A PROJECT REPORT

ON ‘‘SMOOTH SLOPE CONTROLLER’’

Submitted by

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CERTIFICATE

This is to certify that **Saurabh Yejare B73 , Abhishek Rakate B62 Vivekanand Tanawade B69, Ritesh Shinde B67** have satisfactorily completed the project report entitled "**Smooth Slope Controller** " (Sem-VI) during the Academic Year **2022-2023.**

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INDEX

Sr.No.	Title	Page No.
1.	Abstract	5
2.	Introduction	6
3.	Problem Defination	7
4.	Objective	7
5.	Literature Survey	8-9
6.	Block Diagram	10
7.	Circuit Diagram	11
8.	Methodology	12
9.	Components	13
10.	Limitations	14-15
11.	Scope of the Project	16

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ABSTRACT

In many cases, it is desirable to achieve a smooth and gradual response when controlling a system's output. The proposed smooth slope controller aims to address the limitations of traditional PID controllers, which often exhibit abrupt changes and oscillations in the system response. By incorporating a smooth slope mechanism, the controller ensures a gradual transition between control actions, minimizing sudden changes and undesirable overshoot. The smooth slope controller leverages the integral and derivative components of the PID controller to calculate the rate of change and the accumulated error, respectively. It then utilizes this information to control the proportional term in a way that smoothly adjusts the output signal. The smooth slope mechanism introduces a time-varying slope factor that modulates the proportional action, allowing for a more gradual response.

Introduction

The control of dynamic systems plays a vital role in numerous engineering applications, ranging from robotics and industrial automation to process control. One commonly used control strategy is the PID (Proportional-Integral-Derivative) controller, which provides a balance between stability and responsiveness. However, traditional PID controllers often exhibit abrupt changes and oscillations in the system response, leading to undesirable effects such as overshoot and instability. To address these limitations, this introduction presents a novel approach to achieve smooth control using a PID controller by introducing the concept of a smooth slope controller. The smooth slope controller aims to overcome the shortcomings of traditional PID control techniques by ensuring a gradual transition between control actions, resulting in a smoother system response with reduced oscillations and improved stability. The smooth slope controller leverages the fundamental components of a PID controller: the proportional, integral, and derivative terms. By carefully modulating the proportional action, the controller introduces a time-varying slope factor that governs the rate at which the control action is adjusted. This gradual adjustment helps prevent sudden changes in the output signal, promoting smoothness and stability in the system's behavior. Ultimately, the smooth slope controller has the potential to advance control strategies in domains where smooth and stable operation is essential.

Problem statement

Traditional control methods for UAV slope control are imprecise and Ineffective In handling external disturbances, leading to unstable and unpredictable flight behavior in outdoor environments.

Objective

This research aims to develope a PID control to achive precise and stable inclination control, overcoming limitation of traditional methodes and enabling rellable fight performance in the presence of external disturbance.

The PID controller is a widely used feedback control algorithm that adjusts the system's output based on the error between the desired setpoint and the actual output. In this case, the setpoint represents the desired slope angle, and the output corresponds to the physical adjustment or actuation mechanism that changes the slope.

Literature

This literature survey focuses on the application of PID (Proportional-Integral-Derivative) controllers in achieving smooth slope control. The smooth slope control refers to maintaining a desired slope or rate of change for a controlled variable in a dynamic system. PID controllers are widely used in various industrial processes due to their simplicity, effectiveness, and ability to handle a wide range of system dynamics. This survey aims to explore the existing research and approaches that utilize PID controllers for achieving smooth slope control.

1. Fundamentals of PID Controller

- Detailed explanation of the proportional, integral, and derivative terms in PID controllers.
- Discussion on tuning methods for PID controllers.
- Overview of common challenges and limitations associated with PID control.

2. Smooth Slope Control Techniques

- Review of different techniques and algorithms employed to achieve smooth slope control using PID controllers.
- Analysis of feedforward and feedback-based approaches.
- Examination of advanced methods such as model predictive control (MPC) combined with PID.

3. Experimental Studies

- Presentation of case studies and experimental setups where PID controllers were used for smooth slope control.
- Description of the systems and processes involved.
- Discussion on the performance and effectiveness of PID controllers in achieving smooth slope control.

4. Comparative Analysis

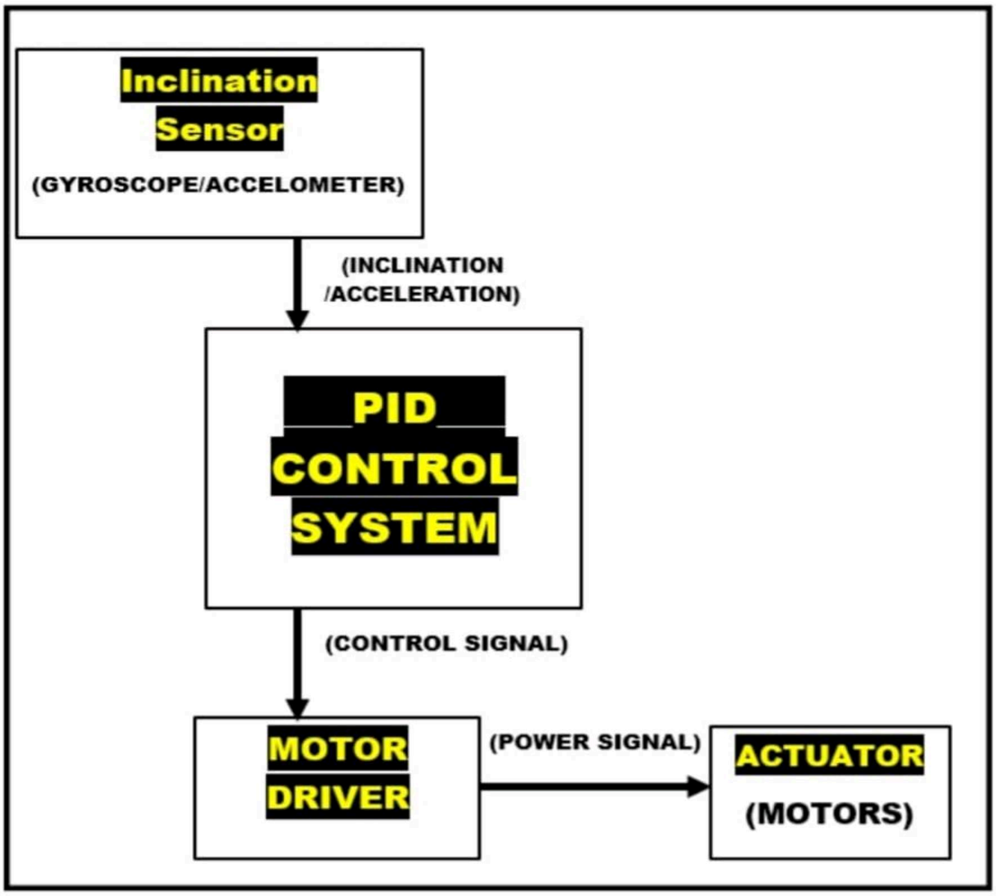
- Comparative study of different approaches and variations of PID controllers for smooth slope control.
- Evaluation of their advantages, limitations, and performance metrics.
- Identification of trends, common challenges, and potential areas for improvement.

5. Recent Advances and Future Directions

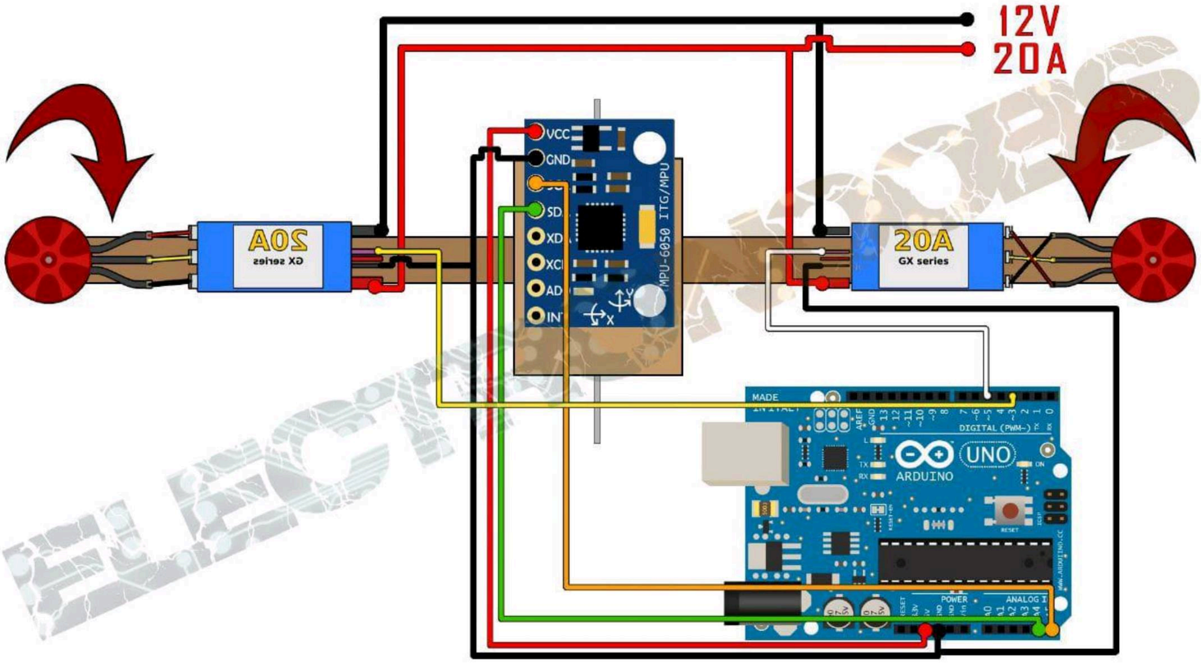
- Discussion on recent advancements in smooth slope control using PID controllers.
- Overview of emerging techniques and technologies in this field.
- Suggested areas for future research and development.

This literature survey provides a comprehensive overview of the utilization of PID controllers for achieving smooth slope control. It explores the fundamentals of PID control, different techniques, experimental studies, comparative analysis, recent advances, and future directions. By reviewing the existing literature, this survey serves as a valuable resource for researchers, engineers, and practitioners interested in applying PID controllers for smooth slope control in various industries.

Block Diagram :



Circuit Diagram :



Methodology

A smooth slope controller using a PID (Proportional-Integral-Derivative) controller can be implemented by considering the rate of change of the controlled variable (error). This approach aims to minimize abrupt changes in the control signal, leading to a smoother response.:

1. Define the control objective: Clearly define the variable you want to control and the desired behavior. For example, if you want to control the speed of a motor, specify the desired speed profile and any constraints.
2. Measure the controlled variable: Obtain real-time measurements of the variable you want to control. In the case of motor speed control, you would measure the actual speed using a sensor.
3. Calculate the error: Calculate the error between the desired value and the measured value. This is typically done by subtracting the measured value from the desired value.
4. Determine the rate of change of the error: Calculate the derivative of the error with respect to time. This can be done by taking the difference between the current error and the previous error, divided by the time elapsed.
5. Configure the PID controller: Set the gains (proportional, integral, and derivative) of the PID controller based on the control objective and system dynamics. The gains determine the controller's response to error, error accumulation, and error rate of change, respectively.
6. Calculate the control signal: Use the PID controller to calculate the control signal based on the error, error accumulation (integral), and error rate of change (derivative). The control signal represents the corrective action that needs to be applied to the system.
7. Smooth the control signal: Apply a smoothing algorithm to the control signal to achieve a gradual change. For example, you can use a low-pass filter or a moving average filter to reduce abrupt changes.
8. Apply the control signal: Send the smoothed control signal to the actuator or system being controlled. In the motor speed control example, the control signal would be used to adjust the motor's input voltage or current.

It's important to note that the specific implementation details may vary depending on the programming language, hardware, and control system you are using. experimentation and optimization based on the specific system being controlled.

Components

- Microcontroller : A microcontroller is a small, self-contained computer system on a single integrated circuit (IC) chip. It consists of a microprocessor core, memory, input/output (I/O) ports, and various peripheral devices.
- BLDC(Brush less DC)motor : It is an electric motor that operates using electronic commutation rather than traditional brushes and commutators found in brushed DC motors. It is also known as a synchronous electric motor
- Propeller : It is a device used to generate thrust in order to propel vehicles through a fluid medium, typically air or water. It consists of rotating blades that produce a force called thrust by accelerating the fluid in the opposite direction.
- ESC (Electronic speed controller) : It is an electronic device used to control the speed and direction of electric motors, primarily in applications such as RC (remote control) vehicles, drones, electric bicycles, and robotic systems.
- MPU 6050 gyroscope and accelerometer : The MPU-6050 is a popular integrated circuit (IC) that combines a three-axis gyroscope and a three-axis accelerometer into a single chip. It is commonly used for motion sensing applications in various electronic devices, including drones, robots
- Lithium Polymer battery (LIPO) : Lithium Polymer (LiPo) batteries are rechargeable energy storage devices that use lithium-ion technology. They are widely used in a range of electronic devices, including smartphones, tablets, drones, RC vehicles, portable electronics.
- Prototype Structure

Limitations

When working on a Smooth Slop Controller Using PID controller project, there are several limitations that should be considered:

1. **Overshoot:**
   PID controllers can lead to overshoot when controlling systems with smooth slops. The integral and derivative terms in the controller can cause the system to respond too aggressively and go beyond the desired setpoint. This overshoot can lead to instability or oscillations in the system.

2. **Settling Time:**
   PID controllers may require longer settling times when dealing with smooth slops. The derivative term in the controller is sensitive to rapid changes in the error, which can lead to excessive control action and prolonged settling times. Achieving smooth and precise control in these scenarios may require tuning the controller parameters carefully.

3. **Tuning Challenges:**
   Tuning a PID controller for smooth slops can be challenging. The controller gains (proportional, integral, and derivative) need to be adjusted appropriately to achieve the desired control performance. However, finding the optimal tuning parameters for smooth slops may involve trial and error or advanced tuning methods.

4. **Non-Linearities**:
   PID controllers assume linearity in the system dynamics, which may not hold true for systems with smooth slops. Nonlinearities in the system can lead to poor performance or even instability with a standard PID controller. Nonlinearities could arise from factors such as friction, saturation, or other complex behaviors.

5. **Model Mismatch:**
   PID controllers typically rely on a model of the system to estimate the control actions accurately. In the case of systems with smooth slops, if the model does not accurately capture the dynamics, the controller's performance may be compromised. Accurate modeling becomes crucial for achieving smooth control in these scenarios.

To address these limitations, more advanced control techniques or modifications to the PID controller may be necessary. For example, model predictive control (MPC), adaptive control, or fuzzy logic control can be considered for improved performance when dealing with systems featuring smooth slops.

Scope of the project

- Researchers and engineers are continually exploring advanced control strategies to enhance the performance of PID controllers.
- PID controllers are extensively used in industrial automation to regulate and stabilize processes in manufacturing plants, power generation, chemical processing, and other industries.
- PID controllers play a crucial role in controlling the motion and stability of robots and autonomous systems.
- With the growing emphasis on energy efficiency and renewable energy sources, PID controllers can contribute to energy management systems.
- PID controllers can be integrated into IoT devices and cyber-physical systems to enable distributed control and real-time monitoring. The ability to collect and analyze data from various sensors and actuators in these interconnected systems allows for enhanced PID control and system optimization.