Challenge

Students will design, build, and program a gesture-controlled surgical robot. The robot should be able to mimic making surgical incisions by using gestures to move a dry-erase marker around a torso drawn on a whiteboard.

Materials Needed

Each pair of students will create one robot.

- Use one of these sets:
  - TETRIX® MAX Programmable Robotics Set (43053)
  - TETRIX MAX Dual-Control Robotics Set (43054)
- Items to create challenge field:
  - Small whiteboard that can lie flat
  - Two dry-erase markers of different colors
- Adafruit APDS9960 Gesture Sensor
  - This sensor is available from:

    Adafruit Industries
    Adafruit.com
    Sensor: Adafruit APDS9960 Proximity, Light, RGB, and Gesture Sensor
    Product ID: 3595
- TETRIX Gesture Sensor Adapter Board (46035)
  - This adapter board is available at Pitsco.com/TETRIX-Adafruit-Proximity-Sensor-Adapter.
- Engineering logbook

Objectives

By the end of the lesson, students will be able to:

- Create a challenge field (in this case, an image of a human torso).
- Write the steps for the robot to follow to complete the challenge.
- Design, build, and program a robot that meets the criteria and constraints of the challenge.
- Test, analyze, and refine the robot to improve its performance.
- Demonstrate the robot's effectiveness at meeting the challenge.
- Reflect on and discuss the challenge including its real-world applications.

Activity

Gesture-Controlled Surgery Robot Autonomous Challenge

Difficulty

Difficult

Class Time

13 or more 45-minute class periods

Grade Level

- High school

Learning Focus

- Assistive and collaborative robotics
- Programming/coding
- Engineering problem-solving

Step 1: Determine the Challenge and Specifications (15 minutes)

- Share, define, and refine the challenge. Ask questions to help you get a clear understanding of the challenge. Document this information in the engineering logbook.
- Write the challenge in your own words. Record the constraints you should follow, the materials that can be used for the solution, and what the testing field will look like. Discuss the constraints and materials that are allowed.

Step 2: Brainstorm Solutions (30 minutes)

- Brainstorm ideas to solve the challenge. Think of as many possible solutions as you can in the given time frame.
- Considerations for your design:
  - Surgery requires precision. How can you design your robot to get the most precise movements?
  - What are the trade-offs of using DC motors versus servos motors to control the movement of the robot?
  - How will the robot operator interact with the robot?
  - How will the robot hold the dry-erase marker to simulate performing surgery on the whiteboard?

Step 3: Set Up (20 minutes)

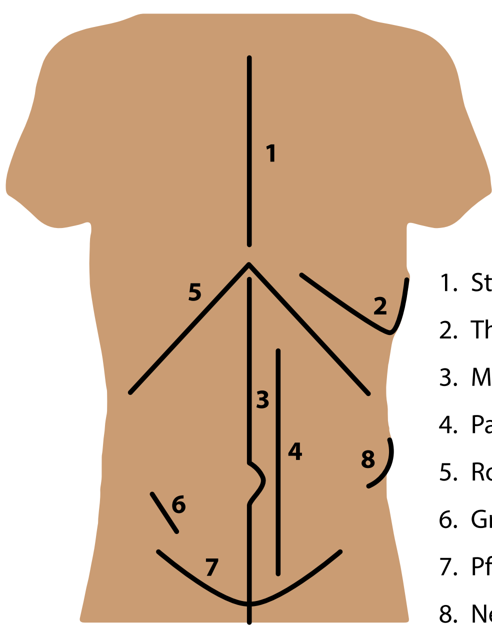
- Refer to the following torso graphic for creating the surgical robot challenge torso.
  - Using a single color of dry-erase marker, create the outline of a human torso.
  - Using the same dry-erase marker, draw the incision lines shown inside your torso on the whiteboard.

Criteria and Constraints

The team's robots must:

- Contain no bent, cut, or broken pieces.
- Be able to hold a dry-erase marker that will take the place of a scalpel.
- Be able to move the dry-erase marker in any direction (left, right, forward, backward, up, and down).
- Be able to draw a line on a whiteboard to represent making an incision.
- Utilize a gesture sensor to control the movement of the robot to make an incision.

Common Abdominal Surgical Incisions



1. Sternotomy
2. Thoracotomy
3. Midline laparotomy
4. Paramedian
5. Rooftop
6. Gridiron
7. Pfannenstiel
8. Nephrectomy

Note: The other color of dry-erase marker will be held by the robot to simulate making incisions in the locations indicated by the incision lines you just drew.

Step 4: Formulate a Solution (45 minutes)

- Consider the ideas you brainstormed in Step 2. Which of these ideas do you think will have the most success at creating the incision patterns you drew on the challenge torso?
- Turn your best ideas into a design for your robot.
- In your engineering logbook:
    - Create a detailed sketch of your chosen solution to the challenge.
    - List materials you will use.
    - Write a detailed description of how your solution meets the challenge criteria and constraints.

Step 5: Prototype the Solution (180 minutes)

- Build the robot according to the designs you created in Step 4. If you modify the design as you build your robot prototype, remember to change the design in your engineering logbook.
    - Attach a different colored dry-erase marker to your robot than what was used to create the human torso challenge field.
    - **Note:** The creation of the robot could take longer depending on the complexity of the robot solution.

Step 6: Develop a Process (15 minutes)

- Robotic challenges often require robots to complete a series of tasks in a certain order. This series of steps is called a process. Think through the process your robot needs to complete to be successful in the challenge. Planning this series of steps is sometimes referred to as creating pseudocode for your robot.
    - Record your robot's process in your engineering logbook. Use this process as a guide when operating the robot and completing the challenge.

Step 7: Program Your Robot (180 minutes)

- Create a program for your robot using the process you wrote in Step 6.
- Verify your program for errors and the upload your program to your robot.

Step 8: Test and Analyze (45 minutes)

- Test your robotic solution. Place the robot in front of your human torso challenge field. Then, execute the program. Use the gesture sensor to try to draw incisions in the places indicated on the challenge field.
- As you test your robot, record observations and data in your engineering logbook. Determine if your robot meets the requirements of the challenge.

Step 9: Redesign or Improve the Solution (45 minutes)

- Refine your challenge solution. Adjust the robot design, process, and program as needed. Document any changes in the engineering logbook.
- Make the physical changes to your prototype robot according to your design modifications.
- Continue to modify the robot's design and program until it can successfully complete the challenge.

Sample Process for Making an Incision

1. Set up the robot and move its arm to the neutral position.
2. Read the gesture sensor.
3. Store the gesture in a variable.
4. Determine which way to move the robot's motors and servos based on the gesture stored in the variable.
5. Move the arm into position.
6. Continue moving the arm until a new gesture is detected.
7. Repeat Steps 2-6.

Step 10: Demonstrate (15 minutes)

- When the robot has been tested and successfully completes the challenge, demonstrate its performance in a final test.

Step 11: Reflect and Share (15 minutes)

- Reflect on the changes your robot went through from original idea to final design.
- Reflect on the results of the challenge. What elements of your robot design brought you success or failure?
- Discuss the roles and responsibilities each team member fulfilled. How did teamwork and collaboration help you complete the challenge?
- Discuss how this challenge relates to robot design in the real world.

Step 12: Extensions

- Multiple Tools
    - Modify your robot to include a gripper that can hold different surgical tools. What could you use to represent tools such as scissors, forceps, clamps, and hemostats?
- Degrees of Freedom
    - Degrees of freedom are the number of directions that movement can occur. Determine how many degrees of freedom your robot has. The number of servos and motors you have is often a good indication. Then, redesign your robot to include more degrees of freedom.
- Other Sensors
    - Incorporate other sensors into your robot design and prototype to give you more control of your robot.