Hand Tremor Controlling Spoon or Brush

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Digital Systems
Design BCSE102L
SCOPE

by

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Executive Summary

Parkinson’s disease is a progressive neurological disorder that commonly causes involuntary hand tremors, making everyday activities such as eating, brushing, and writing difficult. These limitations reduce independence and negatively impact the quality of life. Existing solutions, such as weighted utensils and commercial stabilizing spoons, either lack effectiveness or are too expensive for widespread use. Therefore, there is a need for an affordable, lightweight, and easy-to-use assistive device that can help individuals manage tremors during daily tasks.

This project proposes the design and development of a hand tremor controlling spoon/brush that stabilizes hand movements in real time. The device uses an Inertial Measurement Unit (IMU) sensor to detect tremor vibrations, and a microcontroller-based control system drives small servo motors to counteract these tremors. By compensating for involuntary oscillations while allowing voluntary movements, the tool improves control and stability.

The main objectives of the project are:

1. To sense and analyze tremor motion accurately.
2. To stabilize the spoon/brush using a lightweight and portable mechanism.
3. To provide a low-cost, user-friendly alternative to commercial solutions.

The developed device is intended to help people with Parkinson’s maintain independence and perform essential everyday activities with improved confidence and comfort. This project demonstrates how sensor-based stabilization and simple embedded control systems can be used to create effective and affordable assistive technology.

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1. INTRODUCTION

1.1 Literature Review

1. Sharma, P., & Mehta, A. (2024). Tremor Detection in Parkinson's Patients Using IMU-Based Sensors. Journal of Biomedical Engineering and Technology.
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1.2 Research Gap

Despite significant advancements in assistive technology for Parkinson's patients, existing solutions mainly focus on complete stabilization systems that use complex algorithms and expensive hardware. These commercial products are often priced beyond the reach of most patients and offer little transparency regarding how tremor detection actually works.

There is a clear gap in research involving low-cost, easy-to-build prototypes that:

- focus solely on detecting tremor intensity,
- allow students and researchers to understand the underlying motion-sensing mechanisms,
- use readily available components like Arduino and low-cost IMU sensors, and
- provide a foundation for further innovation.

Furthermore, very few studies address entry-level educational implementations that demonstrate tremor identification before stabilization techniques are added. Thus, this project fills the research gap by developing a simple, affordable tremor-detection spoon prototype that can be used for learning, experimentation, and future expansion.

1.3 Problem Statement : Hand Tremor Controlling Spoon or Brush

1.3.1 The problem statement of developing a tremor-detection spoon for Parkinson's patients is strongly connected to the United Nations Sustainable Development Goal 3: Good Health and Well-Being. SDG 3 aims to reduce illness, support early diagnosis, and improve quality of life through affordable and inclusive healthcare innovations. Parkinson's disease is a growing global health challenge, and existing assistive devices are often expensive or inaccessible, leaving many patients without support for daily tasks such as eating. This project addresses that gap by proposing a low-cost, sensor-based tremor detection system that can help monitor symptoms and assist patients in daily activities.

By focusing on affordability, accessibility, and user well-being, the project contributes to the broader objective of SDG 3, while also encouraging innovation in the healthcare and biomedical device sector.

2. PROJECT REVIEW

This project offered an excellent opportunity to explore the practical application of sensors and microcontrollers in real-world assistive technologies. The integration of the MPU6050 with the Arduino Nano allowed for accurate real-time tremor detection, while the LED provided a reliable visual indicator. Throughout the building process, important concepts such as I²C communication, breadboard power management, and data filtering became clearer. The challenges faced—such as ensuring correct pin alignment, stabilizing sensor readings, and adjusting sensitivity thresholds—helped deepen understanding of hardware-software debugging.

Overall, the project was educational, successful, and rewarding. It demonstrated that even a simple setup can replicate the core function of advanced assistive devices. This experience builds a strong foundation for future work in embedded systems, biomedical devices, and sensor-based automation.

3. PROPOSED WORK

3.1 Design Approach / System model / Algorithm

Design Approach

1. Use Arduino Nano as the main controller for processing sensor data.
2. Interface MPU6050 using the I²C protocol (SDA → A4, SCL → A5).
3. Capture accelerometer readings (ax, ay, az) in real time.
4. Compute movement magnitude using:

$$M = \sqrt{ax^2 + ay^2 + az^2}$$

5. Compare the magnitude with a threshold to determine tremor intensity.
6. Activate an LED connected to Digital Pin 3 when tremor > threshold.
7. Keep the LED OFF during normal, low-intensity movement.

System Model (Block Explanation)

- Power Supply (USB to Nano)
- Arduino Nano processes incoming sensor data

- MPU6050 Sensor collects real-time hand motion values
- Data Analysis Unit (program logic on Nano)
- Output Unit
    - LED indicator for tremor status

Algorithm

1. Start
2. Initialize I^2C communication
3. Initialize MPU6050 sensor
4. Read accelerometer values (ax, ay, az)
5. Convert raw values to g-force
6. Calculate total movement magnitude
7. If magnitude > threshold
   → Turn LED ON
   Else
   → Turn LED OFF
8. Repeat steps 4–7 continuously
9. End

3.2 Technical Description

Hardware Components Used

- Arduino Nano (ATmega328P microcontroller)
- MPU6050 (3-axis accelerometer + 3-axis gyroscope)
- LED (indicator output device)
- 220 Ω resistor (current limiting for LED)
- Breadboard (prototyping platform)
- 22 AWG jumper wires (interconnections)
- USB cable (power + programming interface)

Hardware Connection Summary

- Arduino 5V → Breadboard + rail
- Arduino GND → Breadboard – rail
- MPU6050 VCC → + rail
- MPU6050 GND → – rail
- MPU6050 SDA → A4
- MPU6050 SCL → A5
- LED Anode → 220 Ω Resistor → D3
- LED Cathode → GND

4. HARDWARE/SOFTWARE TOOLS USED

1. Arduino Nano (or compatible clone)
2. MPU6050 IMU sensor
3. Breadboard + jumper wires
4. 1× LED (any color)
5. 1× 220 Ω resistor (for the LED)
6. USB cable (for programming and power)

5. RESULT ANALYSIS

The results demonstrate that the implemented system successfully detects tremor activity with reasonable accuracy. During controlled tests, the MPU6050 sensor captured movement data in real time, and the Arduino Nano processed the values to calculate tremor magnitude. When the motion intensity stayed within normal limits, the LED remained OFF, confirming that the system could filter out ordinary hand movement.
As the hand shaking increased beyond the calibrated threshold, the LED consistently turned ON, indicating that the tremor was detected. Multiple trials were conducted with varying speeds and intensities of hand motion. The system showed reliable response patterns with minimal delay. Sensitivity analysis revealed that adjusting the threshold value directly affected performance:

- Lower thresholds increased responsiveness but caused occasional false positives.
- Higher thresholds reduced false triggers but required stronger tremors for LED activation.

Overall, the prototype behaved as expected and showed that even using simple, low-cost components, accurate tremor detection can be achieved. The results validate the concept and show potential for further enhancement, such as real-time stabilization or data logging

6. CONCLUSION AND FUTURE WORK

6.1 Summary

This project successfully demonstrated the design and implementation of a low-cost tremor-detection system using an Arduino Nano, MPU6050 sensor, and LED indicator. The system effectively measured hand movements, calculated tremor intensity, and activated the LED when the threshold was exceeded.
The prototype proved that basic embedded systems can detect abnormal tremors in real time, offering a foundational understanding of sensor interfacing, I²C communication, and biomedical assistive technology concepts. The results validated the objective of creating a simple and functional model that represents how assistive devices for Parkinson’s patients operate.

6.2 Limitations and Constraints

Although the project achieved its goals, certain limitations were observed:

1. Single Output Feedback:
   Only an LED indicator was used. No detailed data logging or display system was included.
2. No Stabilization Mechanism:
   The system detects tremors but does not compensate or counteract them as real stabilizing spoons do.
3. Threshold Sensitivity:
   The tremor threshold must be manually adjusted, and incorrect values can cause false positives or missed detections.
4. Breadboard Instability:
   Breadboard connections can loosen and cause inaccurate sensor readings.
5. Limited Real-World Testing:
   Actual tremor profiles vary widely; the prototype was tested only under simulated shaking conditions.
6. No Battery or Portable Design:
   The device currently depends on USB power and lacks enclosure or ergonomic spoon integration.

6.3 Improvement / Future Work

Several enhancements can be made to advance this prototype into a more realistic assistive device:

1. Add Stabilizing Motors (Servo or Brushless Motors):
   Implement active tremor compensation using PID control to create a true Parkinson's stabilizing spoon.
2. Use a Display or Mobile App:
   Show real-time tremor intensity, graphs, or logs using OLED, LCD, or Bluetooth app.
3. Add Battery Power:
   Make the device portable using a Li-ion battery and TP4056 charging module.
4. 3D Printed Spoon Attachment:
   Design a practical spoon handle that houses the electronics.
5. Data Logging for Medical Use:
   Store tremor readings on an SD card or cloud platform to track patient health trends.
6. Machine Learning Based Tremor Classification:
   Use ML models to distinguish between normal movement, intentional motion, and actual tremors.
7. Improve Accuracy with Sensor Fusion:
   Use Kalman or Complementary filters for smoother and more precise motion detection.

7. SOCIAL AND ENVIRONMENTAL IMPACT

- Improves quality of life for Parkinson's patients.
- Restores dignity and independence in daily activities.
- Reduces caregiver burden and emotional stress on families.
- Makes assistive technology more affordable and accessible to wider communities.
- Promotes inclusive healthcare and social equality.
- Inspires innovation in low-cost medical assistive devices.

8. WORK PLAN

A. Hardware Implementation

1. Mount Arduino Nano into the breadboard.
2. Connect Nano 5V row → + rail.
3. Connect Nano GND row → – rail.
4. Connect MPU6050:
    - VCC → +
    - GND → –
    - SDA → A4
    - SCL → A5
5. Insert LED:
    - Long leg (anode) → resistor → D3
    - Short leg (cathode) → – rail
6. Ensure all grounds and power lines are common.

B. Software Implementation

1. Install libraries (Wire.h, MPU6050.h).
2. Initialize MPU6050.
3. Read accelerometer values.
4. Calculate motion magnitude.
5. If value > threshold → turn LED ON.
6. Else → LED OFF.
7. Upload and test using Serial Monitor

9. COST ANALYSIS

The entire project costed a total of ₹951

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11. Appendix-1 –(8086 ALP code)

```
START:
    INITIALIZE I2C BUS
    INITIALIZE MPU6050 SENSOR
    CONFIGURE LED_PIN AS OUTPUT

MAIN_LOOP:
    READ ACCEL_X, ACCEL_Y, ACCEL_Z FROM SENSOR
    CONVERT RAW VALUES TO G-FORCE
    CALCULATE MAGNITUDE = √(X² + Y² + Z²)
    SUBTRACT NORMAL GRAVITY (1g) TO GET TREMOR_VALUE

    COMPARE TREMOR_VALUE WITH THRESHOLD
    IF TREMOR_VALUE > THRESHOLD THEN
        SET LED_PIN HIGH        ; TURN ON LED
    ELSE
        SET LED_PIN LOW         ; TURN OFF LED
    ENDIF

    GOTO MAIN_LOOP

END
```