Robotic Sensing System Basics

Grade Range: Career & Technical Education (CTE)

Lesson Time: 55 minutes

Key Terms Defined	
Acceleration	Open loop
Closed loop	Output
Displacement	Sensing element
Electrical energy	Sensor
Heat	Servo-control system
Light	Transducer
Manipulator	Transduction element
Mechanical energy	Velocity

Materials and Resources

Activity Overview

Do you ever wonder how industrial robots know exactly what to do and when to do it? How do robots work with such precision and reliability? Robots use sensors to convert light, heat, or mechanical energy into electrical energy. The signal produced by the electrical energy affects the operation of the robot. This activity provides an introduction to internal sensors in industrial robots.

Essential Questions

- What is the function of industrial robot sensors?
- What are open loop and closed loop systems?
- What are the two different types of sensors when classified by purpose?
- What are types of internal sensors and how do they function?

Objectives

- Interpret appropriate industrial robotic functions and applications
- Identify various industrial robotic design features

Introduction

Prior to this activity, students should be familiar with the structure and control systems within the industrial robot. To begin this experience, ask students what features they would expect to find within a sensing system. Be sure that students understand the role of sensing elements, transduction elements, and output. Ask students to provide examples of internal and external sensors that they see in daily life.

zSpace Activity

Answers may vary. Sample answers are provided below.

1. Launch Industrial Robotics Expert by GTAFE and select “Sensing System”.
2. Select “Sensor Basics”.

Teacher Note: “Sensor Basics” should open to an open-loop system under “Automatic Measuring and Controlling System”.

3. Observe and review the components of the pictured open loop system. Why do you think this is referred to as an open loop?

Teacher Note: Students can explain that in an open-loop system the output signal or condition is neither measured nor “fed back” for comparison with the input signal or system set point.

4. Select “Next” and observe the components of the pictured closed loop system. What is the main difference between the open loop system and the closed loop system?

Teacher Note: Students should explain a closed-loop system or control system is a set of mechanical or electronic devices that automatically regulates a process variable to a desired state or set point without human interaction. Closed-loop systems unlike open-loop systems don’t require human interaction.

5. Select “Sensor” in the left panel. What is a sensor? Where does the term originate?

Teacher Note: Students should define the sensor as a device that can sense the measured and converted to a usable signal according to a certain rule, usually consisting of a sensitive element and a conversion element. Students should explain that the term “sensor” comes from “sensus” or to feel something.

6. What are the three types of measurable detected information that can be transformed into correlatively electrical signals?

Teacher Note: Students should explain that biological, physical, and chemical information can be transformed into electrical signals.

7. Select “Static characteristics” under “Classification of sensors”. What are the two different types of sensors when classified by purpose?

Teacher Note: Students should explain that the two different types of sensors when classified by purpose include internal sensors and external sensors.

8. The focus of this activity is internal sensors. Describe an internal sensor.

Teacher Note: Students should explain that an internal sensor is usually mounted on the manipulator and detects the internal status of the manipulator. It offers a response signal to the servo-control system and these might include velocity, displacement, or acceleration sensor

9. Select “Back” and “Internal sensor”.

Teacher Note: Internal sensor should open to a trough photoelectric switch, which is an example of a position/displacement sensor.

10. One type of sensor is a position/displacement sensor. This type of sensor measures the distance between the sensor and an object. Select “Counter photoelectric switch”.

Teacher Note: The option to select different types of switches is located on the right hand side of the screen.

11. Select “Principle” to view the counter photoelectric switch in action. What is happening as the box moves along the conveyor belt? What is being measured?

Teacher Note: Students should explain that the box is intercepting a beam of light as it moves along the conveyor belt. This provides a measure of where the box is located.

12. Select “Reflective photoelectric switch”. Select “Principle” to view the reflective photoelectric switch in action. What is the main difference between the counter photoelectric switch and the reflective photoelectric switch?

Teacher Note: Students should explain that with the reflective photoelectric switch, the box reflects the beam of light whereas with the counter photoelectric switch, the box intercepts the beam of light.

13. What is the same about the counter photoelectric switch and the reflective photoelectric switch?

Teacher Note: Students should explain that both the counter photoelectric switch and the reflective photoelectric switch provide a measure of where the box is located.

14. Select “Grating”. Select “Principle” to view the grating in action. What might be an advantage of the grating system over the counter system?

Teacher Note: Students should explain that the grating system can provide information on the size of the box in addition to its location.

15. Another type of sensor is a velocity sensor. Velocity is the rate at which an object’s position changes over time. Select “Photoelectric Velocity Sensor” under “Velocity Sensor”. Then select “Principle”.
16. Pause the animation. What was the velocity of the fan when you paused the animation?

Teacher Note: Students should indicate a velocity of between 42 and 120 RPM.

17. Sensors can also measure the change in velocity or acceleration. Select “Servo Acceleration Sensor” under “Acceleration Sensor”. Select “Principle” to see the servo acceleration sensor in action.
18. The servo acceleration sensor includes a sensing element. It also includes a component that converts the sensory information into electrical energy. What is this component?

Teacher Note: Students should explain that the component converting the sensory information into electrical energy is the capacitive displacement transducer.

19. Transducers are devices that convert light, heat, or mechanical energy into electrical energy. The capacitive displacement transducer in the servo acceleration sensor measures changes in an electrical property called capacitance. Capacitance describes how two conductive objects with a space between them respond to a voltage difference applied to them.
20. Where would you expect to find each of the following types of internal sensors: displacement, velocity, and acceleration?

Teacher Note: Students should explain that displacement sensors may be found in buildings to measure stability during an earthquake or on bridges to detect movement over time. Velocity sensors include engine speed sensors which measure the spinning speed of the crankshaft. Acceleration sensors are extremely useful when studying windmills and wind farms.

Closing

In conclusion, review with students the different types of internal sensors that can be found in industrial robots including those discussed above as well as other sensors including encoder displacement sensors and photoelectric velocity sensors.

Ask students about the purpose of all of these sensing systems. Discuss the advantages and disadvantages of the different types of sensors, specifically displacement, velocity, and acceleration sensors.

Differentiation

- Group students heterogeneously to allow students with a strong command of the English language to assist in reading or interpreting questions
- Provide a handout with a list of vocabulary terms and definitions that will appear in the experience
- Allow students to provide answers that are handwritten, typed, or verbal
- Have students work as partners or in small groups
- Enrichment: Students can build robots in the classroom or virtually using Tinkercad.