

How Does a Light Sensor Work?



Light Sensor Pre-Quiz

- 1. How do humans sense light?**
- 2. Provide an example “stimulus-sensor-coordinator-effector-response” framework using the human light sensor.**
- 3. Give some examples of light sensors in engineering systems.**

Light Sensor Pre-Quiz Answers

1. How do humans sense light?

Humans have two eyes that collect light that falls on objects in front of them, and helps them to “see” the objects.

2. Provide an example “stimulus-sensor-coordinator-effector-response” framework using the light sensor.

Example: sight of a scary object such as a wasp > two eyes > signals to human brain via nerves > signal to leg muscles > run to safety

3. Give some examples of light sensors in engineering systems.

Examples: cameras; sensors that turn lights on when it gets dark outside; porch lights, streetlights and car headlights that turn on automatically in low light or at night

Review: From Stimulus to Response

stimulus > sensor > coordinator > effector > response

light > eyes > nervous system > muscle > run

From the sequence of steps above, what might happen in the **example** of a child seeing a wasp? The **stimulus** is light from wasp, the **sensor** is the eye that senses it and relays it to the nervous system (spinal cord and brain) which is the **coordinator**. The coordinator makes the decision of how to react, and then commands the leg muscles (the **effector**) to run for shelter quickly. So, we go from **stimulus** (sight) to **response** (movement of legs).

Do This: Sketch out a stimulus-to-response sequence for how this might be implemented in a robot. Identify all the components, as in the example above.

Sense of Sight



- Close your eyes for a second. Then open your eyes and look around you.
- Have you ever wondered, how you are able to see things around you? How do your eyes function?
- When light rays fall on the eye they pass through the **pupil** of the eye.
- The **iris** changes the size of the pupil depending on the amount of light. It shrinks in the presence of less light and enlarges in the presence of more light.
- Then, what happens at the back of the eye ball?

Vision & Human Eye Anatomy

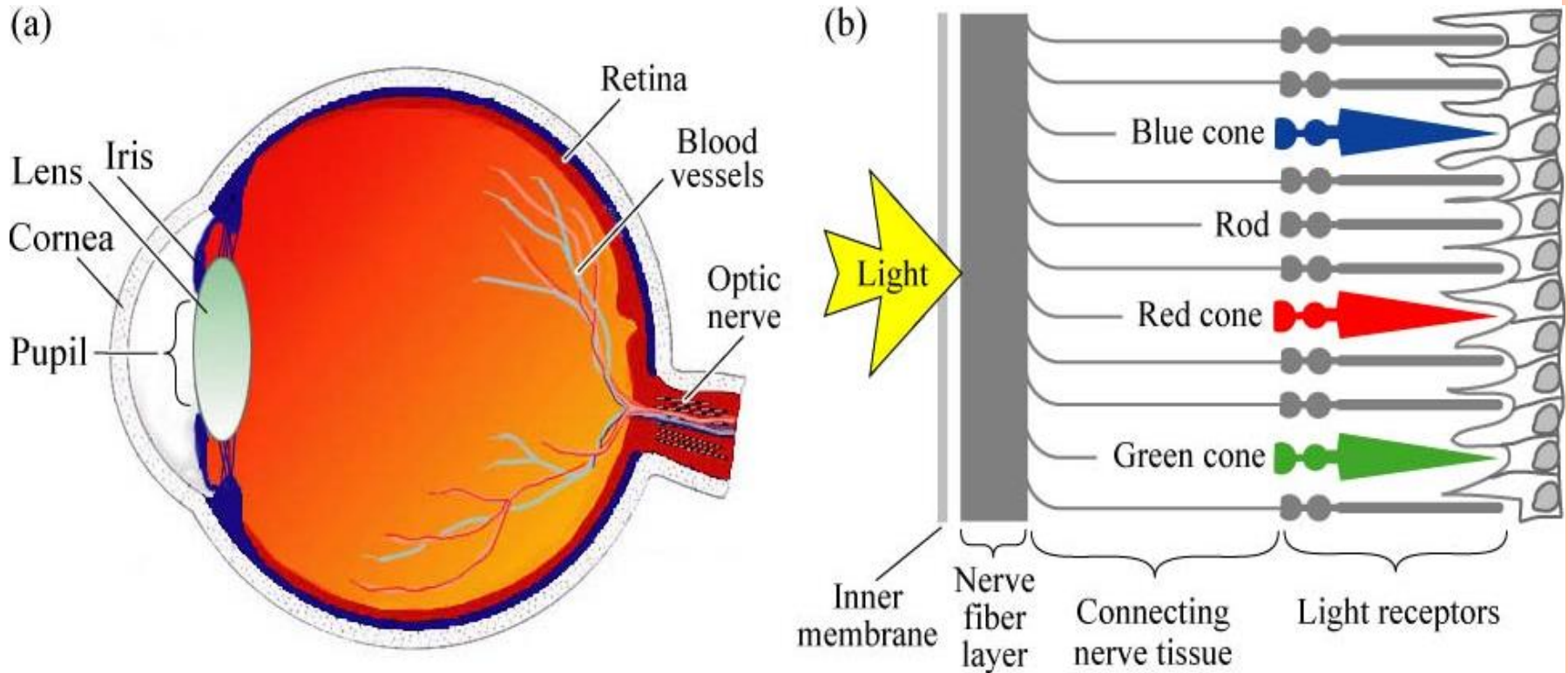


Fig. 16.1. (a) Cross section through a human eye. (b) Schematic view of the retina including rod and cone light receptors (adapted from Encyclopedia Britannica, 1994).

Sense of Sight (continued)

- A **lens** behind the pupil focuses the image onto the **retina**.
- The image is upside down, but the **visual cortex** in the brain helps you identify the image.
- The retina is filled with light-sensitive cells called rods and cones.
 - **Rods** identify shapes.
 - **Cones** identify color.

Sense of Sight (continued)

- Watch the **“Sense of Sight – How Human Eyes Work”** video (1:39 minutes) and try the activity in the video:

<http://www.youtube.com/watch?v=ZH8L3i-qxuE>

- (optional) Watch this optical illusion:

<http://www.michaelbach.de/ot/index.html>



Review:

Robot Sensors



(As stated in an earlier activity,) robot sensors:

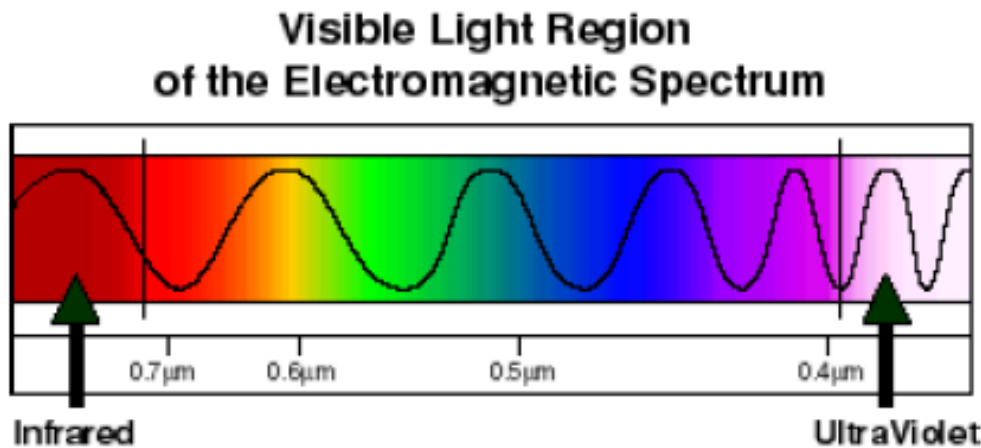
- Gather information from the surroundings and send it to the computer brick
- Robot sensors can only be used if a robot's program asks for information from them!
- Similarly, a robot can only act on information from the sensors if its program tells it to do so!

How do sensors send signals to the NXT brick?

- The sensors send information through the wires (similar to the nervous system in your body) that connect them to the computer brick, which uses the information if its program requires it.

How Are Light Sensors Made?

- Light sensors are made using electronics.
- The electronics enable the sensor to distinguish between the different colors in the light spectrum.



- The NXT light sensor does not detect colors, only **brightness**, also called **intensity**.
- (Another NXT color sensor exists that can detect colors, but our light sensor does not.)

How Does the NXT Light Sensor Work?

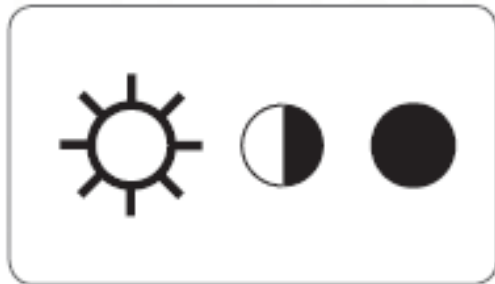
top: light sensor
bottom: lamp (sends out light)



The LEGO MINDSTORMS NXT light sensor works in 2 different ways:

- It can **detect** the amount of **ambient light** and convert it to a numerical value. This value is sent to the NXT brick.
- It can **send out light** and detect **how much is reflected** by an object. The sensor detects the brightness of an object and converts it to a numerical value and sends it to the NXT brick. If no object is in front of the sensor, it sends a value of zero.

How Does the NXT Light Sensor Work?



This is what your eyes see.

This is what your robot sees using the light sensor.

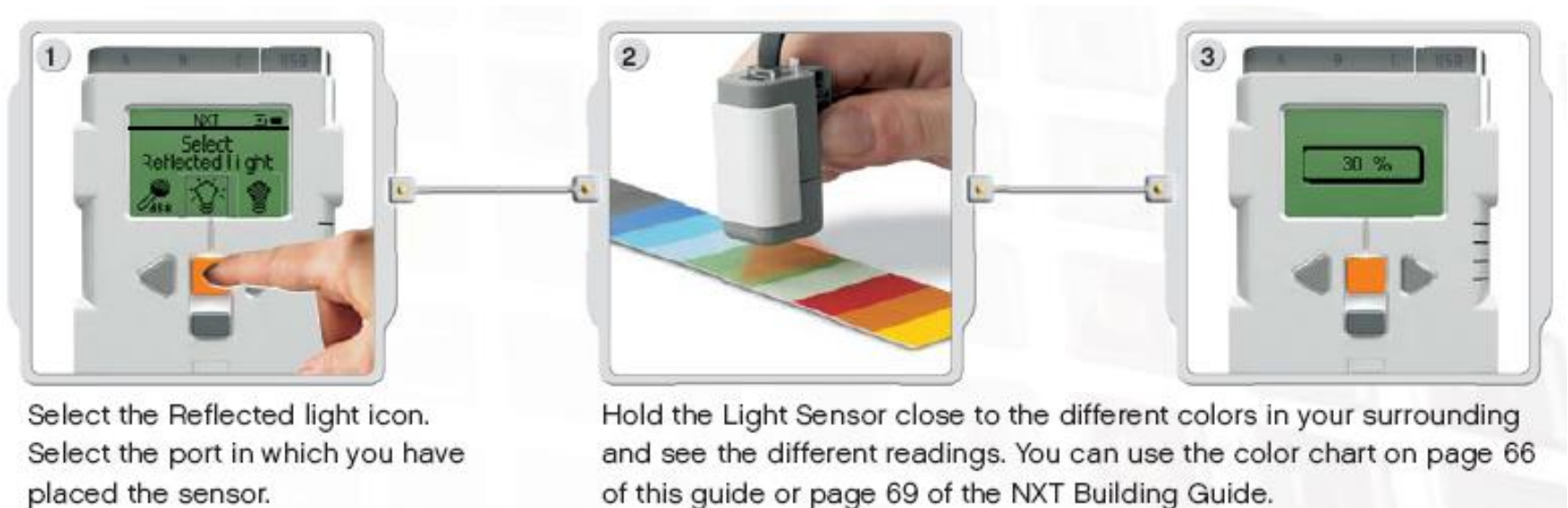
- Remember: the NXT light sensor sees shades of black and white; it cannot distinguish colors.
- Now let's check the readings from the light sensor for different cases.

Let's Investigate

How does the brick read the signal from the light sensor?

Do This: Attach the sensor to the LEGO brick. Then use the VIEW command and go to the light sensor. **Test the light sensor in 2 modes.**

1. In the **“reflected light” mode**, the sensor’s flood light (the bottom) is turned on. Follow the instructions in the diagram below.



- **Higher numbers** indicate **BRIGHTER** light (as a % of light that the maximum the sensor can read)
- **Lower numbers** indicate a lower brightness of light.

Let's Investigate (continued)

2. In the “ambient light” mode, the flood light is turned off. Follow the instructions in the diagram below.



Select the ambient light icon. Select the port in which you have placed the sensor.

Test the Light Sensor's ability to read the surrounding light by measuring the light level in different parts of the room. For example, first hold the sensor against the window, then hold it under the table. Notice the difference in the readings. Higher numbers indicate more light (as a percentage of the light the sensor can read). Lower numbers indicate a lower amount of light.



3. Then check out the Try Me option.

Light Sensor Post-Quiz

- 1. How does the LEGO NXT light sensor work?**
- 2. Provide an example “stimulus-sensor-coordinator-effector-response” framework using the NXT light sensor.**
- 3. Give some examples of light sensors in engineering systems.**

Light Sensor Post-Quiz Answers

1. How does the LEGO NXT light sensor work?

The light sensor detects the brightness of light it receives and converts it to a numerical value as a percentage (%) of the maximum brightness it can detect.

2. Provide an example “stimulus-sensor-coordinator-effector-response” framework using the NXT light sensor.

Example: light > LEGO NXT light sensor > (transmission to coordinator) value sent to NXT brick via wire > brick sends a signal to the NXT motors > robot moves

3. Give some examples of light sensors in engineering systems.

Examples: cameras; sensors that turn lights on when it gets dark outside; porch lights, streetlights and car headlights that turn on automatically in the low light or at night

Vocabulary

- **sensor**: A device that converts one type of signal to another; for instance, the speedometer in a car collects physical data and calculates and displays the speed the car is moving.
- **visual**: Related to seeing.
- **transducer**: Another term for a sensor (see above).
- **peripheral**: Surrounding.

Image Sources

Slide 1: row of streetlights; source: Microsoft® clipart: <http://office.microsoft.com/en-us/images/results.aspx?qu=street+lights&ex=1#ai:MP900385958> |

Slides 1, 9-15: LEGO device & instruction images; source: LEGO MINDSTORMS NXT User's Guide

Slide 5: closed eyes; source: Microsoft® clipart: <http://office.microsoft.com/en-us/images/results.aspx?qu=eyes&ex=1#ai:MP900426560|mt:2> |

Slide 6: cross-section of human eye and rod & cones diagram; adapted from Encyclopedia Britannica, 1994

Slide 8: child's brown eyes; source: Microsoft® clipart: <http://office.microsoft.com/en-us/images/results.aspx?qu=eyes&ex=1#ai:MP900423034|mt:2> |

Slide 10: light spectrum chart; source: NASA: <http://science.hq.nasa.gov/kids/imagers/ems/visible.html>

Slide 12: gray and colors diagram; source: adapted from LEGO MINDSTORMS NXT User's Guide

Slide 13-14: screen captures; source: author