

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING

KATHMANDU ENGINEERING COLLEGE

KALIMATI, KATHMANDU



MAJOR PROJECT PROPOSAL REPORT ON

Your Project

BY

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TO

DEPARTMENT OF ELECTRONICS, COMMUNICATION AND INFORMATION
ENGINEERING

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List of Abbreviation

AI Artificial Intelligence

GPIO General Purpose Input Output

IoT Internet of Things

ML Machine Learning

RAM Random Access Memory

OS Operating System

BRNN Bidirectional Recurrent Neural Networks

GRU Gated Recurrent Units

MIMO Multiple Input Multiple Output

SoC System-on-Chip

USB Universal Serial Bus

Wi-Fi Wireless Fidelity

NLP Natural Language Processing

TTS Text-To-Speech

API Application Programming Interface

ARM Advanced RISC Machine

RISC Reduced Instruction Set Computer

IP Internet Protocol

MCU Micro-Controller Unit

Chapter 1: Introduction

1.1 Background Theory

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1.2 Problem Statement

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Chapter 2: Literature Review

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Chapter 3: Related Theory

3.1 Hardware

MPU6050 Sensor: The MPU6050 is a widely used 6-axis MEMS-based Inertial Measurement Unit (IMU) that integrates a 3-axis accelerometer and a 3-axis gyroscope within a single chip. It is capable of detecting linear acceleration in the range of $\pm 2g$ to $\pm 16g$ and angular velocity from $\pm 250^\circ/s$ to $\pm 2000^\circ/s$, making it highly suitable for motion tracking and gesture recognition applications. A notable feature of the MPU6050 is its onboard Digital Motion Processor (DMP), which performs real-time sensor fusion using algorithms such as Kalman or complementary filtering. This significantly reduces noise and drift in gyroscopic data, enabling stable orientation tracking through the calculation of quaternions or Euler angles (roll, pitch, and yaw). The sensor communicates with microcontrollers through the I²C interface, supporting clock speeds between 100 kHz and 400 kHz for efficient data exchange. Its compact design, reliability, and real-time capabilities make it ideal for wearable systems. It enables precise and responsive motion capture for interactive systems in gesture-based applications.

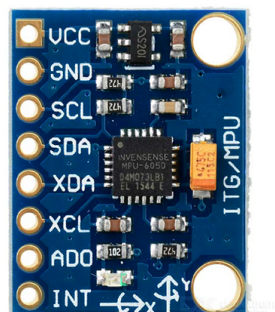


Figure 3.1: MPU6050 Sensor

Arduino Mega: The Arduino Mega is an open-source microcontroller board based on the ATmega2560, designed for projects requiring extensive input/output operations and greater memory capacity. It features 54 digital I/O pins, 16 analog inputs, and four UARTs for serial communication, making it suitable for complex hardware interfacing. With 256 KB of flash memory and a 16 MHz clock speed, it can handle multiple sensors and real-time data processing efficiently. In this project, the Arduino Mega serves as the central controller, managing input from multiple MPU6050 sensors and switches to ensure accurate and synchronized gesture-

based interactions within the game environment.

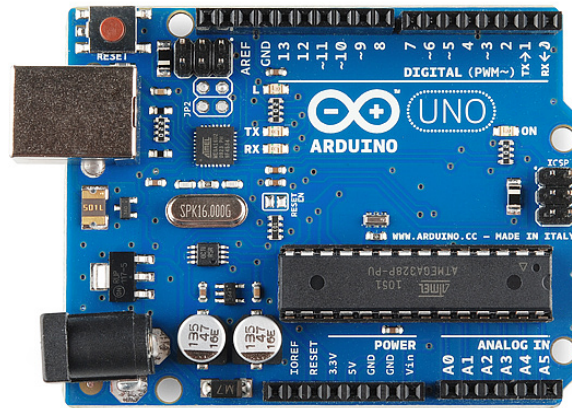


Figure 3.2: Arduino Uno Board

ESP8266: The ESP8266 is a low-cost, high-performance Wi-Fi microcontroller based on a 32-bit RISC CPU core (Tensilica L106), operating at 80–160 MHz. It integrates TCP/IP protocol stack and supports IEEE 802.11 b/g/n standards, enabling wireless connectivity with low power consumption (80 mA active mode). It enables devices to connect to wireless networks and communicate over the internet or within local networks. The ESP8266 supports multiple modes such as station, access point, and both simultaneously, making it highly versatile for wireless communication. It can be programmed using the Arduino IDE and is capable of handling HTTP requests, data transfer, and remote control functionalities. The ESP8266 is used to explore wireless communication possibilities between the hardware controller and the game system, potentially allowing untethered interaction.

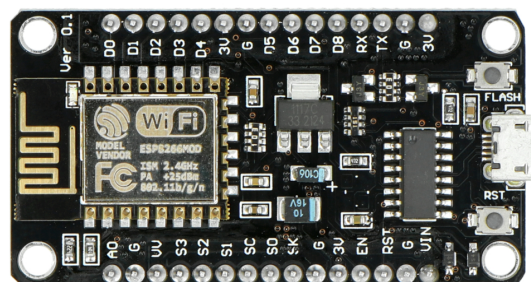


Figure 3.3: ESP8266 Wi-Fi Module

Flex Sensors: Flex sensors are passive resistive devices that change their resistance based on the amount of bend applied to them. Typically constructed using a flexible substrate coated

with conductive ink, their resistance increases as the sensor is bent. This property allows them to detect the degree of bending or curvature, making them suitable for applications involving motion capture, wearable electronics, and gesture recognition. When integrated with microcontrollers, the analog resistance change can be converted into meaningful input data. In this project, flex sensors are considered for detecting finger movements by measuring the degree of bend in each finger.

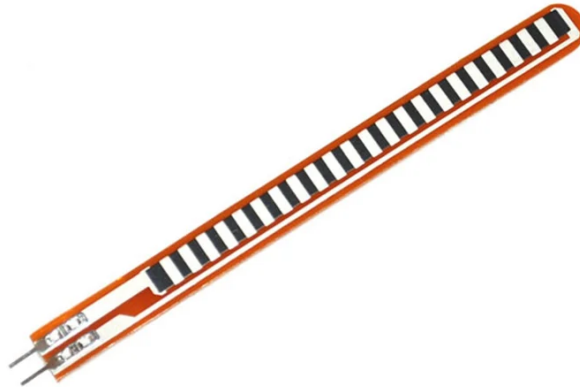


Figure 3.4: **Flex Sensor**

3.2 Software

Arduino IDE: The Arduino Integrated Development Environment (IDE) is the core programming tool for the Arduino Uno microcontroller in this project. Using C/C++, it configures the microcontroller to process digital signals from switches and analog data from MPU6050 sensors. Essential libraries like `Wire.h` and `MPU6050.h` manage I²C communication, while serial protocols handle data transmission to the rendering engine. The IDE's debugging tools, including serial monitors, are crucial for verifying signal integrity and latency. Firmware algorithms integrate sensor fusion and debouncing logic for accurate gesture detection. This open-source platform significantly aids rapid prototyping and hardware-software integration for real-time interactive systems.

Rendering Engine: The Rendering Engine is a fundamental software component that generates real-time visual output based on physical hand gestures captured by the hardware. Initially considering Unreal Engine, this prototype utilizes Blender's integrated Eevee and Cycles engines for rendering and simulation. The engine displays a first-person perspective with visible virtual hands, mirroring gestures like finger bends and wrist rotations instantly. This real-time visual feedback is vital for player immersion and interaction. The engine processes data from the microcontroller, supplied through middleware, to dynamically adjust hand poses and object interactions. Its capability to reflect hardware input with minimal latency ensures intuitive and

responsive gameplay, serving as the core of the gesture-controlled gaming experience. Optimized for low latency with GPU acceleration, it manages environmental elements and physics simulations via Blender's Python API.

Blender: Blender is an open-source 3D creation suite which is utilized for designing and developing game assets. This includes 3D modeling, UV mapping, texturing, and rigging, crucial for creating realistic hand models and interactive objects. Blender's EEVEE and Cycles engines provide real-time previews and high-fidelity final renders, respectively. Its Python scripting capabilities facilitate customization and workflow automation. Blender functions as both a design tool and a visual integration layer, ensuring in-game visuals accurately reflect physical gestures captured by the hardware with minimal latency through automated workflows linking it to the Arduino's output.

Python: Python serves as the middleware layer, connecting hardware data with the rendering engine. Custom scripts, utilizing libraries like PySerial, parse serial data from the Arduino, converting raw sensor values into actionable game inputs. Python's integration with Blender via the bpy module maps gestures to in-game animations and automates tasks. It can also be used externally to interpret sensor data and relay it to the rendering engine via custom protocols. Python's versatility and extensive library support are crucial for efficient data translation and seamless interaction between the wearable hardware and the virtual environment, enabling real-time mapping of physical movements to game commands.

Chapter 4: Feasibility Study

4.1 Technical Feasibility

Table 4.1: Hardware Specification Table

Column 1	Column 2	Column 3
Item 1	Item 2	Item 3
Item 4	Item 5	Item 6
Item 7	Item 8	Item 9

4.2 Economic Feasibility

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Chapter 5: Methodology

5.1 System Block Diagram

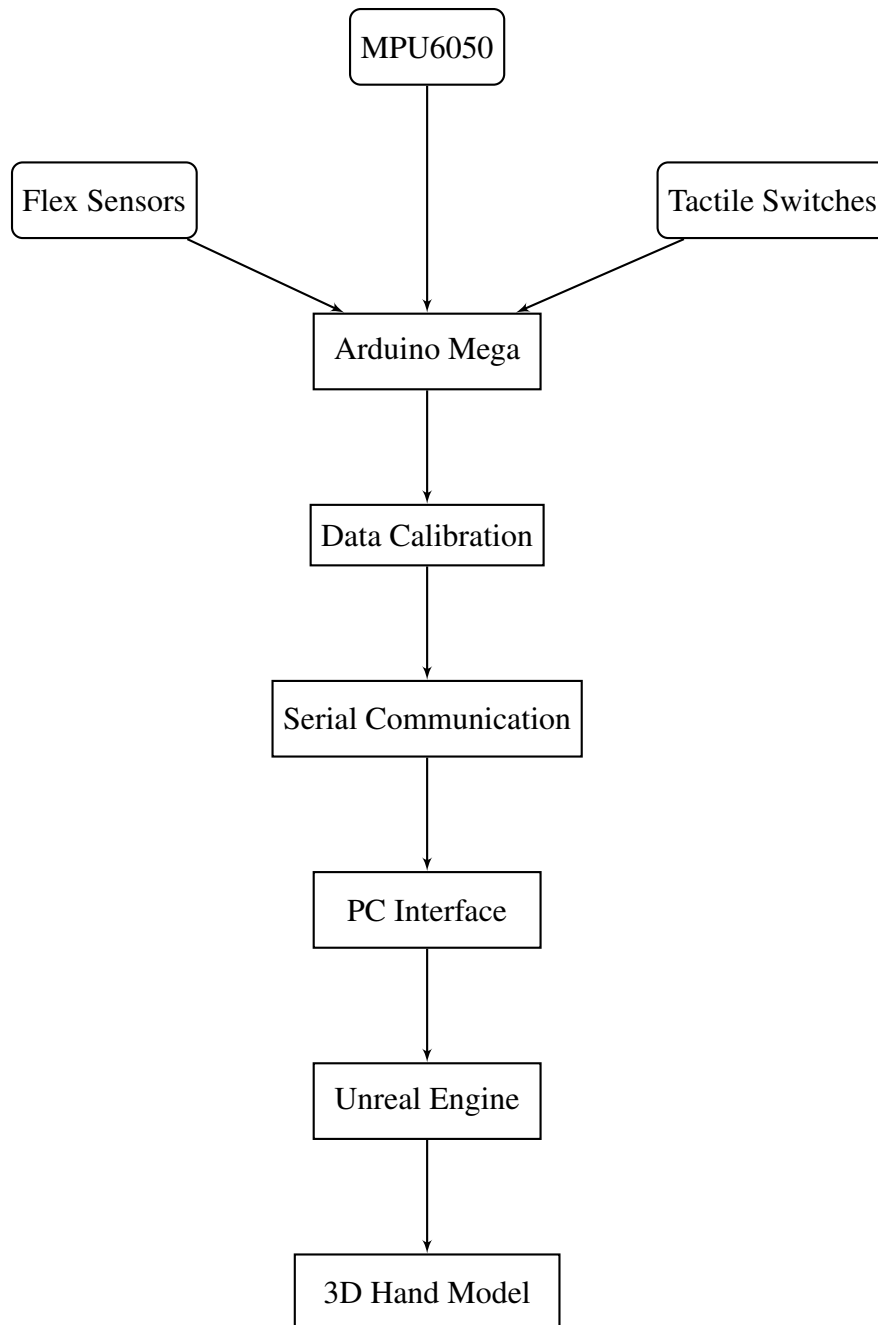


Figure 5.1: Detailed Block Diagram of Hand Motion Replicator System

5.2 Algorithm

1. System Initialization

- Configure MPU6050 for 6-DoF motion tracking
- Initialize analog inputs for flex sensors
- Set up digital inputs for tactile switches
- Configure serial communication parameters

2. Sensor Data Acquisition

- Read accelerometer and gyroscope data from MPU6050
- Measure resistance values from flex sensors
- Monitor state of tactile switches
- Apply calibration offsets

3. Data Processing

- Filter sensor noise using moving average
- Calculate hand orientation from IMU data
- Convert flex sensor values to finger angles
- Detect finger press events

4. Data Transmission

- Package processed data into structured format
- Implement error checking
- Transmit data packets via serial communication

5. Virtual Model Update

- Parse received data packets
- Update hand skeleton parameters
- Apply inverse kinematics for finger movements
- Render updated hand model

Chapter 6: Expected Output

- **Real-time Hand Motion Tracking:**

The system will accurately track and measure hand movements using the MPU6050 sensor for orientation ($\pm 2^\circ$ accuracy), flex sensors for finger bending (0° to 90° range), and tactile switches for touch detection. The combined sensor data will provide comprehensive hand position and gesture information with minimal latency ($\leq 100\text{ms}$).

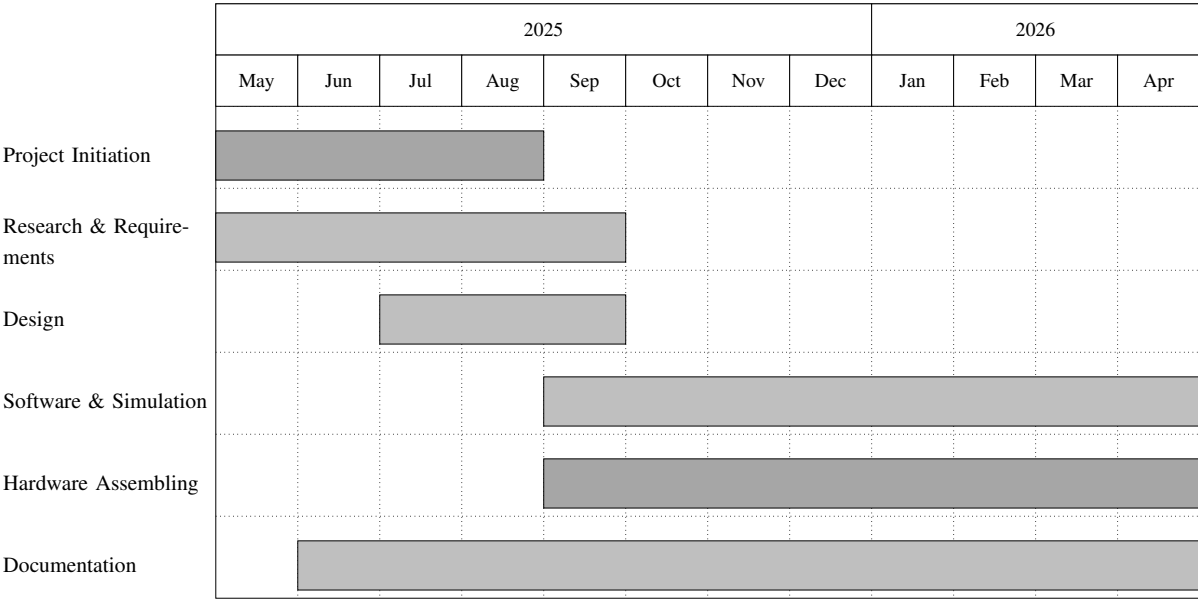
- **Virtual Hand Replication:**

The tracked hand movements will be replicated in real-time on a 3D hand model in Unreal Engine. The virtual hand will accurately mirror all finger movements, hand rotations, and touch interactions with smooth articulation and natural movement visualization. The system will maintain a consistent frame rate above 30 FPS to ensure fluid motion reproduction.

- **Interactive Response System:**

The system will provide immediate feedback through the virtual hand model, responding to user inputs with less than 50ms latency. This includes accurate finger bend representation ($\pm 5^\circ$ accuracy), precise hand orientation tracking, and immediate response to touch inputs with over 95% reliability. The communication system will maintain a stable 60 Hz update rate to ensure seamless interaction between the physical and virtual hands.

Gantt Chart



Cost Estimation

Electronics & Core Components

Item	Quantity	Cost (NRs)
FLYSKY Receiver	1	8000
30A ESC Skywalker	1	2000
Flight Stabilizer (NXE4 EVO)	1	4500
1000KV Brushless Motor	1	800
MG996 Metal Gear Servo	4	3040
2200mAh 3S LiPo Battery	1	3150
Buck Module Voltage Regulator	1	550
Raspberry Pi 4B with USB Camera and HDMI Cable	1	0
Total		22040

Table 6.1: Electronics and Core Components for Fixed-Wing UAV

Frame & Construction Materials

Item	Quantity	Cost (NRs)
Depron Sheet(1000*600 mm)	4	10000
Aluminum Motor Mount (L-shape)	1	150
Push Rod (1m)	2	400
Total		10550

Table 6.2: Frame and Construction Materials for Fixed-Wing UAV

Miscellaneous Accessories

Item	Quantity	Cost (NRs)
Hot Glue Gun Stick	10	200
Duct/Binding Tape	3 rolls	300
XT60 Connector Pair	2	500
3-Pin Orange Connector Pair	4	60
Servo Wire Cable (5m)	1	75
Propeller (7x5 inch)	4	300
Bullet Propeller Holder Adapter	1	170
Jumper Wire (MM, MF, FF, each 5)	15	30
Total		1635

Table 6.3: Miscellaneous Accessories for Fixed-Wing UAV

Grand Total

Category	Cost (NRs)
Electronics and Core Components	22 040
Frame and Construction Materials	10 550
Miscellaneous Accessories	1 635
Grand Total	34 225

Table 6.4: Grand Total Cost for Fixed-Wing UAV

References

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