يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ

"ALLAH WILL RAISE THOSE WHO HAVE BELIEVED AMONG YOU AND THOSE WHO WERE GIVEN KNOWLEDGE, BY DEGREES."

AUTO-LEVELING CONTROL SYSTEM

A Dual-Arduino Camera Stabilization Platform

- MPU6050
- SERVO CONTROL
- BLUETOOTH INTERFACE
- LCD DISPLAY

System Architecture

MODULE A — Stabilization

Arduino Uno + MPU6050

Real-time pitch angle compensation

MODULE B — Control & Interface

Arduino Uno + Bluetooth + LCD

User interaction & lighting control

SENSOR
6-DOF IMU

ACTUATORS
2× Servo Motors

COMMUNICATION
HC-05/06 BT

DISPLAY
16×2 I2C LCD

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ABSTRACT

Dual-Arduino Architecture

Low-Cost Prototype

Two independent Arduino Uno boards implement camera stabilization and user interface functionality

Wireless Control

Bluetooth communication enables remote operation and real-time monitoring via mobile application

Modular Design

Independent subsystems simplify wiring, improve reliability, and enhance debugging capabilities

A Stabilization Unit

ARDUINO UNO

- MPU6050 gyroscope & accelerometer
- Single-axis (Pitch) stabilization
- Servo motor with step-based control
- Low-pass filtering & threshold logic

B Control & Interface

ARDUINO UNO

- HC-05/06 Bluetooth module
- 16×2 I2C LCD display
- LDR-based LED lighting control
- Manual servo base rotation

GYROSCOPE EVOLUTION

Historical Development

1743
Whirling Speculum
John Serson
Horizon location in foggy conditions using mirrored spinning top

1817
Bohnenberger's Machine
Johann Bohnenberger
First gyroscope-like instrument with rotating sphere

1852
Foucault's Experiment
Léon Foucault
Demonstrated Earth's rotation; named the "gyroscope"

1904
Gyrocompass
Hermann Anschütz-Kaempfe
Electric motor enabled indefinite rotation for navigation

Modern Applications

- Smartphones
- Ship Navigation
- AWD Vehicles
- Robotics

MEMS Technology

Compact, cost-effective 6-DOF sensors combining accelerometers and gyroscopes

- MOTION SENSING
- SCREEN ORIENTATION
- INERTIAL NAVIGATION

PROBLEM & OBJECTIVES

Problem Statement

System Challenges

Traditional stabilization methods rely on complex mechanical structures or high-cost control systems, making them unsuitable for low-cost academic environments.

- **Complex Integration**
  Single microcontroller leads to performance limitations and increased latency
- **High Cost**
  Existing solutions exceed budget for educational applications
- **Reduced Reliability**
  Timing conflicts between sensor processing and user interface

Project Objectives

1. **Auto-Leveling Platform**
   Detect inclination with MPU6050
2. **Real-Time Processing**
   Generate corrective servo movements
3. **Dual-Microcontroller**
   Separate control from UI tasks
4. **Control Modes**
   Automatic & manual operation
5. **Bluetooth Interface**
   Wireless mobile control
6. **LCD Display**
   Real-time status monitoring
7. **LDR Lighting Control**
   Automatic ambient response
8. **Modular Design**
   Expandable architecture

METHODOLOGY

Gyroscope Orientation

X	Y	Z
PITCH	ROLL	YAW
Forward/Backward	Side-to-Side	Spinning Left/Right

MPU6050 Sensor

- 6-DOF Motion Tracking
- Integrated Accelerometer
- I2C Communication
- Low-Pass Filtering

Control Principles

Servo Motors

TYPE
Position Control

SIGNAL
PWM Output

ARDUINO A
Stabilization

ARDUINO B
Base Rotation

Newton's Third Law

Action-reaction principle applied for weight determination and motor selection based on camera base load.

• FORCE ANALYSIS • TORQUE CALCULATION

SYSTEM MODEL

A Stabilization Unit

ARDUINO UNO

INPUTS

- MPU6050 Sensor Data
- Reference Pitch Capture

PROCESSING

- Angle Estimation
- Low-Pass Filtering
- Threshold-Based Control Law

OUTPUT

Stabilization Servo (Pitch)

Step-Based Correction

B Control & Interface

ARDUINO UNO

INPUTS

- Bluetooth Commands
- LDR Sensor Readings

PROCESSING

- Command Interpretation
- Automatic Lighting Logic
- Status Display Update

OUTPUT 1

Base Servo

Manual Control

OUTPUT 2

LCD Display

System Status

HARDWARE COMPONENTS

1

Arduino Uno

Dual boards for distributed control architecture

2

MPU6050

6-DOF motion sensor with accelerometer & gyroscope

3

Servo Motors

Precise angular position control via PWM signals

4

HC-05/HC-06

Wireless serial communication module

5

16×2 LCD

I2C interface for real-time status display

6

LDR Sensor

Ambient light detection for automatic control

7

LED Output

Automatic lighting control with LDR integration

8

Power Supply

Regulated voltage distribution system

9

Prototyping

Breadboards and connecting wires

FINDINGS & ANALYSIS

Key Findings

Low Torque with Heavy Load

Reduced servo torque when using phone/heavy case, affecting stabilization effectiveness

Gyroscope Zero Drift

Multiple X-axis zero values due to uneven sticker distribution on mounting surface

Calibration Solution

Average approach implemented for stable gyroscope zero reference value

System Analysis

1 Gyroscope Reading

X-axis angular velocity measurement determines camera base level status

2 Angular Conversion

Arduino code converts readings to angular values relative to zero reference

3 Servo Correction

Clockwise tilt countered by counter-clockwise servo movement for balance

Edge Leveling

Four 90° angles for plate leveling with motors at corners

Central Leveling

Rotation perpendicular to load center (Selected Approach)

CONCLUSION & FUTURE WORK

Key Achievements

- **Dual-Arduino Design**
  Clear task separation
- **Precise Control**
  Smooth stabilization
- **Bluetooth Interface**
  Wireless communication
- **LCD Feedback**
  Real-time status

Applications

- Camera Stabilization Platforms
- Automated Leveling Systems
- Smart Control Systems

Challenges & Lessons

Single-Microcontroller Limitations
Timing conflicts resolved by dual-architecture

Power Management
Servo current spikes addressed with separate supplies

Future Enhancements

1. **Multi-Axis Stabilization**
   Add Y-axis (roll) control for full leveling
2. **Enhanced Motor Torque**
   Upgrade servos for heavier camera loads
3. **Visual Feedback Integration**
   Connect smartphone camera for real-time monitoring