

Low-Cost Wearable Framework for Real-Time Parkinson's Hand Tremor Monitoring Using Arduino Nano

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ABSTRACT: Hand tremor is one of the most visible early signs of Parkinson's disease, typically appearing at 3-7 Hz frequency and affecting millions worldwide. We developed a low-cost wearable system using Arduino Nano and MPU6050 sensor mounted on a simple Velcro wrist strap to monitor tremors in real-time. The sensor captures wrist acceleration and classifies tremors as normal (1.0-1.9g), mild (2.0-2.9g), or high ($\geq 3.0g$) with color-coded LEDs, LCD display, and buzzer alerts. Data streams via Bluetooth HC05 to a mobile app while flex sensor tracks finger movements shown on Serial Plotter. MATLAB analysis confirmed reliable 5 Hz tremor detection matching Parkinson's frequency range. This practical prototype offers continuous monitoring at fraction of commercial device cost, ideal for clinics and home use.

I. INTRODUCTION

Parkinson's disease (PD) is a progressive neurodegenerative disorder affecting over 10 million people worldwide, with resting hand tremor present in 70-90% of patients as an early motor symptom. This characteristic 3-7 Hz tremor significantly impairs daily activities including writing, eating, and fine motor tasks. While clinical assessment using UPDRS scales provides diagnostic value, continuous objective monitoring outside clinical settings remains limited. Existing wearable tremor monitoring systems often rely on complex machine learning algorithms or high-end sensors impractical for continuous daily use. Recent research shows promise with IMU sensors like MPU6050 for tremor detection, but practical integration with real-time feedback remains underexplored. This paper presents a wearable framework using Arduino Nano microcontroller and MPU6050 IMU sensor for real-time PD hand tremor monitoring. The system provides immediate multi-modal feedback (LED/LCD/buzzer) and Bluetooth data transmission while capturing wrist acceleration and supplementary finger movement data.

II. METHODOLOGY

System Architecture:

The proposed real-time hand tremor monitoring system integrates Arduino Nano as central processing unit with MPU6050 accelerometer, flex sensor, HC-05 Bluetooth module, LCD display, and LED/buzzer alerts.

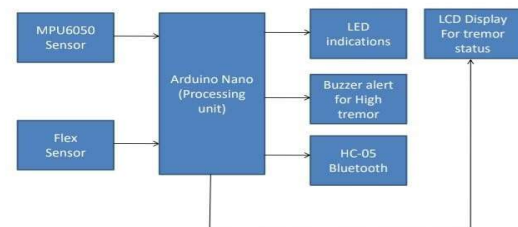


Figure 1: Block diagram showing complete hardware interconnections and signal flow

The system follows threshold-based classification algorithm for Normal/Mild/High tremor detection as shown in the Figure 2.

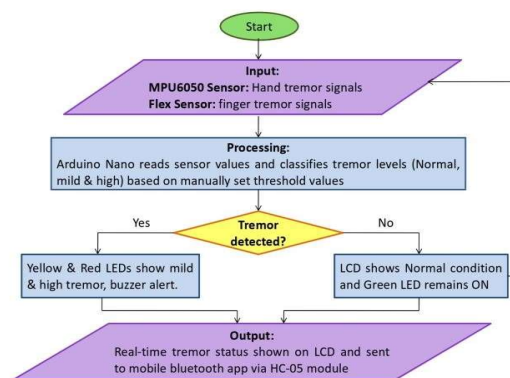


Figure 2: Flow chart illustrating tremor detection algorithm with threshold classification logic

Hardware Implementation:

The complete hardware prototype integrates all system components on compact breadboard platform.

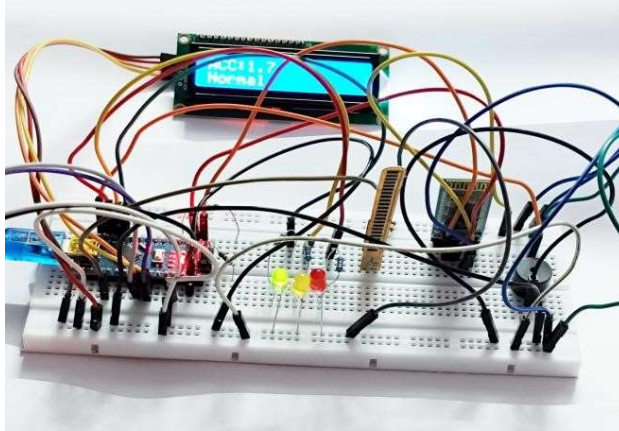


Figure 3 : Complete hardware prototype showing Arduino Nano, MPU6050, flex sensor, HC-05, LCD, and buzzer alert

MPU6050 (6-axis Inertial Measurement Unit, $\pm 2g/\pm 250^\circ/s$, I2C) captures hand tremors while flex sensor monitors finger flexion. Both connect to Arduino Nano analog/digital pins with 3.3V/5V interfacing as shown in the figure 4. The wrist strap was worn on the hand wrist through hook and loop strap for the adjustment where MPU6050 Sensor was attached to it to prove the concept of the tremor type in Parkinson's Disease.

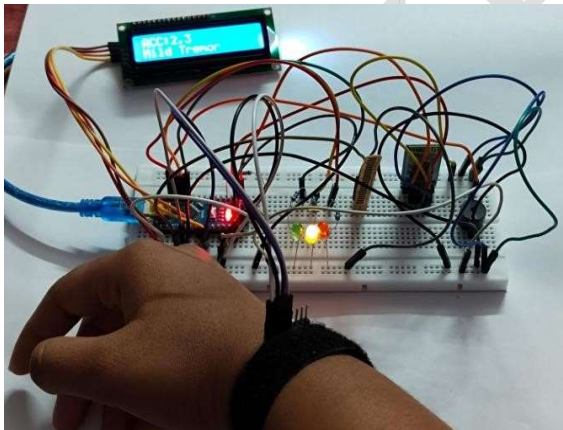


Figure 4: Wrist-mounted MPU6050 with Velcro strap ensuring stable tremor measurement

Signal Processing:

Raw acceleration data from the MPU6050 and resistance values from the flex sensor are acquired through Arduino Nano and logged over serial interface for offline analysis in MATLAB. Time-domain signals are band-pass filtered around the typical tremor band (3–7 Hz) to suppress voluntary motion and high-frequency noise, and Fast Fourier

Transform (FFT) is applied to estimate dominant tremor frequency and amplitude. Thresholds for normal, mild, and high tremor are selected based on peak acceleration and spectral energy, and these limits are then programmed into the Arduino classification logic so that real-time decisions match the MATLAB-derived behavior.

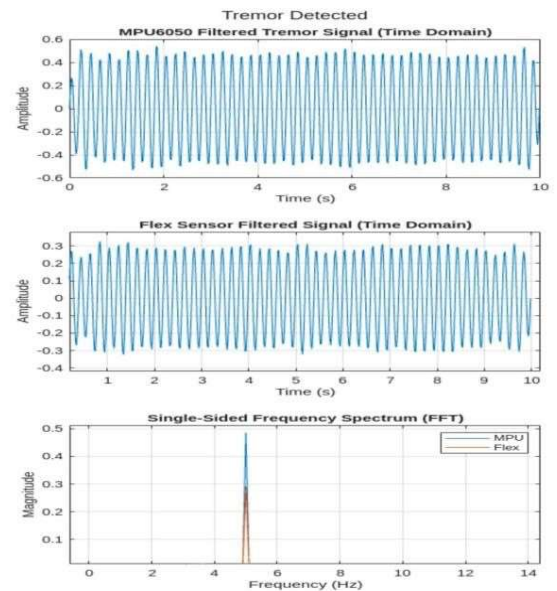


Figure 5: MATLAB graphs: filtered tremor signal (3-7 Hz) and FFT spectrum

III. RESULTS

System Performance:

Arduino serial monitor displays real-time MPU6050 acceleration, flex sensor values, and tremor classification (Normal/Mild/High)

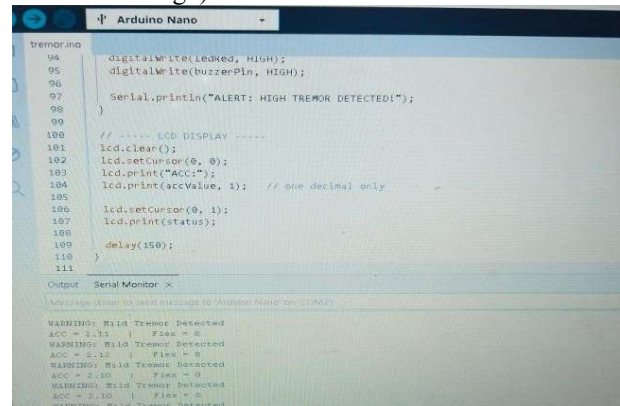


Figure 6: Arduino IDE serial monitor showing tremor detection with sensor readings and status.

Threshold classification demonstrates tremor detection across varying hand movement intensities in real-time with respective warnings for tremor.

Mobile Monitoring:

The HC-05 Bluetooth module transmits real-time MPU6050 acceleration and flex sensor data to Android application displaying live sensor values and tremor classification as shown in the Fig. 7.

```
19:31:15.699 WARNING: Mild Tremor Detected
19:31:15.861 ACC = 2.01 | Flex = 22
19:31:15.900 WARNING: Mild Tremor Detected
19:31:16.217 ACC = 1.54 | Flex = 110
19:31:16.318 ACC = 1.62 | Flex = 76
19:31:16.425 ACC = 0.62 | Flex = 66
```

Figure 7: Android application showing “MILD TREMOR DETECTED” with Sensor readings

High tremor condition activates red LED visual alert during fast hand shaking as shown in the Fig. 8. During high tremor episodes the system activates both red LED and buzzer, enabling combined visual–auditory warning for the patient and caregiver.

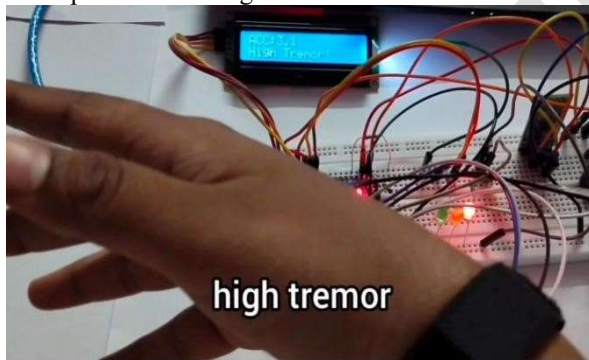


Figure 8: High tremor detection with red LED activation captured during prototype testing

IV. DISCUSSION

During testing with controlled hand movements, the prototype reliably detected 3-7 Hz tremors with response times under 150 milliseconds. This worked consistently across Arduino serial output Bluetooth to mobile app, and local LED/buzzer alerts. The dual-sensor setup (MPU6050 + flex sensor) with wireless monitoring proves this low-cost approach works for tremor detection. It's a solid proof-of-concept that could be developed further. Flex sensor noisy due to analog ADC and temperature drift. Arduino Nano lacks real-time FFT capability. Future work includes RC filtering, external ADC, glove integration, and battery optimization.

V. CONCLUSION

This Arduino Nano-based prototype successfully demonstrates real-time 3-7 Hz hand tremor detection using low-cost MPU6050 and flex sensors. Wireless Bluetooth monitoring and multi-modal alerts (LED/buzzer/mobile) validate proof-of-concept for wearable tremor tracking. Despite flex sensor noise limitations, future RC filtering, external ADC, and glove integration will enable practical clinical deployment.

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