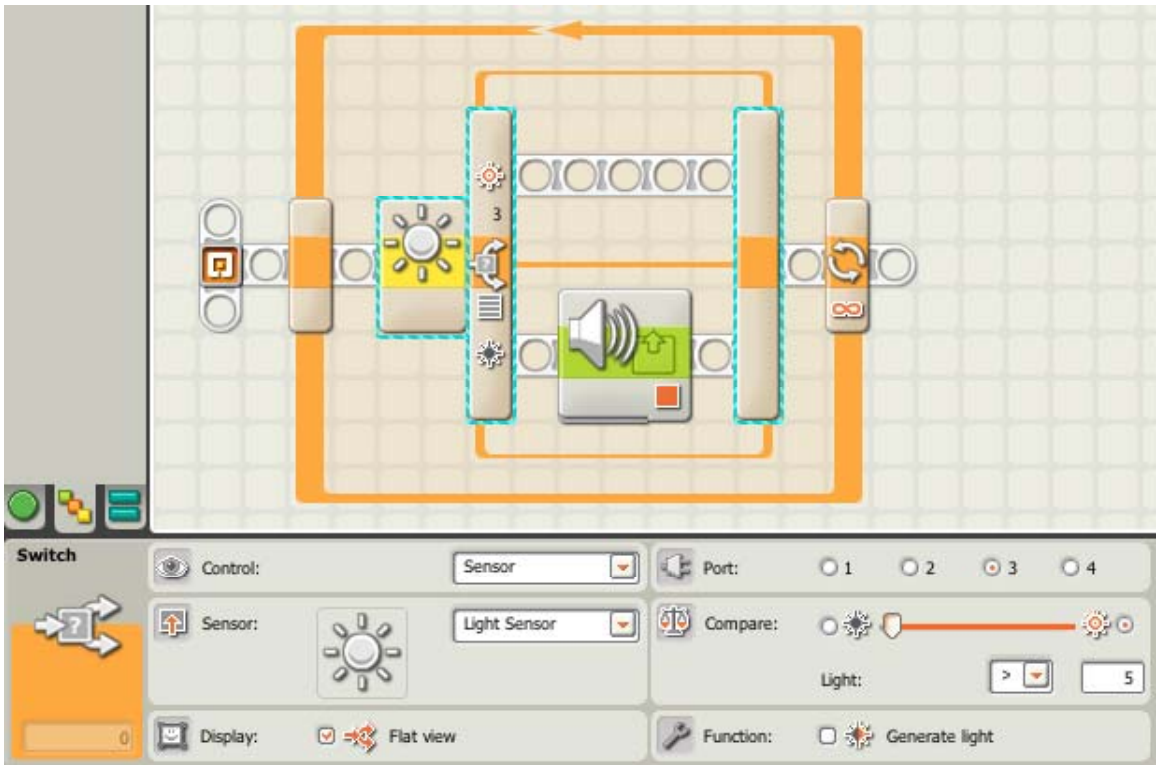
Building Instructions

1. Build a set of platforms to hold the light sensors so that they collect vertical distance data. (See Light_Platform_Instructions.pdf)
2. Connect one sensor each to ports 3 and 4 of an NXT brick.

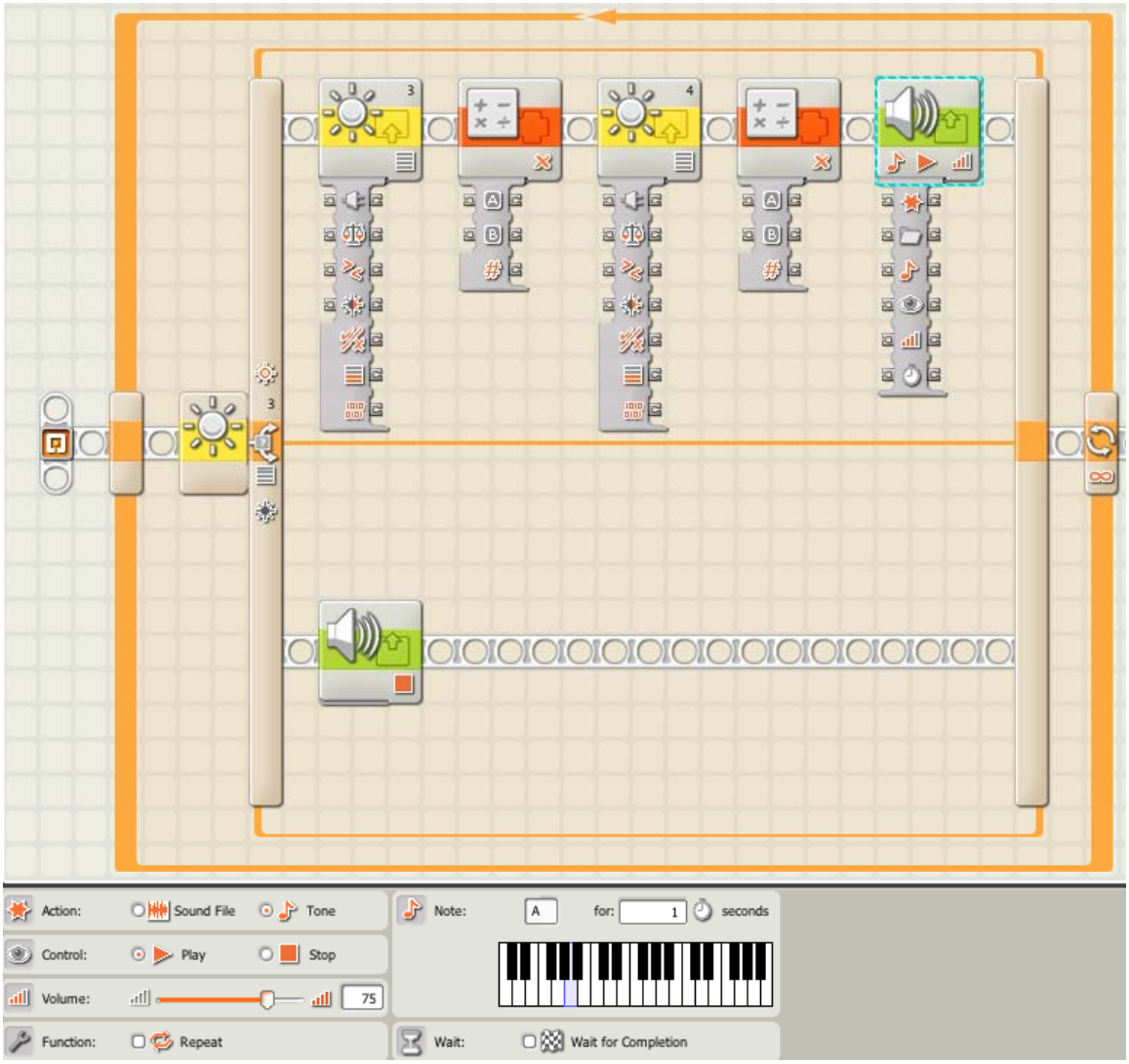
Programming Instructions

Using Mindstorms NXT-G, program one light sensor's raw value data to change the pitch of a sound using math blocks to convert the raw light data values to numbers in the appropriate range for pitch input. Program the second light sensor's intensity to change the volume of a sound, again using math blocks as intermediaries to convert the light intensity into the appropriate range for volume input.

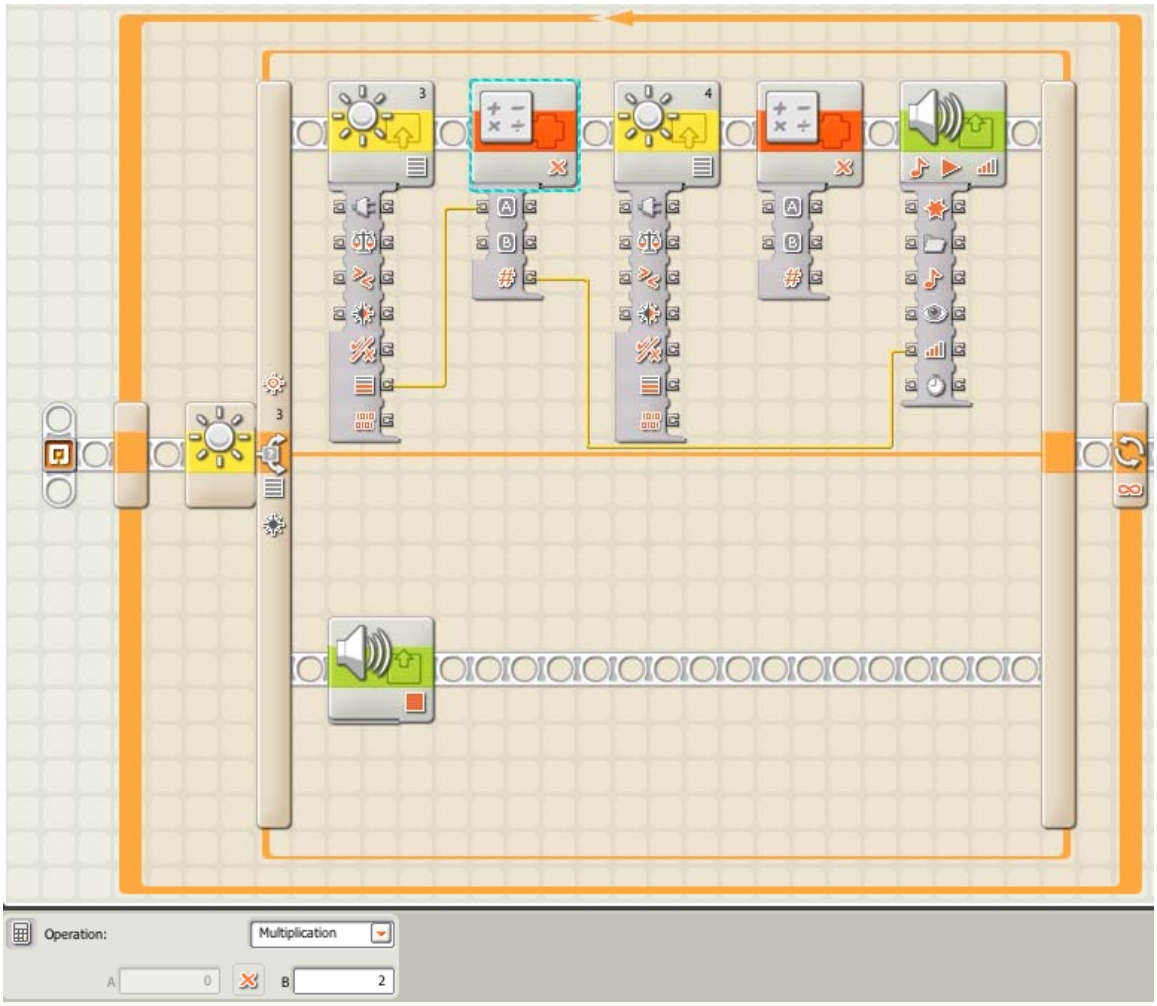
1. Start with an infinite loop with a switch inside, set to be controlled by the light sensor. Set to Compare: > 5 so that the switch is true when the light sensed is greater than five, and false otherwise. Place a "Sound" block set to Stop on the switch's false path, or lower path.



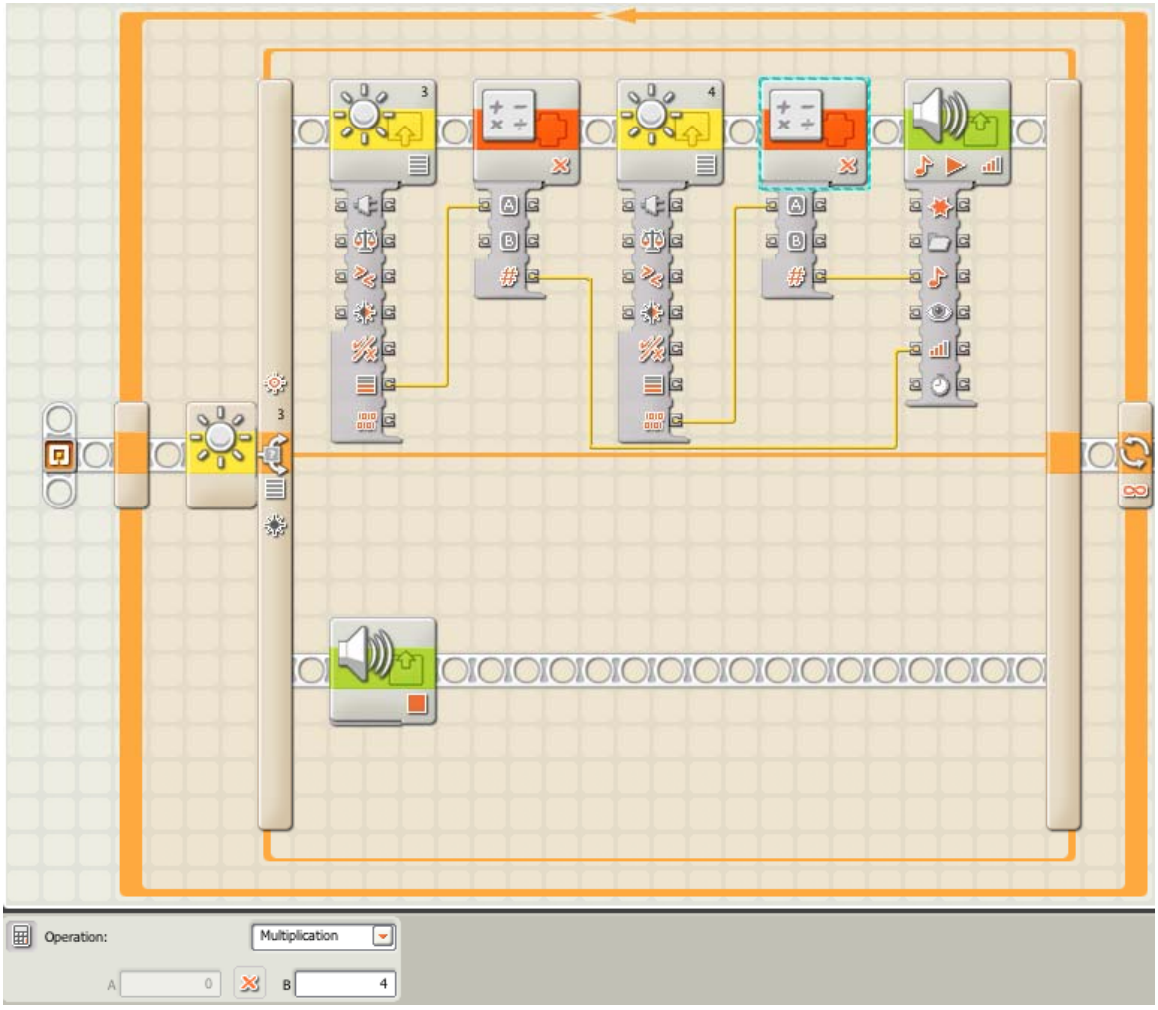
2. Next, set up the switch's true path, or upper path, with the main functions of the Theremin. Add an "Light" block, set to port 3, followed by a "Math" block. Add a second "Light" block, set to port 4, again followed by a "Math" block. Finally, insert a "Sound" block set to play a tone for 1 second.



3. The “Light” block set to port 3 will control the volume of the instrument. To convert the input from the sensor into the right range for volume, first wire the distance output from the sensor to the A input on the first “Math” block. Then, set the first “Math” block to multiplication mode, and set value B = 2. Now, wire the result from the first “Math” block to the volume on the “Sound” block.



4. The “Light” block set to port 4 will control the pitch of the instrument. To convert the input from the sensor into the correct range for pitch, first wire the distance output from the sensor to the A input on the second “Math” block. Then, set the second “Math” block to multiplication mode, and set B = 4. Finally, wire the result from the second “Math” block to the tone frequency of the “Sound” block.



In Action

Set up the instrument by placing the light sensor connected to port 3 (volume) on the left, then placing the light sensor connected to port 4 (pitch) on the right. Use weighted bricks or any small, heavy object on the flat surface of the sensor platforms to get them to stay flat on a table or other surface. Hold your hands over the sensors and move them up and down independently to control the pitch and volume of the instrument. Experiment with different motions and rates of motion over the sensors.

For more variety, change the values in the "Math" blocks and change the duration of the sound in the playing "Sound" block. See if the sound can become smoother or more "stepped" sounding (i.e. there is a lot of "zipper noise" due to the quantization of pitch values and therefore the sound does not seem smooth to the ear).

Resources/Help

Related Activities

- Ultrasonic Theremin
- Music Box
- LEGO RCX Piano
- Homemade Brita Filters
- Hypervelocity
- Line Follower

Building & Programming References

- The NXT
- Light_Theremin.rbt

Knowledge Base

- What are some possible uses for the NXT light sensor? How do I program it in NXT-G?
- I can't figure out what threshold values I should use for my light or sound sensors so that they control an action at the right moment. How can I figure this out?
- What is the NXT-G switch block for?
- How do I create a loop in NXT-G so that I can repeat one sequence of events over and over?

Classroom Management

Procedure

1. Begin the lesson with a description of how light sensing works. An introductory approach might be to explain that as more light hits the sensor, that value is sent to the program. More advanced classes can be taught the electronics of photoresistors, electromagnetism and the physics of light such as photons and the quantization of light as a particle and a wave (wave-particle duality). Electronic instruments, especially the Theremin, can also be included in this introductory period, with the potential addition of how the electronics in a Theremin work.
2. Each student or group of students should have an NXT brick with all parts necessary to create two platforms as detailed in this course pack, as well as two light sensors and two connecting cords.
3. Each student or group of students should construct the platforms for the light sensors and attach one sensor each to ports 3 and 4 of the NXT brick.
4. Have each student or group of students program their NXT bricks either using the instructions, or on their own if they are ready for the challenge. (Alternatively, the NXT bricks can be pre-loaded with the Light Theremin program to save time, if programming equipment is not readily available, or to accommodate younger classes.)
5. Have students experiment with the instrument, making changes to the program as they go if possible.
6. Collaborate as a class and compile a list of changes that might be helpful to the program, changing the qualities of the sound emitted. For example, how can the instrument be programmed to play only in musical half-steps, whole steps, or octaves? How can the smoothest sound gradient be obtained when moving a hand up and down over the pitch-controlling light sensor? Does changing the range of the light sensors (which control the switch, originally set as greater than 5 (of 100) light value in the example program) create more control and effective sound generation? Does the instrument react differently in different light environments (i.e. a room with low ambient lighting vs. a room with bright ambient lighting), and how can this be accounted for in the program?
7. Try out some ideas if the class is motivated and able to, or wrap up by talking about the activity and additional uses of light sensing systems, such as the use of photoresistors in streetlights. Electronic instruments and their design and usage can also be discussed and explored. Further musical instrument-building sessions can be held as a means of progressive learning.

Worksheets & Handouts

1. Light Sensor Platform Building Instructions
   [Light_Platform_Instructions.pdf]