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RESEARCH ARTICLE OPEN ACCESS

Smart Hand Gesture System

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Abstract:

The "Smart Hand Gesture System" is a wearable solution developed to make human–computer interaction more natural and convenient through touchless control. Traditional input devices like keyboards and mice require physical contact and fixed positioning, which can be limiting in situations that demand flexibility, hygiene, or ease of use. To overcome these limitations, this system uses hand gestures to control digital devices in a simple and intuitive way. It is built using an MPU6050 motion sensor to detect hand movements and orientation, along with a Hall Effect sensor to recognize click actions. An ESP32 microcontroller processes this data and sends it wirelessly via Bluetooth HID to perform cursor operations such as movement, clicking, and air drawing in real time. Powered by a compact Li-Po battery, the device is portable and energy-efficient. This system offers a practical and user-friendly alternative to traditional input devices, with applications in areas such as virtual reality, robotics, smart automation, and assistive technologies. Overall, it enhances accessibility, improves user experience, and supports the growing need for touchless digital interaction.

Keywords — **Air Drawing, Gesture Recognition, ESP32, MPU6050, Hall Effect Sensor, Bluetooth HID, Wearable Electronics, Human–Computer Interaction, Touchless Control, Assistive Technology.**

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I. INTRODUCTION

In today's rapidly advancing digital era, the demand for intuitive and flexible human–computer interaction has increased significantly. Traditional input devices such as keyboards and mice, although widely used, require physical contact and a fixed working environment, which limits mobility and convenience. These devices are not always suitable for modern applications where hygiene, portability, and ease of interaction are important. Additionally, they do not provide a natural way of interaction, as human communication is inherently based on gestures and movements. This limitation becomes more evident in areas such as virtual reality, robotics, and assistive technologies, where real-time and touchless control is essential.

To overcome these challenges, a Smart Hand Gesture System has been developed as a wearable solution that allows users to control digital devices using hand gestures. The system utilizes motion sensing and wireless communication to detect and transmit user movements for performing cursor operations such as movement and clicking. It is designed to be compact, portable, and user-friendly, eliminating the need for physical input devices. By providing a more natural and contactless interaction method, the system enhances accessibility, improves user experience, and supports applications in modern smart environments.

PRESENT THEORIES AND PRACTICES

The Smart Hand Gesture System is a modern technological solution developed to enhance human–computer interaction by introducing a touchless and intuitive control mechanism. With the

rapid advancement in embedded systems, wearable electronics, and wireless communication, traditional input devices such as keyboards and mice are gradually being replaced by smarter and more flexible interaction methods. This project is based on the concept of gesture recognition using sensor-based technology, where physical hand movements are captured, processed, and translated into control commands in real time.

The core idea behind this system is to allow users to interact with digital devices using natural hand gestures instead of physical input devices. In conventional systems, users rely on mechanical devices that require direct contact and fixed positioning, which can limit usability and comfort. These systems lack flexibility and are not suitable for applications requiring mobility or touchless interaction. To overcome these limitations, the proposed system integrates motion sensing and magnetic sensing technologies with wireless communication to create a more efficient and user-friendly interface.

The system primarily consists of an MPU6050 motion sensor, Hall Effect sensor, and ESP32 microcontroller. The MPU6050 sensor detects hand orientation, tilt, and movement, while the Hall Effect sensor identifies click actions using magnetic interaction. The ESP32 microcontroller acts as the central processing unit, interpreting sensor data and transmitting it via Bluetooth HID to connected devices.

The working principle involves capturing hand movements through sensors, processing the data in real time, and converting it into cursor operations such as movement, clicking, and air drawing. These commands are transmitted wirelessly to devices like computers or smartphones, enabling seamless interaction. This approach eliminates the need for cameras or external tracking systems, making it more reliable, portable, and efficient.

From a theoretical perspective, the system combines concepts from embedded systems, sensor fusion, wireless communication, and human–computer interaction. It follows a layered approach consisting of sensing, processing, and communication mechanisms. In practical implementation, factors such as sensor calibration, power management, and system responsiveness are considered to ensure accuracy and reliability.

Overall, this system provides a cost-effective, scalable, and efficient solution for modern interaction systems. It improves usability, accessibility, and flexibility, making it suitable for applications in virtual reality, robotics, smart automation, and assistive technologies.

PROBLEM STATEMENT

In the modern era of digital interaction, traditional input devices such as keyboards and mice are widely used for controlling computers and other electronic devices. However, these devices require physical contact and a fixed working surface, which limits flexibility and convenience in many real-world applications. In environments where hygiene, mobility, or accessibility is important, such as healthcare systems, industrial setups, or assistive technologies, the use of conventional input devices becomes inefficient and sometimes impractical.

Moreover, continuous use of these devices can cause discomfort and fatigue, and they do not provide a natural way of interaction, as human communication is primarily based on gestures and movements. Existing systems also lack portability and are not suitable for touchless or real-time interaction in dynamic environments. Additionally, users with physical disabilities may find it difficult to operate traditional input devices, highlighting the need for more accessible solutions.

Therefore, there is a need to develop a smart, wearable, and wireless system that can interpret hand gestures and convert them into control

commands for digital devices. The system should be capable of accurately detecting motion and gesture-based actions, processing them in real time, and transmitting the corresponding commands efficiently. It must also ensure user comfort, portability, low power consumption, and reliable performance to serve as an effective alternative to conventional input devices.

A. PCB Design of Smart Hand Gesture System

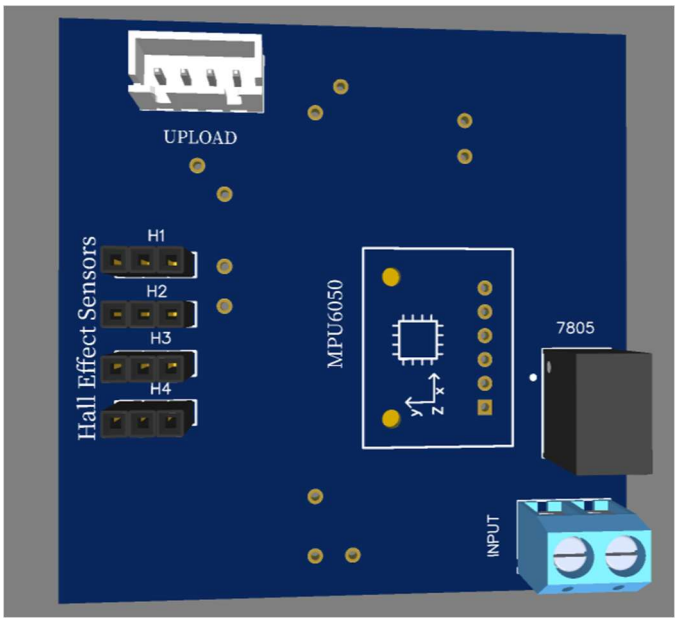

Fig. 1 A PCB design of the Smart Hand Gesture System

Fig. 1 shows the PCB design of the Smart Hand Gesture System, which connects all components in a compact and organized manner. On the left side, connectors labelled H1 to H4 are provided for the Hall Effect sensors, which detect click actions using magnetic interaction. At the centre, a dedicated space is given for the MPU6050 sensor, which plays a key role in detecting hand movement, tilt, and orientation for cursor control and air drawing. At the top, an upload header is included to program the microcontroller.

On the right side of the PCB, a 7805-voltage regulator is used to provide a stable power supply to the system. Below it, an input terminal is provided to connect the battery or external power source. Overall, this PCB design reduces wiring complexity, improves system reliability, and makes the device compact and suitable for wearable applications.

a) Hardware Setup: The hardware setup of the proposed Smart Hand Gesture System consists of several essential components that work together to enable accurate gesture detection and wireless control of digital devices. The system is built around the ESP32 microcontroller, which acts as the main processing unit and handles communication between all components. An MPU6050 motion sensor is used to detect hand orientation, tilt, and movement, while a Hall Effect sensor is employed to recognize click actions through magnetic interaction. In addition to these sensors is integrated into the system to provide real-time feedback such as gesture recognition. The entire system is powered by a rechargeable Li-Po battery, ensuring portability and continuous operation. All these components are mounted on a wearable glove, making the system compact, lightweight, and comfortable for real-time use.

b) Integration: All hardware components, including sensors are integrated with the ESP32 microcontroller. The system combines sensing, processing, and wireless communication to enable real-time gesture-based control. All components are mounted on a glove to ensure smooth and wearable operation.

c) Testing and Deployment: The system is tested in two stages: unit testing for individual components and integration testing for overall performance. Gesture accuracy, response time, and Bluetooth connectivity are verified. After successful testing, the system is deployed as a wearable glove for real-time use.

d) Power Management: The system is powered by a rechargeable Li-Po battery. Voltage regulation ensures stable power supply to all components. The design focuses on low power consumption to provide longer battery life and efficient performance.

II. CONCLUSIONS

The Smart Hand Gesture System successfully improves human–computer interaction by enabling touchless and intuitive control of digital devices. By integrating components such as the ESP32 microcontroller, MPU6050 motion sensor, Hall Effect sensor, and Bluetooth communication, the system allows users to perform operations like cursor movement, clicking, and air drawing in real time. It reduces dependency on traditional input devices such as keyboards and mice, making interaction more flexible and convenient.

The system enhances usability by providing a natural way of interaction through hand gestures. The inclusion of air drawing capability adds an interactive dimension, allowing users to draw or write in the air, which is especially useful in applications like presentations, virtual interfaces, and creative tasks. It also improves accessibility for differently abled users and supports applications in virtual reality, robotics, and smart automation. Overall, the proposed system offers a reliable, portable, and cost-effective solution for modern touchless interaction, improving user experience and efficiency.

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