INDIAN INSTITUTE OF TECHNOLOGY ROPAR
RUPNAGAR 140001, INDIA

GE107 - TINKERING LAB PROJECT
(WRITE-UP)

Group - G14_WED

Our Team Members -

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Progress Report – Week 3

Project Title - Development of a Smart Gesture-Controlled Car

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Introduction

- The primary aim of the project is to design and construct a robotic car that responds to human hand gestures for directional control, instead of traditional remote control systems.
- Gesture recognition is achieved through the integration of an accelerometer, which interprets hand movements into directional commands, while real-time speed data is displayed via an LCD module.
- As of Week 3, the project has transitioned from the conceptual and planning stages into hands-on prototyping. The focus for this phase has been on initial hardware integration and functional testing of core modules, namely the accelerometer, the LCD display unit, and the motor driver assembly.

Objectives

The primary objectives set for Week 3 were -

- To test and calibrate the accelerometer module for gesture detection.
- To configure and test the LCD display for visual feedback on car speed.
- To set up the motor assembly on the car chassis and ensure motion response.
- To initiate integration between gesture input and motor control logic.

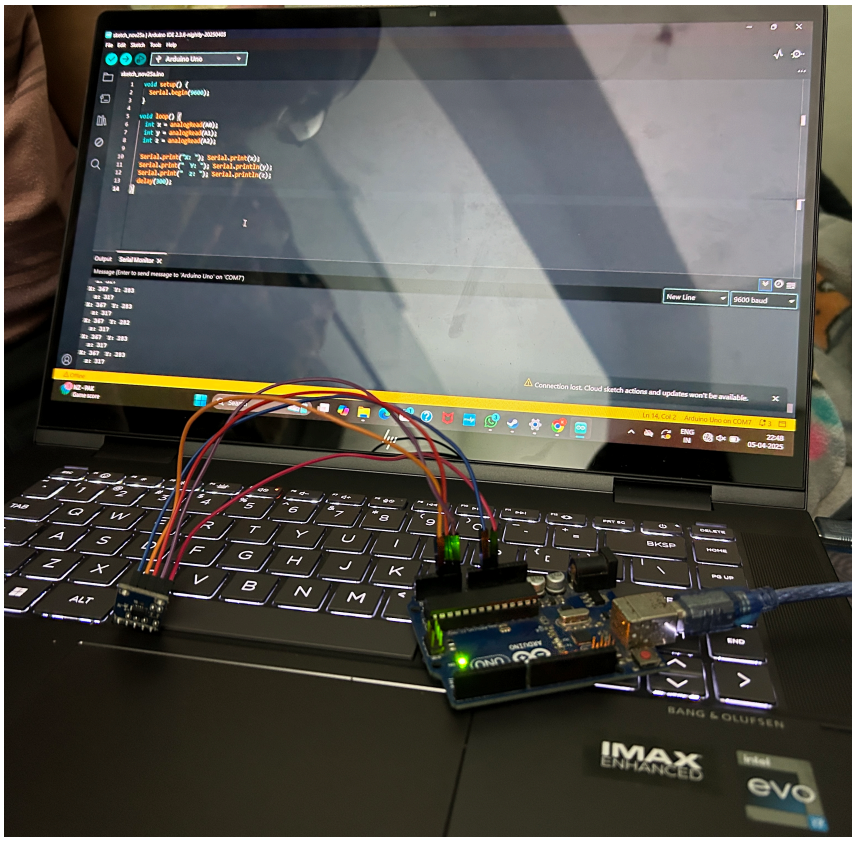
Work Completed

1. Accelerometer Setup and Gesture Testing -

The accelerometer module (lMPU6050) was configured with an Arduino Uno microcontroller. Initial readings were taken through serial monitoring, and variations in analog values were analyzed in response to hand tilt movements in different axes (X, Y, and Z).

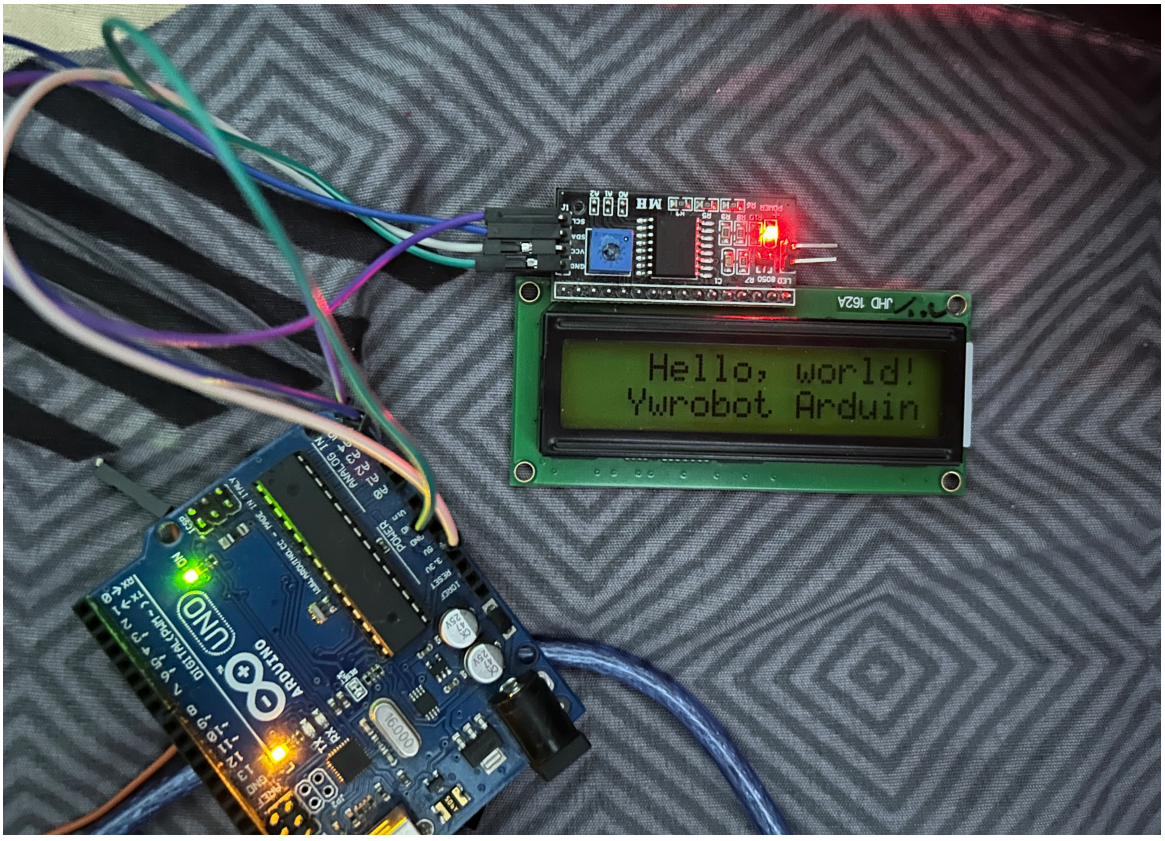
Key accomplishments in this area included -

- **Calibration -** Baseline values were established for neutral hand positioning. Variations were mapped for forward, backward, left, and right hand gestures.
- **Thresholding Logic**: Simple threshold-based decision logic was applied to detect gestures. For example, a tilt greater than +2g in the Y-axis was interpreted as a "forward" command, while a tilt in the negative Y-axis denoted a "reverse" command.
- **Signal Stability**: A preliminary observation of signal stability showed minor fluctuations, attributed to hand tremors and sensor noise. These fluctuations occasionally resulted in false detections, signaling the need for a filtering mechanism such as a moving average or Kalman filter in upcoming iterations.



2. LCD Display Configuration -

The team utilized a 16x2 LCD module with I2C communication for ease of wiring and efficiency in pin usage. The primary goal was to display the speed of the car, calculated either via PWM signal interpretation or motor RPM estimations.



Achievements in this area include -

- **Successful Initialization -** The LCD was correctly wired and initialized using standard libraries. Basic messages were displayed, confirming module functionality.
- **Speed Display -** A prototype function was written to convert analog PWM values into readable speed values, which were then displayed on the LCD. Though not yet calibrated for real-world units (e.g., km/h), the prototype successfully provided relative speed feedback.
- **Design Layout -** The LCD layout includes two lines – the first line showing a constant message ("Speed Monitor") and the second line dynamically updating speed values.

3. Motor Integration -

Two DC motors were mounted on a chassis with a motor driver (L298N) serving as the interface between microcontroller and power supply. The motors were tested for responsiveness using a basic control sketch.

Progress highlights include -

- **Power Distribution Setup -** Motors were connected to an external power source to prevent voltage drops that could affect the microcontroller.
- **Basic Control -** Manual forward, backward, and turning logic was tested using hardcoded values. Motor speed was controlled using PWM output on the enable pins.
- **Mechanical Assembly -** Motors were aligned with the wheels and securely fixed to ensure stable movement and traction during directional shifts.

Challenges Faced

Despite the considerable progress made during the third week, several technical challenges emerged -

- **Gesture Detection Accuracy -** One of the most prominent challenges was the inconsistent detection of hand gestures. The accelerometer, while responsive, produced noisy outputs under minor hand tremors or unintended motion. The current threshold logic lacks adaptability to account for natural variations in gesture execution.
- **PWM to Speed Conversion -** Translating PWM values into accurate speed measurements on the LCD requires calibration against actual motor RPM data. At present, the system displays relative speed, but lacks real-world correlation, making quantitative assessment difficult.
- **Response Time -** There is a slight delay in gesture detection and motor response. This latency, though minor, may affect user experience and control precision, especially in real-time applications.
- **Hardware Limitations -** Heat generation from the motor driver IC and minor voltage drops during simultaneous operation of multiple modules indicate a need for either a heat sink or power optimization strategies.

Proposed Solutions

To mitigate the above challenges, the following steps are planned -

- **Signal Filtering -** Implementing a low-pass filter or a digital smoothing algorithm such as a moving average to clean accelerometer data and reduce false positives.
- **Gesture Mapping Algorithm -** Replacing static thresholding with a dynamic gesture recognition algorithm using finite state machines or a lightweight neural network for improved accuracy.
- **Speed Calibration -** Using an optical encoder or Hall effect sensor for accurate RPM measurement to calibrate LCD output.
- **Power Management -** Introducing a dedicated voltage regulator for motor supply and using capacitors to stabilize voltage fluctuations.

Next Steps (Week 4 Goals)

Looking ahead to Week 4, the following objectives have been set -

- Finalize gesture detection logic with noise filtering.
- Complete motor response integration with gesture inputs.
- Conduct test runs to assess gesture accuracy and control precision.
- Begin work on wireless communication module (e.g., RF or Bluetooth) for remote gesture control.
- Conduct performance testing under different load and motion scenarios.

Conclusion

- In summary, Week 3 of our project has yielded significant foundational progress.
- The successful testing of core components — the accelerometer for gesture input, the LCD for visual feedback, and the motors for movement — demonstrates the technical viability of the proposed system.
- The challenges encountered, while notable, are typical at this phase of prototyping and have been addressed with feasible solution pathways. With continued refinement and integration in the coming weeks, the project is on track to meet its objectives within the designated timeline.