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Sky Pointer ESP32 Based Wireless Air Mouse

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Abstract: ***The Sky Pointer is an innovative ESP32-based wireless air mouse designed to provide an intuitive and touch-free method of controlling a computer cursor through hand movements. The system employs an Inertial Measurement Unit (IMU)—combining accelerometer and gyroscope sensors—to detect motion and orientation in real time. These sensor readings are processed by the ESP32 microcontroller, which translates them into cursor movements and transmits the corresponding signals wirelessly to a host computer via Bluetooth or Wi-Fi. Click and scroll functions are implemented using tactile switches or gesture recognition. This design eliminates the need for a traditional surface-dependent mouse, offering enhanced portability and user convenience, especially for presentations, virtual classrooms, and media control applications. The Sky Pointer demonstrates the potential of low-cost, microcontroller-based systems to deliver natural and ergonomic human–computer interaction through motion sensing and wireless communication.***

Keywords: ESP32, Air Mouse, Wireless Communication, Motion Sensing, Inertial Measurement Unit (IMU), Accelerometer, Gyroscope, Bluetooth, Human–Computer Interaction (HCI), Gesture Control, Cursor Control, Embedded Systems, IoT Device, Microcontroller, Smart Pointer.

I. INTRODUCTION

In the modern era of computing, human–computer interaction (HCI) has evolved from simple wired peripherals to advanced wireless and gesture-based control systems. Traditional computer mice, though efficient, require a flat surface for operation and are limited in range and flexibility. With the growing demand for intuitive, portable, and wireless input devices, motion-sensing technologies have emerged as a promising alternative. The Sky Pointer project introduces an ESP32-based wireless air mouse that allows users to control the computer cursor through natural hand movements, without the need for a physical surface. The system utilizes an Inertial Measurement Unit (IMU) sensor, which combines an accelerometer and a gyroscope to capture real-time motion data. The ESP32 microcontroller processes these signals and transmits them wirelessly via Bluetooth or Wi-Fi to the host computer, effectively replicating the functions of a traditional mouse. This approach provides enhanced freedom of movement and convenience, making it ideal for applications such as presentations, gaming, virtual classrooms, and smart media control. By leveraging affordable microcontroller technology and motion sensors, the Sky Pointer demonstrates how embedded systems can create user-friendly, low-cost, and efficient alternatives to conventional input device

II. BENEFITS

A. Wireless Freedom

The Sky Pointer eliminates the need for wired connections, allowing users to control their computer or device from a distance using Bluetooth or Wi-Fi connectivity.

B. Surface-Independent Operation

Unlike traditional mice that require a flat surface, the air mouse functions through motion sensing, enabling control in mid-air—ideal for presentations or media control.

C. Enhanced Portability

Compact and lightweight, the ESP32-based design makes the device easy to carry and use anywhere without the limitations of traditional peripherals.

D. Cost-Effective Solution

Built using affordable components such as the ESP32 microcontroller and IMU sensors, the Sky Pointer offers advanced functionality at a low production cost.

E. User-Friendly and Intuitive Control

Hand movements provide a natural and engaging way to interact with computers, reducing dependence on traditional input methods.

III. COMPONENT USED

A. ESP32 Microcontroller

o A powerful, low-cost microcontroller with built-in Bluetooth and Wi-Fi capabilities.
o Responsible for sensor data processing and wireless communication..

B. MPU6050 Sensor

o A 6-axis motion tracking device combining a 3-axis gyroscope and a 3-axis accelerometer.
o Captures hand movements and orientation changes in real time.

C. Bluetooth Module (integrated in ESP32)

o Facilitates wireless data transmission between the ESP32 and host device.
o Uses Bluetooth HID (Human Interface Device) profile to emulate a mouse.

D. Power Supply

o Battery or USB power source for portability.

IV. METHODOLOGY

A. Sensor Initialization

- The MPU6050 is calibrated to detect pitch, roll, and yaw.
- Raw data is filtered using complementary or Kalman filters to reduce noise.

B. Gesture Mapping

Specific hand movements are mapped to mouse actions:

- Tilt left/right → Move cursor horizontally
- Tilt forward/backward → Move cursor vertically
- Quick flicks or taps → Click action

C. Bluetooth Communication

- ESP32 uses the HID protocol to send mouse movement and click signals to the paired device.
- The device appears as a Bluetooth mouse to the host system.

D. Power Management

- A voltage regulator ensures stable power supply from a 9V battery.
- Sleep modes may be used to conserve energy when idle.

V. LITERATURE SURVEY

Title	Author	Date	Description
Design and development of air mouse using ESP32 and MPU6050 sensor	Muhammad Ryan Prayogi	June 2025	In the era of modern technology, innovations in digital input devices are growing, one of which is an air mouse based on ESP32 and MPU6050 sensors.
ESP32 air mouse using Bluetooth and MPU6050	Rithik Krisna	April 2025	Gesture control is one of the coolest ways to interact with technology—no buttons, no touchscreens, just simple hand movements. It almost feels like magic when you can control devices with a wave of your hand!

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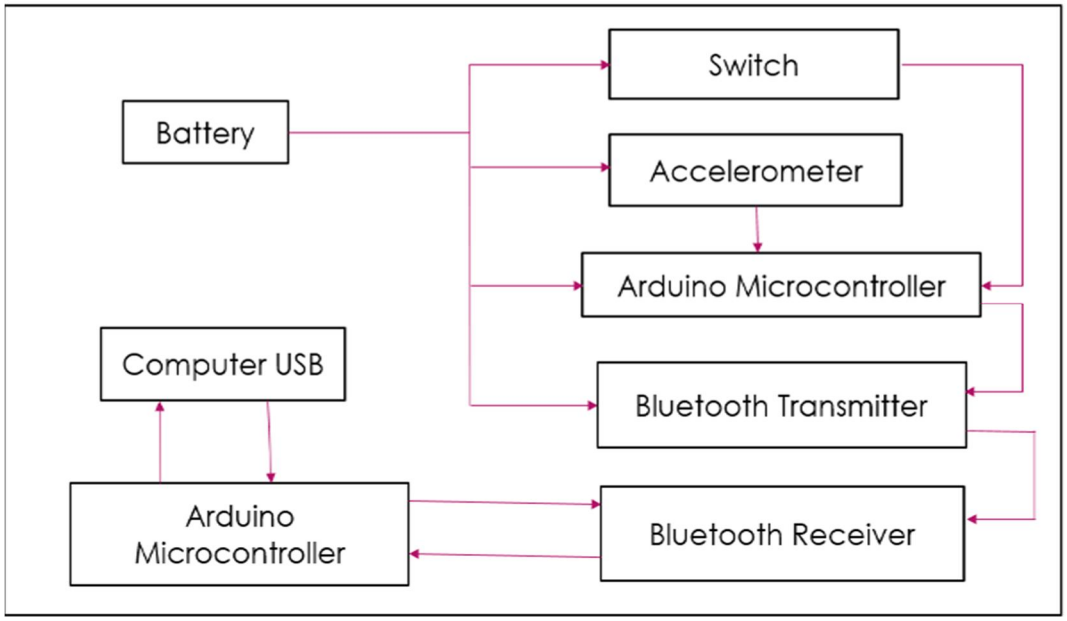
VI. BLOCK DIAGRAM



VII. EXPLANATION

A. Battery Function

The battery provides the DC power supply to the system. It powers components such as the accelerometer, switch, Bluetooth module, and Arduino microcontroller.

Details:

- Typically a 3.7V Li-ion or 9V battery.
- Powers the circuit when not connected to a computer USB.

B. Switch Function

The switch is used to turn the system ON or OFF. It controls the power flow from the battery to the rest of the components.

Details: • A simple toggle or push-button switch.

- When turned ON, it allows current from the battery to reach the Arduino and sensors

C. Accelerometer Function

The accelerometer senses motion or tilt (acceleration in X, Y, and Z axes). It detects orientation or movement and sends that data to the Arduino microcontroller.

Details: • Common models: ADXL335, MPU6050, etc

- Converts analog or digital signals of acceleration into readable values.

D. Arduino Microcontroller Function

The Arduino acts as the brain of the system. It processes the accelerometer data, interprets it according to the programmed logic, and then transmits or receives data via Bluetooth.

Details: • Examples: Arduino Uno, Nano, or Mega

.• Collects sensor data (from accelerometer).

- Sends processed data to Bluetooth Transmitter for wireless communication

E. Bluetooth Transmitter Functio

The Bluetooth Transmitter module sends data wirelessly to another Bluetooth-enabled device (like a computer, smartphone, or another Arduino setup).

Details: • Common modules: HC-05, HC-06.
•Transmits processed data (e.g., movement, sensor readings) to the receiver module
• Operates typically at 3.3V logic level.

F. Bluetooth Receiver Function

The Bluetooth Receiver module receives data sent by the transmitter. It forwards this data to another Arduino microcontroller or directly to the computer via USB.

Details: • Also can be HC-05/HC-06 or BLE modules.
• Receives signals wirelessly from the transmitting module.

G. Computer USB Function

The Computer USB connection serves multiple purposes — power supply, programming, and data communication.

VIII. SCOPE OF PROJECT

1) Wireless Cursor Control: Successful implementation of a wireless air mouse that can control the cursor movement on a Bluetooth-enabled device (such as a laptop or smartphone) through hand gestures detected by the MPU6050 sensor.

2) Accurate Motion Tracking: The system will accurately capture and interpret hand motions such as tilting, shaking, and rotation to translate these into smooth and responsive cursor movements on the screen.

3) Bluetooth HID Communication: The ESP32 will effectively act as a Bluetooth Human Interface Device (HID), ensuring stable and low-latency communication with the host device without the need for additional drivers.

4) Basic Mouse Functionality: Incorporation of functional buttons for left-click, right-click, and possibly scroll functions to provide a complete mouse-like experience

5) Portability and Ease of Use: The device will be lightweight, compact, and powered by a rechargeable battery, making it convenient for use in various environments such as presentations, gaming, or general computing.

6) User-Friendly Interface: Minimal setup and calibration will be required, allowing users to start controlling the cursor with intuitive hand movements almost immediately.

IX. CONCLUSION

The Sky Pointer : ESP32 – Based Wireless Air Mouse project successfully demonstrates an innovative approach to human-computer interaction by replacing traditional mice with a wireless, gesture-based input device. By leveraging the combined capabilities of the MPU6050 sensor for motion detection and the ESP32 microcontroller's Bluetooth HID profile, the system enables intuitive and responsive cursor control without the need for physical contact or surfaces. This design enhances portability and user convenience, making it suitable for a variety of applications ranging from presentations to gaming and accessibility solutions. Although challenges such as sensor drift and Bluetooth latency exist, proper calibration and efficient algorithms can mitigate these issues to provide a smooth user experience.

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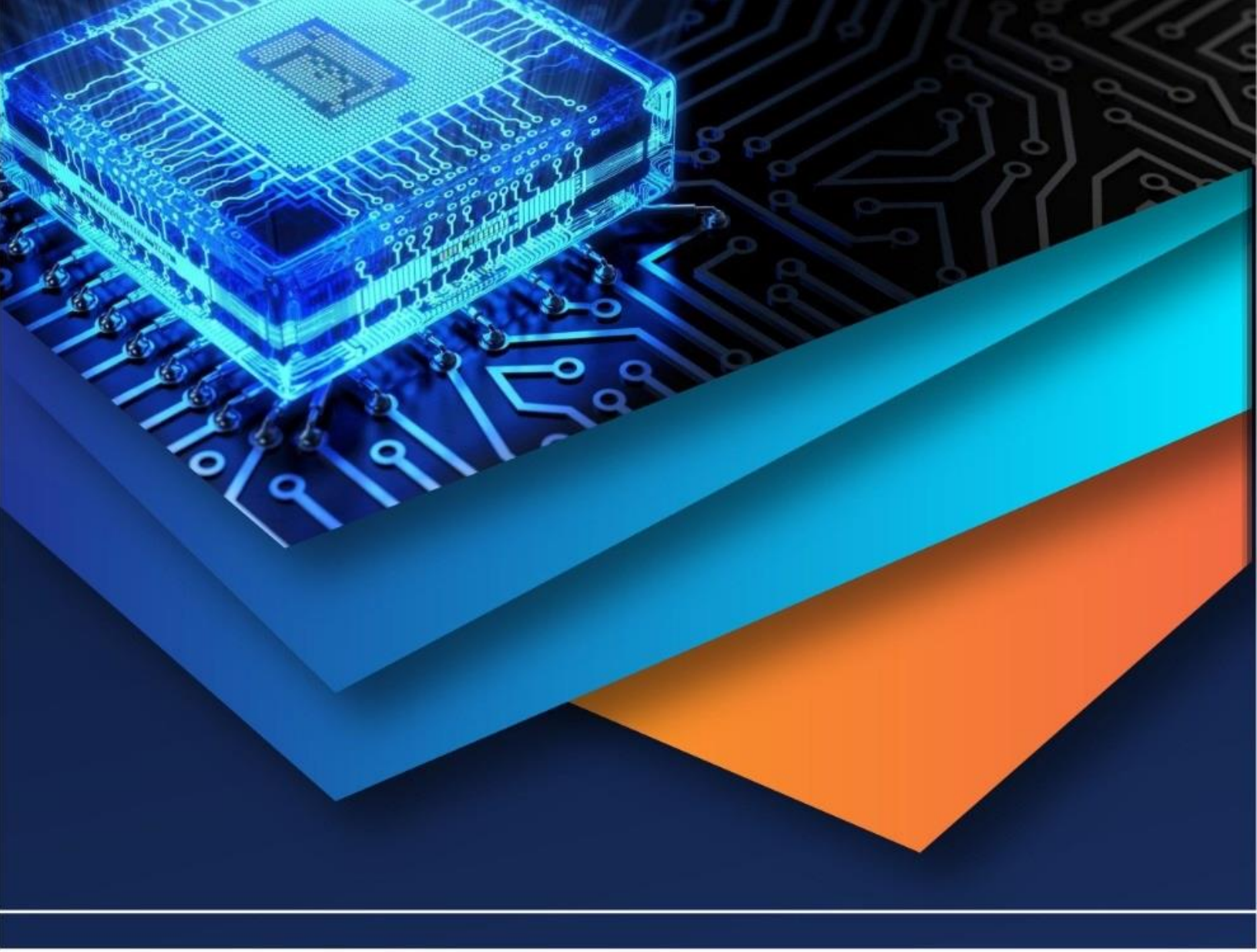

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