

Activity Template

Subject Area(s)	Science and Technology
Associated Unit	None
Associated Lesson	None
Activity Title	Automated Image Scanner

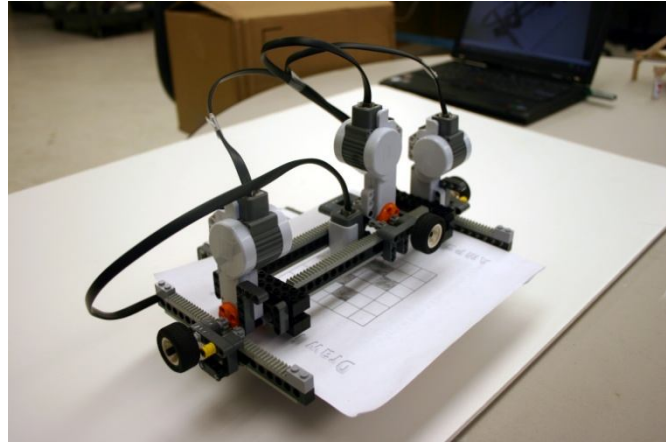
Image 1

ADA Description: Photo of the LEGO Automated Image Scanner

Caption: LEGO Automated Image Scanner?

Image file: Scanner.jpg?

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Grade Level	6-12
Time Required	40 Minutes
Group Size	Unlimited

Summary

This activity introduces students to the processes involved in automated image scanning via a scanning bed. The scanner itself consists of a LEGO Mindstorms Light Sensor mounted to a traversing xy-stage, all connected to and controlled by a LEGO Mindstorms NXT intelligent brick. After students fill out a 7x7 grid, drawing whatever pattern/image they wish, the image is then scanned by the machine. The image data is then offloaded from the brick into the Processing programming environment whereby their image is rendered and displayed on a computer screen.

Engineering Connection

Mechanical engineers design machines to automate processes that would otherwise be considered tedious and cumbersome. Image engineers can utilize the tools that mechanical engineers develop in order to automate the scanning of images into computer. Such examples of this range from scanning a picture into your desktop computer, to processing the structure of your brain from an MRI machine.

Engineering Category = #3

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

image, pixel, scanner, xy-stage, light sensor, traverse, linear stage, resolution

Educational Standards

- New York state intermediate-level science: Standard 1: T1.4b, T1.5a
- New York state technology: engineering design, information systems, computer technology

Pre-Requisite Knowledge

Ability to open and run a programming sketch written in Processing.

Ability to work with the LEGO NXT system.

Ability to use the LEGO Mindstorms software

Learning Objectives

After this activity, students should be able to:

- Understand the concepts of pixels and resolution
- Explain how images are transferred from paper to digital files
- Explain how an automated image scanner works
- Understand the functions of common components inside image scanners such as motors and encoders

Materials List

Each group needs:

- One NXT Scanner assembly
- Minimum of one Scanner Worksheet
- Computer with LEGO Mindstorms v2.0 or greater software
- Processing Software
- Black Marker

Introduction / Motivation

Surely you have once wanted to scan a picture you took, or a drawing you made, into the computer in order to save the image and send it to your family friends. Maybe you even have, making use of an image scanner. Have you ever thought to wonder though, exactly how that image scanner works? The process is much simpler than you may think...

Images in the computer are all made up of pixels, tiny elements containing color data such as black, white, red, etc. When all of these pixels are arranged together, an image is formed. An image scanner works by first taking the size of your image and breaking down, or decomposing the area, into these individual pixels. It does so by framing your image with a rectangular grid of a certain resolution. The amount of pixels there are in your image is determined by the resolution you desire. For instance, a resolution of 500 x 500 describes a rectangular grid 500 pixels long by 500 pixels wide. The higher the resolution of your image, the more detail you will be able to capture, however, the file will also become much larger. It is the usual give and take caveat of engineering. This is all nice and dandy but now we need a way to actually capture the image and store the data into each one of these tiny, and quite numerous, pixels. We could do this by hand, however, it would take forever for a high resolution image. In order to do this automatically, an image scanner uses a light/color sensing element connected to a xy-stage.

In engineering, we refer to a device which moves an object along a single axis as a linear, or translation stage. If we combine two of these stages such that one is perpendicular to the other, we create what is known as a xy-stage. This device allows us to move an object of our desire to an x and y location of a Cartesian grid (or any two-dimensional grid for that matter). This is great because it will allow us to scan the entire rectangular area of the image we wish to scan. The final bit of information we need to know is how the scanner knows exactly where each pixel is.

You might think that the scanner knows precisely where every pixel is on the image and is able to move to it at its desire. This is only partly true. What the scanner really knows is how big a pixel is and as such, how much the linear stage needs to shift in order to move the sensor by one pixel. Because linear stages typically work by rotating a shaft (which is attached to a motor in the case of a scanner), we can measure how many rotations it will take to move the distance of one pixel. This distance is measured with the use of a Rotary Encoder, which a device is used to measure rotations as that of a shaft, axle, wheel, etc. Now, if we want to get to a certain pixel, the scanner knows it has to move a certain amount of pixels in the x direction and a certain amount in the y direction. The brain of the system then instructs the motor how many rotations to turn, these rotations being read by the encoder.

Vocabulary / Definitions

Word	Definition
Pixel	An element used to create a digital image.
Resolution	The amount of pixels able to be rendered or displayed.
Rotary Encoder	A device used to count rotations such as that of a shaft, axle, wheel, etc.
Linear Stage	A device which is able to move, or translate, an object along a single, fixed axis. Also, known as a translation stage.
XY-stage	A device which is able to move along two-axis simultaneously in order to traverse a grid.

Procedure

Calibration

Note: Do this before running the scanner and whenever lighting conditions change or the scanner returns incorrect images)

1. Load the calibration program, named **calibration.rbt**, onto the NXT Brick.
2. Take a blank activity sheet and on the bottom row, fill in one square entirely black.
3. Run the calibration program.
4. Using the wheels on the linear stages, move the light sensor to a white square on the bottom row, making sure that the red circle from the light center is in the absolute center of the square.
5. Press the orange button on the NXT Brick.
6. Using the wheels again, move the light sensor to the absolute center of the black square.
7. Press the orange button on the NXT Brick.
8. The system is now calibrated

Create an Image

1. Using a black marker, color in the squares on the worksheet creating your desired image. Stay between the lines as best as you can. The squares **must** be completely filled.

Load Software

1. On your computer, open up the LEGO Mindstorms software and open the file **scanner.rbt**.
2. On your computer, open up the Processing sketch named, **scanner.pde**

Operating the Scanner

1. Load the scanner program named, **scanner.rbt**, onto the NXT brick.
2. With the scanner in the starting position, load the image into the scanning bed.
3. Start the scanner program on the NXT.
4. Move the light sensor, via the wheel, until the light is in the absolute center of the bottom left square of your picture.
5. Press the orange button on the NXT twice and the scanner will begin to scan your image.

6. Wait for the scanner to finish and return to the home position... your image has now been scanned.

Loading Image

1. Open up the NXT memory management window.
2. On the left hand side, choose the folder **Other**
3. Select the file **image.txt**
4. Click **upload**.
5. Choose the same folder where the file, **scanner.pde**, is saved.
6. Switch over to the **Processing** program.
7. Click the **Play** button. The image you scanned should now be displayed on the computer.
8. When finished, click the **Stop** button.

Before the Activity

- Print out the scanner worksheet: **scanner_worksheet.ppt**
- Calibrate the scanner's light sensor as per the procedure

With the Students

1. Build the LEGO Automated Image Scanner.
2. Run the scanner as per the instructions in the procedure section.

Image 2

ADA Description: Students working with the LEGO Automated Image Scanner

Caption: Image 2: Students working to scan an image with the scanner?

Image file: students.jpg

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Attachments

Scanner.rbt
Scanner.pde
Scanner_Worksheet.ppt
Calibration.rbt

Troubleshooting Tips

1. If the image you see on the computer does not match what you scanned in, recalibrate the scanner.
2. Before starting each scan, rotate the wheels of the traverse such that the scanner is in the starting position.

Assessment

Pre-Activity Assessment

Informal Discussion: Ask the students if they know how images are created on the computer. See if they have had experiences transferring images to the computer such as taking pictures with a digital camera, or using a scanner. Ask the students if they have ever heard of any of the vocabulary words present in this activity

Activity Embedded Assessment

Analysis: While the scanner is running, ask the students to comment on the steps that it is taking to store the image.

Post-Activity Assessment

Formal Discussion: Ask the students to explain the entire procedure of how the automated scanner works as well as all of the internal components, i.e. light sensor, encoder, traverse. Ask the students to explain what a pixel is, what resolution is, and how they relate to computer images.

References

Processing Software. Accessed April 27, 2011. <http://processing.org/>

Redirect URL

<http://gk12.poly.edu/amps-cbri>

Contributors

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Supporting Program

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