DESIGN AND FABRICATION OF A 3DOF TESTING MECHANISM FOR UAV

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College ***:*** *Gopalan College of Engineering and Management, Bengaluru*
Branch ***:*** *Department of Aeronautical Engineering*
Guide(s) ***:*** *Mr. Adarsh Krishnamurthy*
Student(S) ***:*** *Mr. Gagan D*
Ms. Hemashree D S
Mr. Syed Sulthan K
Mr. Varun Reddy

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Introduction:

The advancement in drone technology has necessitated the development of robust and accurate control mechanisms to ensure optimal performance and stability. One such innovation is the gimbal mechanism, which provides three degrees of freedom (3DOF) to control the pitch, yaw, and roll of a mounted object, such as a drone. This project focuses on the design and fabrication of a 3DOF gimbal mechanism tailored for drone mounting. The mechanism not only allows for precise control of the drone's orientation but also serves as a platform for PID tuning, enhancing the drone's flight stability and performance. The use of stepper motors and guide rails to convert rotational movement into linear displacement enables manual adjustment of the gimbal, thereby providing a versatile tool for both testing and operational purposes.

Objectives:

- To design and fabricate a 3DOF gimbal mechanism capable of mounting and controlling a drone.
- To integrate sensors for real-time feedback on the drone's orientation.
- To facilitate PID tuning for improved drone performance and stability.
- To provide a versatile platform for testing and development of drone control systems.

Methodology:

1. **Design**: The gimbal mechanism was designed using CATIA V5. The base plate was created by drawing a 200mm diameter circle and extruding it by 10mm. Additional components, including the rotating plate, hollow cylinder, and slider, were designed to provide the necessary degrees of freedom.

2. **Materials**: The primary materials used include stainless steel for springs, aluminium for the base and rotating plates, and standard stepper motors for actuation.
3. **Fabrication**: The designed components were fabricated using CNC machining and assembly techniques. Springs with specific stiffness were selected and integrated into the mechanism.
4. **Sensors**: An accelerometer and gyroscope were mounted on the top plate of the gimbal mechanism to measure pitch, yaw, and roll angles. These sensors provided real-time data to the Arduino, which displayed the angles on an OLED screen.
5. **Stepper Motors and Guide Rails**: Stepper motors were connected to guide rails to convert rotational movement into linear displacement, allowing manual adjustment of the gimbal's angles.
6. **PID Tuning**: The system was tested using known pitch and roll angles input through the Mission Planner software. The feedback from the sensors was used to calibrate the system and minimize the error.

Results and Conclusions:

The fabricated 3DOF gimbal mechanism successfully mounted the drone and provided precise control over pitch, yaw, and roll angles. The integration of stepper motors and guide rails allowed for manual adjustments, and the real-time feedback from the sensors facilitated accurate PID tuning. The mechanism demonstrated reliable performance, with minimal error between the known input angles and the sensor readings. This project has laid the foundation for further advancements in drone control systems, particularly in enhancing stability and performance through precise mechanical adjustments and PID tuning.

Description of the Innovation in the Project:

The innovative aspect of this project lies in the integration of a Stewart platform-like mechanism with a gimbal system to provide three degrees of freedom for drone control. The use of stepper motors and guide rails to convert rotational movements into linear displacements for pitch, yaw, and roll adjustments is a novel approach. Additionally, the real-time feedback mechanism using accelerometers and gyroscopes, coupled with PID tuning, ensures high precision and stability in drone control.

Future Work Scope:

Future work can explore the following areas to enhance the functionality and applicability of the gimbal mechanism:

1. **Automated PID Tuning**: Implementing advanced algorithms for automated PID tuning based on real-time feedback from multiple sensors.

2. **Enhanced Materials**: Using lightweight and more durable materials to reduce the overall weight of the mechanism and improve its response time.
3. **Wireless Communication**: Integrating wireless communication modules to enable remote control and monitoring of the gimbal mechanism.
4. **Dynamic Load Adjustment**: Developing mechanisms to dynamically adjust the load capacity to accommodate drones of varying weights.
5. **Environmental Adaptability**: Testing and modifying the gimbal mechanism for different environmental conditions, such as high winds or turbulent flights.
6. **Integration with Advanced Control Systems**: Incorporating the gimbal mechanism into more complex drone control systems for autonomous navigation and obstacle avoidance.
7. **Commercialization**: Exploring the commercial viability of the gimbal mechanism for use in various drone applications, including photography, surveillance, and delivery systems.

This project represents a significant step towards enhancing drone control mechanisms, providing a robust platform for both research and practical applications in the field of unmanned aerial vehicles (UAVs).