Design and Implementation of Discrete Incremental PID Controller in ROS 2 Environment

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Abstract

This report presents the design and implementation of a discrete incremental PID controller based on ROS 2 for 3D target tracking.

Keywords: ROS 2, PID Control, Target Tracking

Contents

1 Introduction

PID controllers are widely used in industrial control systems due to their simplicity and robustness. This research implements a discrete incremental PID controller in the ROS 2 environment.

2 Theoretical Foundation

2.1 PID Control Principle

The output of a PID controller consists of three components: proportional, integral, and derivative:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt} \tag{1}$$

where $e(t)$ is the error, and K_p, K_i, K_d are the proportional, integral, and derivative coefficients, respectively.

2.2 Discrete Incremental PID

In Industrial control systems, the discrete form of the PID algorithm is commonly used:

$$\Delta u(k) = K_p[e(k) - e(k-1)] + K_i e(k) + K_d[e(k) - 2e(k-1) + e(k-2)] \tag{2}$$

3 System Design

3.1 Overall Architecture

The system consists of two main nodes:

- Driver Node: Publishes 3D target values
- Control Node: Implements the PID control algorithm and outputs control signals

3.2 PID Controller Implementation

The incremental PID directly calculates the increment of the control quantity (u(k)) rather than the full-scale output (u(k)), avoiding the accumulation of historical data and simplifying the calculation logic.Adding restrictions on the dead zone here makes it closer to the control logic in the industrial field.

4 Experimental Results

4.1 Parameter Configuration

The final PID parameters are shown in Table 1.

Table 1: PID Parameter Configuration

Parameter	X-axis	Y-axis	Z-axis
K_p	10	10	12.5
K_i	0.0	0.0	0.0
K_d	0.01	0.01	0.1

5 Conclusion

This research successfully implements a discrete incremental PID controller based on ROS 2. meets the requirements for 3D target tracking.