Straight-line course, no compass

FizziQ activity · Middle school · 40 min

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Walking 150 steps blindfolded, students hold a heading with the smartphone gyroscope and accelerometer in FizziQ, then judge the sensor drift rovers face on Mars.

Learning objectives

- Attempt to maintain a straight-line trajectory using only smartphone sensor feedback
- Compare the effectiveness of different sensors (accelerometer, gyroscope, light meter) for heading maintenance
- Understand the concept of sensor drift and its consequences for navigation
- Connect the experiment to the real navigation challenges of Mars rovers
- Evaluate the strengths and limitations of inertial navigation systems

Instruments and sensors

Accelerometer (lateral/Y-axis acceleration) · Gyroscope (yaw / angular velocity) · Light meter · Accelerometer · Gyroscope · Light sensor

Materials

- Smartphone or tablet with the FizziQ app installed
- A clear, open outdoor space at least 100 meters long for walking in a straight line
- Markers (cones, stones, or chalk) to mark the starting line, target direction, and 30-meter reference points
- Note: the protocol remains adaptable to any comparable smartphone sensor / data acquisition tool.

Protocol

1. Find a large, open outdoor space (at least 100 meters long) where you can walk freely in any direction.
2. Mark a starting line and a target direction (e.g., toward a distant landmark). Place markers every 30 meters along the straight path for reference.
3. Trial 1 (No sensor): Close your eyes (or wear a blindfold with a partner guiding for safety) and try to walk 150 steps in a straight line. Mark your ending position.
4. Trial 2 (Accelerometer): Open FizziQ and select the lateral (Y-axis) accelerometer. Try to maintain zero lateral acceleration as you walk 150 steps with eyes closed. Mark your ending position.
5. Trial 3 (Gyroscope): Use the FizziQ gyroscope (yaw/heading component). Try to maintain zero angular velocity (no turning) as you walk 150 steps with eyes closed. Mark your ending position.
6. Trial 4 (Light sensor): If sunny, use the FizziQ light sensor to maintain a constant light reading (keeping the sun at a fixed angle). Walk 150 steps. Mark your ending position.
7. For each trial, measure the lateral deviation (perpendicular distance from the intended straight line) at the endpoint.
8. Also measure the total distance walked along the intended direction to check for distance accuracy.
9. Create a comparison table: method, lateral deviation, final heading error, ease of use.
10. Rank the methods from most to least effective for maintaining a straight course.
11. Discuss why even the best sensor method shows significant drift after 150 steps.
12. Research how Perseverance actually navigates on Mars and compare its methods with your experiment.

Expected results

Without any sensor aid, most people will deviate 10-30 meters laterally over 150 steps due to unequal leg lengths and unconscious turning tendencies. With the accelerometer, the deviation may improve to 5-15 meters, but lateral acceleration is difficult to interpret in real time. The gyroscope typically gives the best results (3-10 meters deviation) because heading changes are directly measured, but gyroscope drift accumulates steadily. The light sensor works well on sunny days if the sun's position provides a clear directional reference, but cloud cover renders it useless. The key takeaway is that all inertial methods suffer from drift, explaining why real rovers must combine multiple sensors and periodically recalibrate using external references.

Questions

- Why do humans tend to walk in circles when blindfolded?
- What is sensor drift, and why does it accumulate over time?
- How does Perseverance navigate on Mars without GPS or a magnetic compass?
- What is visual odometry, and how does it complement inertial navigation?
- Why is the gyroscope generally more effective than the accelerometer for maintaining heading?
- Could you use the stars for navigation on Mars, as sailors did on Earth?

Going further

- Repeat each trial multiple times and calculate average deviations for statistical reliability
- Try different walking speeds and investigate whether speed affects the accuracy of each method
- Use FizziQ to record the complete sensor data during each walk and analyze the drift patterns afterward
- Combine two sensors simultaneously (e.g., gyroscope + accelerometer) and see if the combined approach reduces deviation
- Design a navigation challenge course with turns and obstacles, simulating a rover's path planning on Mars