Challenge

Students will design, build, and program a three-axis robotic stabilizer for a smartphone camera. The stabilizer must be able to securely hold a smartphone so that its camera can be used to make videos. An IMU attached to the camera mount will be used to control servos and/or DC motors that rotate the camera. One servo/DC motor will adjust the pitch while the other servo/DC motor will adjust the roll of the camera. This keeps the camera level and pointed straight ahead no matter how the mount is held, giving a steady and vibration-free picture. **Note:** As an added challenge, students can include a third servo/DC motor to control the yaw of the camera. By doing this, the camera should stay pointed in the same direction no matter how the mount is rotated. However, keeping the yaw steady means the user would not be able to pan the camera left or right. This can be overcome by programming a way to turn the yaw control on or off.

Materials Needed

Each pair of students will create one robotic stabilizer.

- Use one of these sets:
  - TETRIX® MAX Programmable Robotics Set (43053)
  - TETRIX MAX Dual-Control Robotics Set (43054)
- Grove 6-Axis Accelerometer & Gyroscope LSM6DS3 sensor (IMU)
  - This sensor is available from:

    Seeed Studio
    SeeedStudio.com
    Sensor: Grove 6-Axis Accelerometer & Gyroscope LSM6DS3 sensor
    Product ID: 105020012
- Smartphone
- Engineering logbook

Objectives

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

- Utilize an IMU to gather motion data.
- Write the steps for the robotic device to follow to complete the challenge.
- Design and build a robotic device that meets the criteria and constraints of the challenge.
- Program the robotic device to complete the challenge.
- Test, analyze, and refine the robotic device to improve its performance.
- Demonstrate the device's effectiveness at meeting the challenge.
- Reflect on and discuss the challenge including its real-world applications.

Activity

IMU Camera Stabilizer Autonomous Challenge

Difficulty

Difficult

Class Time

Seven or more 45-minute class periods

Grade Level

- High school

Learning Focus

- Motion sensing and directional control
- Programming/coding
- Engineering design and problem-solving

Note: It is highly recommended that students complete the TETRIX® MAX IMU Extension Activity before attempting this challenge. This activity can be downloaded at Pitsco.com/TETRIX-PRIZM-Robotics-Controller#Resources.

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:
  - How can servos and motors be mounted to automatically tilt the camera up or down (pitch) or side to side (roll)?
  - What are the trade-offs of using DC motors vs servo motors for moving the camera?
  - What data from the IMU will be most useful for controlling the servos/DC motors?
  - How can you design the camera mount to be ergonomic and easy to hold?

Step 3: Set Up (5 minutes)

- If you have little or no experience with using the IMU sensor, it is recommended that you complete the TETRIX MAX IMU Extension Activity before attempting this challenge. The extension activity will guide you through interpreting and using the data from the IMU's accelerometer and gyroscope.
  - **Note:** Time for completing this extension activity is not included in the time estimates of this challenge.
- Gather all materials.

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?
- Turn your best ideas into a design for your robotic stabilizer.
- 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 (135 minutes)

- Build the robotic camera mount according to the designs you created in Step 4. If you modify the design as you build your prototype, remember to change the design in your engineering logbook.
  - **Note:** The creation of the camera mount could take longer depending on the complexity of the solution.

Criteria and Constraints

The team's smartphone camera mount must:

- Utilize parts from only one set.
- Contain no bent, cut, or broken pieces.
- Securely hold a smartphone so the camera can be used to take video.
- Include an IMU to measure pitch and roll.
- Utilize servos and/or DC motors to rotate the camera around the *x*- and *y*-axes.
- Be programmed to keep the camera steady and level, no matter how the mount is rotated.
- Be ergonomically designed with handles to hold the device.

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 robotic camera stabilizer's process in your engineering logbook. Use this process as a guide when programming the stabilizer and completing the challenge.

Step 7: Program Your Robotic Camera Stabilizer (180 minutes)

- Create a program for your camera stabilizer using the process you wrote in Step 6.
- Verify your program for errors and then upload your program.

Step 8: Test and Analyze (15 minutes)

- Test your robotic camera stabilizer solution. Attach a smartphone to your robotic camera stabilizer, run the program, and capture a video of an object. Move the stabilizer around to see if the camera stays focused and aimed at the object.
- As you test your robot, record observations and data in your engineering logbook. Determine if your robotic camera stabilizer meets the requirements of the challenge.

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

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

Step 10: Demonstrate (15 minutes)

- When the robotic stabilizer 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 robotic stabilizer went through from original idea to final design.
- Reflect on the results of the challenge. What elements of your 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 robotic applications and design in the real world.

Sample Process for a Robotic Camera Stabilizer

1. Attach the smartphone to the camera mount.
2. Start the camera stabilizer program.
3. Gather data from the IMU's accelerometer and gyroscope.
4. Calculate the pitch and roll of the camera mount.
5. Adjust the *x*- and *y*-axis servos to adjust the tilt of the smartphone so the camera stays level.
6. Repeat Steps 3 through 5 while the camera shoots video.

Step 12: Extensions

- Adjusting for Yaw
  - Modify your robotic stabilizer to account for yaw as well as pitch and roll. You'll need to add a third servo or DC motor to rotate the camera around the *z*-axis.
- Program a Hold Button
  - Program the camera stabilizer to hold its position when PRIZM®'s green Start button is pressed. This allows you to point the camera in any direction and then hold that position when the button is pressed.