Time-of-Flight Sensors

Vocabulary

Time-of-Flight Sensor - A sensor that emits a signal and calculates the distance to an object based on how long it takes for the signal to return.

Direct Instruction

Introduction

1. Pose the following question to the class: "When you see lightning, you can estimate how far away it is by counting how long it takes to hear the thunder. How do you think this works? Why do you see lightning before you hear thunder?"

   Give students time to think and write down their thoughts, then ask for volunteers to share their responses.

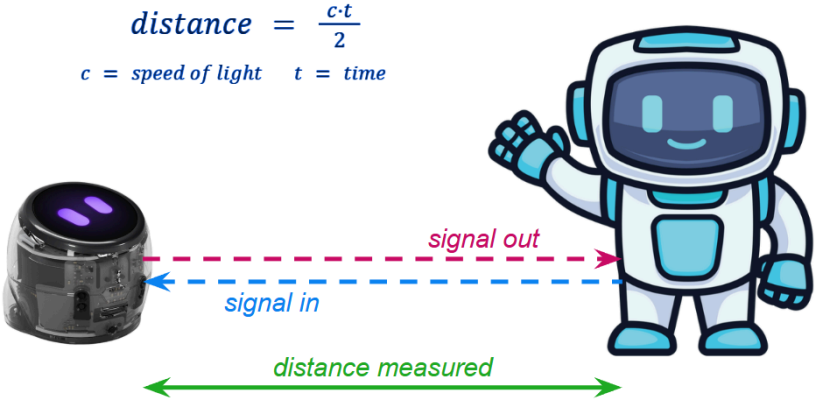
2. Lightning (light waves) and thunder (sound waves) both travel through the air before arriving to us. The faster a wave moves, the quicker it gets to us, which is why we see lightning before we hear thunder.

3. But how does Ari's distance sensor work? Much like how our eyes see light, Ari uses Time-of-flight technology to measure distance. Ari has an emitter inside it, which shoots out invisible light that bounces off a surface it hits. Ari also has a sensor inside that waits to see if that light returns.

If the light hits an object and bounces back, Ari does some quick math. Based on how long it took for the light to return, Ari can tell the distance the light traveled.

$$distance = \frac{c \cdot t}{2}$$

c = speed of light t = time



4. This type of sensor is called a Time-of-Flight (ToF) sensor because it times how long the light "flies" to figure out the distance it traveled.

5. Time-of-flight sensors are used for various applications, such as:
   - In smartphone cameras for depth perception and facial recognition
   - Obstacle detection sensors like those used by Roomba
   - Smart autofocus in cameras
   - Augmented Reality apps use ToF to place virtual objects in the real world

Activity 1 - Mapping with Ari

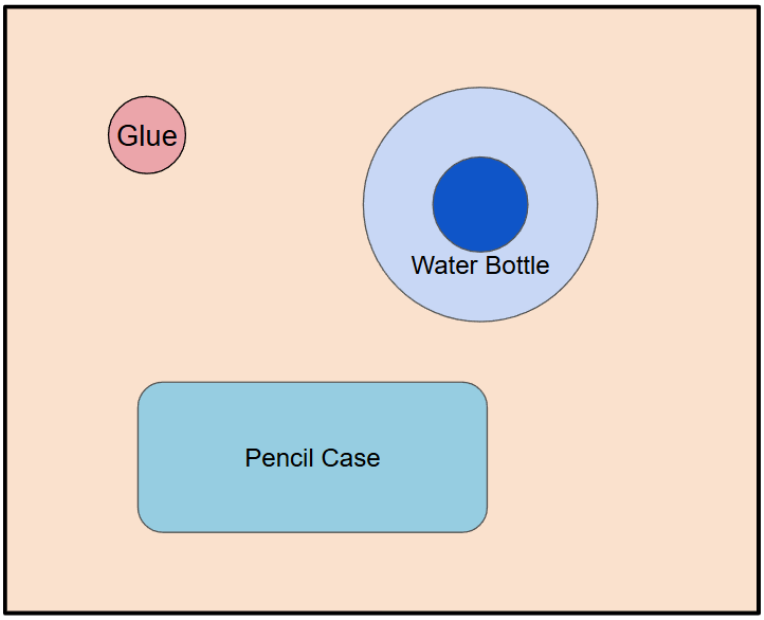
1. In this activity, students will take turns creating an obstacle course inside of a box. Other students will try to map out the inside of the box using only Ari's distance readings.

2. Place students into groups and provide each group with an Ari, a box, and 3-4 objects to use as obstacles inside of the box.

3. Before building the obstacle course, have students measure the length and width of the box and record it on their Student Activity Sheets.

4. Each group should split into two halves, Team A and Team B.

5. Team A will create their obstacle first. They should place their 3-4 objects inside of the box to create an obstacle course.

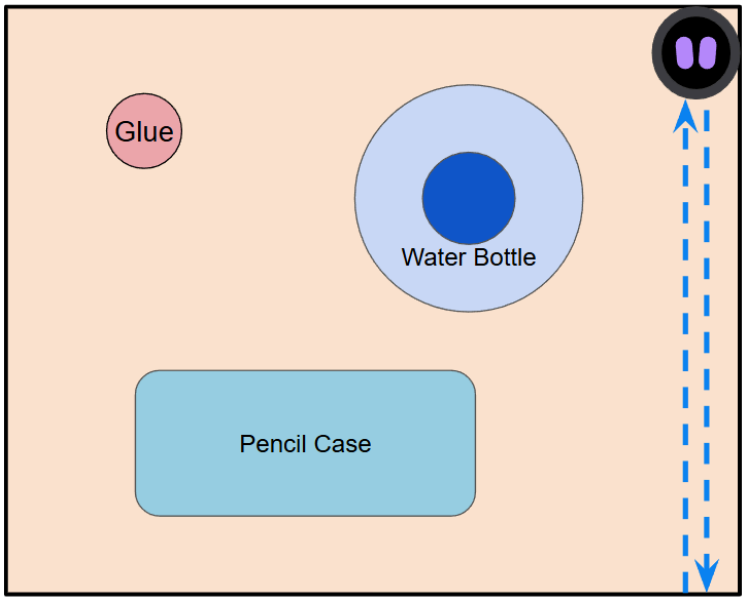


6. While Team A is setting up their obstacle course, Team B should draw the border of the box on their Student Activity Sheet.

7. Once the obstacle course is set up, Team B should avoid looking into the box. The only things Team B can do are:

    - Tell Team A where to move Ari
    - Tell Team A which direction to turn Ari
    - Tell Team A to read Ari's distance measurement

    Note: Ari's diameter is around 4.5 cm. Students will need to account for this to create an accurate representation of the inside of the course.



8. Once Team B is finished mapping, they should compare their map with the actual obstacle course.

9. Finally, students should switch roles and repeat steps 5-8.

Evaluate: Exit Ticket

Students will fill out and submit their Exit Tickets (The last page of the Student Activity Sheet).