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GIMBAL USING ACCELEROMETER & ARDUINO

Shahajan Pathan[*1], Uday Patil[*2], Veenit Jadhav[*3], Mr. R.S. Khamitkar[*4]

[*1,2,3]B.Tech. Student, Department Of Electronics Engineering, Walchand Institute Of Technology, Solapur, Maharashtra, India.

[*4]Supervisor, Head Of Department Of Electronics Engineering, Walchand Institute Of Technology, Solapur, Maharashtra, India.

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ABSTRACT

This study presents the design and implementation of a gimbal system using an accelerometer and Arduino for effective motion stabilization. The primary objective is to create an affordable, responsive gimbal capable of maintaining a stable orientation of a mounted device, such as a camera, by compensating for unwanted movements. The system integrates a 3-axis accelerometer with an Arduino microcontroller to continuously measure and respond to tilt and acceleration. The Arduino processes this data in real-time and adjusts the servo motors accordingly to counteract detected movements. Experimental results demonstrate that the gimbal system significantly reduces vibrations and maintains a steady platform, with orientation accuracy within a margin of error of less than 2 degrees. This improvement highlights the system's effectiveness compared to non-stabilized platforms. The developed gimbal system, therefore, provides a reliable and efficient solution for applications requiring precise stabilization, showcasing the potential of accessible technology for advanced motion control in fields such as photography, videography, and robotics.

Keywords: Gimbal Stabilization, Accelerometer, Arduino, Motion Control, Servo Motors, Real-Time Processing.

I. INTRODUCTION

The development of gimbal systems has revolutionized the fields of photography, videography, and robotics by providing enhanced stability and smooth motion control. A gimbal stabilizer employs sensors and motors to correct for unwanted movements, ensuring that the mounted device, such as a camera, remains steady. This project focuses on creating a cost-effective and responsive gimbal system using an accelerometer and Arduino microcontroller. The accelerometer, a 3-axis device, continuously measures tilt and acceleration, providing real-time data to the Arduino. The Arduino processes this information and adjusts the servo motors to counteract detected movements, maintaining a stable orientation. By leveraging accessible and affordable technology, this project aims to make sophisticated motion control systems available to a broader audience. The implementation of this gimbal system demonstrates its potential in various applications, including professional filming, hobbyist projects, and robotic systems, showcasing significant improvements in stability and performance compared to non-stabilized platforms.

II. METHODOLOGY

Component Selection:

1. Arduino Nano:

The Arduino Nano is a compact and versatile microcontroller board based on the ATmega328P chip. It's a popular choice for hobbyists, educators, and professionals due to its:

- Small size: Ideal for projects with limited space constraints.
- Breadboard-friendly: Pins are arranged in a way that makes it easy to connect components on a breadboard without wires.

The Arduino Nano can be programmed using the Arduino IDE (Integrated Development Environment), a user-friendly software that allows you to write code, compile it for theATmega328P, and upload it to the board. The Nano comes pre-programmed with a bootloader, eliminating the need for an external programmer.

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2. **Accelerometer sensor:**

MPU6050 IMU: A Compact 6-Axis Motion Sensor

The **MPU6050** is a popular Inertial Measurement Unit (IMU) that combines a 3-axis accelerometer and a 3-axis gyroscope in a single compact module. This makes it a valuable tool for projects that require sensing motion, orientation, and acceleration.

- **Key Features:**

- **Senses 6 Degrees of Freedom (DOF):** Combines accelerometer data (g-force) for static orientation and low-frequency motion with gyroscope data (rotational rate) for dynamic motion, enabling accurate tracking in 3D space.
- **Small Size:** Packaged in a tiny 4mm x 4mm x 0.9mm QFN package, making it ideal for space-constrained applications.
- **Digital Motion Processor (DMP):** Includes an onboard DMP that simplifies complex sensor fusion algorithms, reducing processing load on your main microcontroller. (Note: DMP functionality is considered deprecated by the manufacturer.)
- **Multiple Interfaces:** Supports both I2C (Inter-Integrated Circuit) and SPI (Serial Peripheral Interface) communication protocols, offering flexibility for integration with various microcontrollers.

3. **Servo Motor:**

MG996R Servo Motor: A Powerful and Precise Choice

The MG996R servo motor is a popular option for robotics and automation projects due to its combination of high torque, precise control, and affordability. Here's a detailed breakdown of its features:

- **Key Features:**

- **High Torque:** Delivers a maximum stall torque of 11 kg/cm (around 15.5 lb-in), making it suitable for applications requiring strong rotational force to move heavier objects.
- **Wide Rotation Angle:** Offers a controllable range of motion from 0 to 180 degrees, allowing for versatile positioning tasks.
- **Metal Gearbox:** Utilizes a robust metal gearbox for increased durability and longevity, especially under moderate loads.
- **Double Ball Bearings:** Employs double ball bearings that enhance shaft support and reduce friction, leading to smoother operation and potentially longer lifespan.

4. **Buck Converter:**

LM2596: A Versatile Buck Converter for Adjustable Voltage Needs

The LM2596 is a popular and efficient DC-DC buck converter integrated circuit (IC) widely used for regulating and stepping down a higher input voltage to a lower, adjustable output voltage. Here's a comprehensive look at its features and applications:

- **Key Features**

- **Buck Converter:** Operates as a buck (step-down) converter, reducing a DC input voltage to a lower DC output voltage.
- **Adjustable Output:** Incorporates an adjustable output voltage range. By adjusting a potentiometer (variable resistor) connected to the IC, you can set the desired output voltage within its specified range. (Note: Some pre-set voltage versions are also available.)
- **High Efficiency:** Offers high efficiency (typically up to 92%), minimizing power loss during voltage conversion.
- **Wide Input Voltage Range:** Accepts a wide range of input voltages, typically from 3V to 40V DC.

5. **Battery:**

18650 Lithium-Ion Battery: A Workhorse for Portable Power

The 18650 lithium-ion (Li-ion) battery is a popular rechargeable battery format widely used in various electronic devices due to its combination of portability, power capacity, and reusability.

Here's a breakdown of its key characteristics:

- **Size and Naming:**
- **18650:** The name refers to the battery's cylindrical shape with a diameter of 18 mm and a length of 65 mm.
- **Rechargeable:** Unlike disposable batteries, 18650 Li-ion batteries can be recharged hundreds of times.
- **Performance:**
- **Nominal Voltage:** Typically operates around 3.7 volts (V), with a charging voltage of up to 4.2V and a discharge cut-off voltage of around 3.0V.
- **Capacity:** Offers capacities ranging from 2200mAh (milliampere-hours) to 3500mAh, indicating the amount of electric charge it can store. Higher capacity translates to longer runtime for your device.
- **High Energy Density:** Stores a significant amount of energy in a compact size compared to other battery chemistries.
- **Long Cycle Life:** Can typically withstand hundreds of charge and discharge cycles before significant capacity degradation.
- **Discharge Rate:** Different 18650 cells have varying discharge rate capabilities. Some are optimized for high discharge suitable for powering devices requiring short bursts of high power, while others prioritize sustained lower power output.

III. DESIGN PROCESS

This project builds a motion-controlled system that translates sensor data into controlled movements of a servo motor. Here's a breakdown of the core functionalities:

1. **Sensor Data Acquisition:**
   - The MPU6050 IMU onboard the system houses a 3-axis accelerometer and a 3axis gyroscope.
   - The accelerometer measures linear acceleration along the X, Y, and Z axes.
   - The gyroscope measures the system's angular rotation around the X, Y, and Z axes.
   - The Arduino Nano communicates with the MPU6050 via I2C communication protocol to continuously acquire sensor data (acceleration and gyroscope readings) representing the system's orientation and movement.
2. **Data Processing and Control Signal Generation:**
   - The Arduino Nano processes the raw sensor data from the MPU6050. This may involve filtering, calibration, and calculations to extract meaningful information about the system's movement and orientation.
   - Based on the processed data and the desired motion behavior programmed in the Arduino code, the system generates control signals. These signals are typically pulse width modulation (PWM) signals with varying pulse widths.
3. **Servo Motor Control:**
   - The MG996R servo motor receives the PWM control signals from the Arduino. The pulse width of the PWM signal determines the position of the servo motor shaft within its controllable range (typically 0 to 180 degrees).
   - By varying the pulse width of the control signal, the Arduino can precisely control the angular position of the servo motor shaft.
4. **Power Delivery:**
   - The LM2596 buck converter steps down a higher input voltage (typically from a battery) to a lower, regulated voltage suitable for powering both the Arduino Nano and the servo motor.
   - This ensures stable and efficient power delivery for optimal performance of the system.

Overall System Operation:

The system operates in a continuous loop:

1. The Arduino acquires sensor data from the MPU6050.
2. The Arduino processes the data and generates control signals based on the desired motion behavior.
3. The control signals are sent to the servo motor, which adjusts its position accordingly.
4. This cycle repeats, allowing for real-time motion control based on sensor readings.

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By effectively combining these functionalities, the project creates a system that can react and adapt to its surroundings through sensor data, translating that information into controlled movements of the servo motor. The specific movements will depend on the code written on the Arduino, allowing for customization based on the project's application.

IV. SYSTEM IMPLEMENTATION

1. Circuit Design

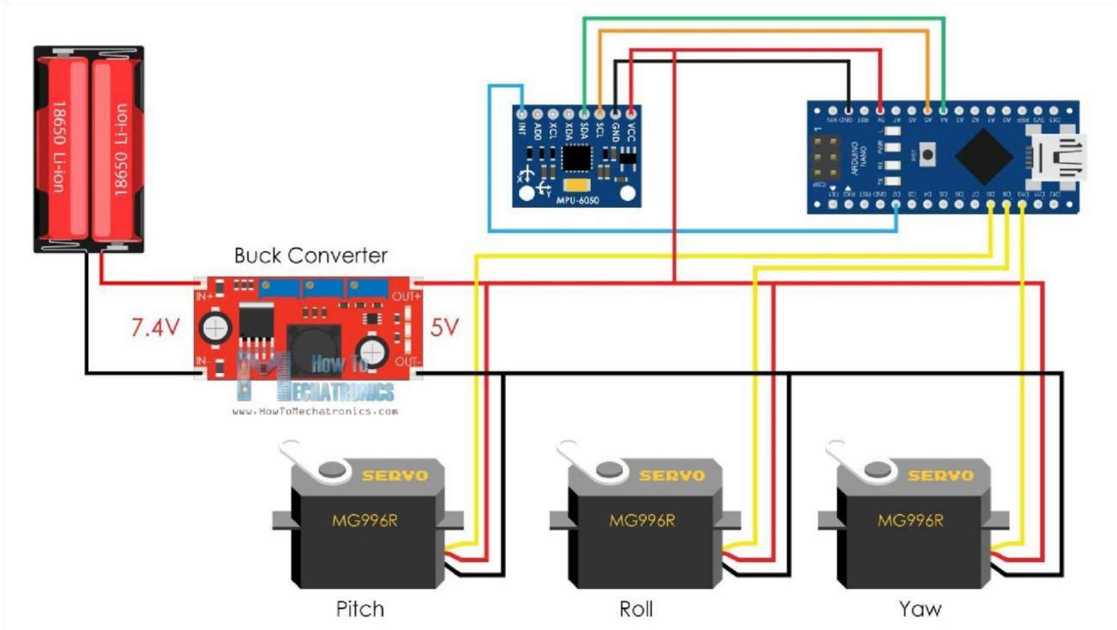

Fig 1. Circuit Diagram

Working of Circuit:

- **Power Source:** The circuit uses two 18650 Li-ion batteries in series to provide a voltage around 7.4 V.
- **Buck Converter:** A LM2596 buck converter steps down the voltage from the batteries to 5V to power the Arduino Nano and servo motors. This ensures they receive a stable voltage for proper operation.
- **Microcontroller:** An Arduino Nano microcontroller serves as the brain of the system. It receives signals from the MPU-6050 IMU sensor and sends control signals to the servo motors based on the code uploaded to it.
- **MPU-6050 IMU Sensor:** The MPU-6050 IMU (Inertial Measurement Unit) sensor measures the gimbal's orientation and movement in space using a gyroscope and accelerometer. This information is then sent to the Arduino Nano.
- **Servo Motors:** Three MG996R servo motors are used to control the pitch, roll, and yaw of the gimbal. The Arduino Nano sends control signals (PWM signals) to each servo motor, telling them how far to rotate in a specific direction.

In essence, the circuit works like this:

1. The batteries provide power to the circuit.
2. The buck converter regulates the voltage to 5V.
3. The MPU-6050 IMU sensor sends orientation and movement data to the Arduino Nano.
4. The Arduino Nano processes the sensor data and determines how to move the gimbal based on the uploaded code.
5. The Arduino Nano sends PWM signals to the three servo motors.
6. Each servo motor rotates according to the received signal, controlling the gimbal's pitch, roll, and yaw. This design allows for creating a stabilized gimbal platform that can keep a camera or other object level, even when the base is tilted or moving

2. 3D Model Design Of Gimbal:

V. CONCLUSION

This project successfully designed and constructed a versatile motion-controlled system leveraging readily available electronic components. The system integrates an Arduino Nano microcontroller for processing, an MPU6050 IMU sensor for motion detection, an MG996R servo motor for controlled movement, and an LM2596 buck converter for efficient power regulation.

VI. REFERENCES

[1] Arduino Nano Datasheet. (n.d.). Retrieved from https://docs.arduino.cc/resources/datasheets/A000005datasheet.pdf

[2] MPU6050 Datasheet. (n.d.). Retrieved from https://invensense.tdk.com/products/motiontracking/6axis/mpu-6050/

[3] MG996R Servo Motor Datasheet. (n.d.). Retrieved from https://www.towerpro.com.tw/product/mg996r/

[4] LM2596 Buck Converter Datasheet. (n.d.). Retrieved from https://www.ti.com/lit/gpn/LM2596

[5] Lupia, M., & al. (2014). A Low-Cost IMU-Based Orientation Estimation for an Unmanned Aerial Vehicle (UAV). Retrieved from https://www.researchgate.net/publication/280052023_Low_cost_surveying_using_an_unmanned_aerial_vehicle

[6] Huang, Y. M., & al. (2012). Human Activity Recognition Using a Smartphone Embedded Accelerometer and Gyroscope. Retrieved from https://ieeexplore.ieee.org/document/9117456

[7] Arduino Project Hub. (n.d.). Controlling a Servo Motor with Arduino. Retrieved from https://docs.arduino.cc/learn/electronics/servo-motors

[8] Random Nerd Tutorials. (n.d.). Using an LM2596 Step-Down Converter with Arduino. Retrieved from https://randomnerdtutorials.com/