Python GUI for Ball and Beam System

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1 OVERVIEW

1.1 Introduction

The Ball and Beam system is a classic example of a control system, where the goal is to maintain the position of a ball on a beam by applying control actions. In this report, we present a Python Graphical User Interface (GUI) designed for the Ball and Beam system by Acrome Robotics. The GUI provides an interactive and intuitive platform to visualize and control the behavior of the Ball and Beam system.

1.2 Objective

The objective of this user-friendly Python GUI is to provide an intuitive platform for students and researchers to easily grasp the fundamentals of control systems. The GUI offers an interactive and visually appealing environment that allows users to experiment with various control inputs, observe real-time responses, and fine-tune control strategies using a PID controller. By offering a hands-on approach to control system analysis and experimentation, this GUI aims to enhance students' understanding of control theory.

1.1 Key Features

1. **User-Friendly Interface:** The GUI is designed with simplicity and ease of use in mind. The layout is intuitive, providing users with easy access to control elements, real-time data visualization, and all the functions.
2. **Control Options:** The GUI offers various control options, including Step, Sin, and Ramp inputs. Users can set the amplitude and frequency of the Sin input to observe different ball motion patterns.
3. **PID Controller:** The GUI incorporates a PID controller with adjustable gains (Kp, Ki, Kd) to regulate the ball's position on the beam. Users can input PID gains to fine-tune the control performance.
4. **Real-Time Data Plotting:** The GUI includes a real-time data plotter that displays the ball's position over time. This plot provides users with immediate feedback on the system's behavior and the effectiveness of control actions.
5. **Serial Communication:** The GUI establishes serial communication with Arduino, enabling seamless data exchange between Python and Arduino.

6. **Port Detection:** The GUI automatically detects all available COM ports, making it convenient for users to connect to the correct Arduino device.
7. **Stop Time Input:** This feature introduces the ability for users to enter a stop time input in the application. With this feature, users can specify the duration for which they want the real-time data plotting to continue. By entering a specific stop time, users can customize their data visualization experience according to their requirements, allowing them to precisely monitor the ball position within the defined time frame.

2 FUNCTIONALITIES

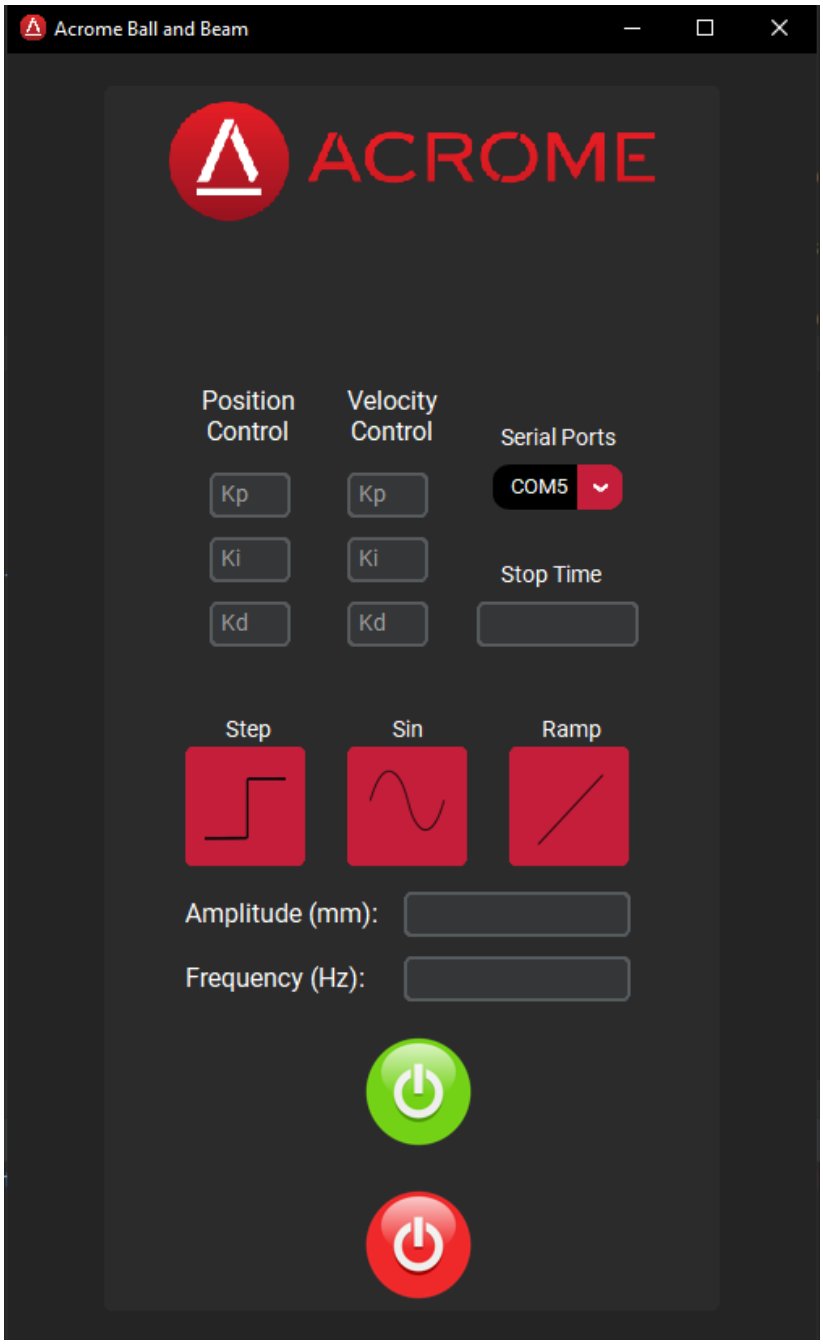

Figure 1. Visual of GUI

The code automatically detects the available serial ports. First of all, the user should select the specific COM Port where the Arduino is connected.

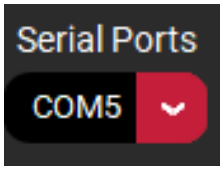

Figure 2. Arduino Serial Port Selection Menu

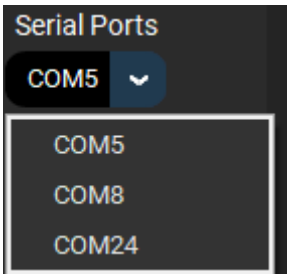

Figure 3. Available Arduino COM Ports

The user can enter amplitude and frequency values for various input types. The amplitude value is fixed between -250 and 250 mm since the beam is 500 mm long. The center point is assumed at 0 mm. The frequency value is fixed between 1 and 1000 hertz.

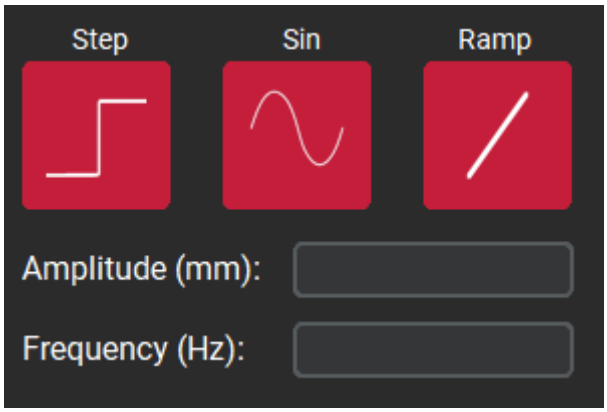

Figure 4. Amplitude and Frequency Input Part

GUI provides two PID controllers with adjustable gains (Kp, Ki, Kd). The first PID is for position control and the second is for velocity control.

Figure 5. PID Input Part

Position and velocity controllers have different structures. Their corresponding structures are stated below.

Position Control: $\frac{U(s)}{E(s)} = K_p + \frac{K_i}{s} + K_d s$

Velocity Control: $\frac{sU(s)}{E(s)} = K_p + \frac{K_i}{s} + K_d s$, $sU(s) = sE(s) + K_d sE(s)$

GUI has start and stop buttons, which enable real-time position data plotting and terminating the code, respectively.

Figure 6. Start and Stop Buttons.

When the user presses the start button, real-time position data plotting begins. The y-axis was selected as Position in terms of mm and the x-axis was selected as time in terms of seconds.

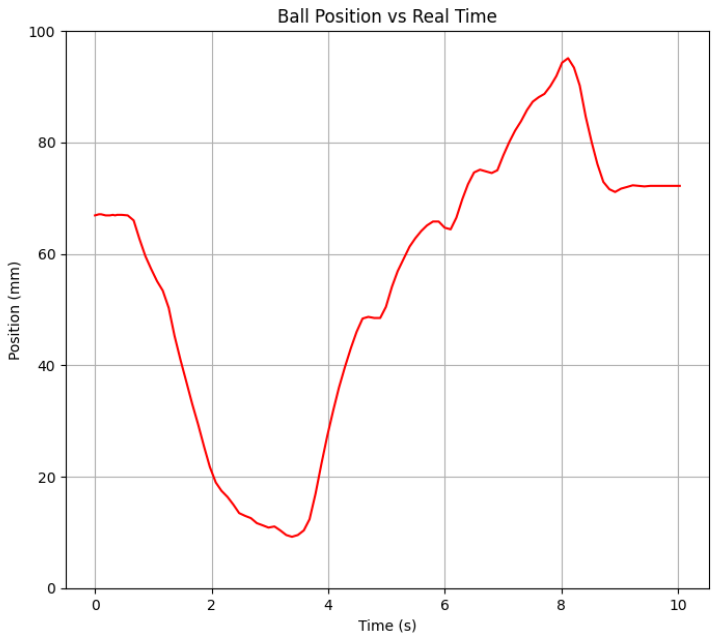

Figure 7. Real-Time Position Data Plotting

When the user presses the stop button, the program terminates itself.

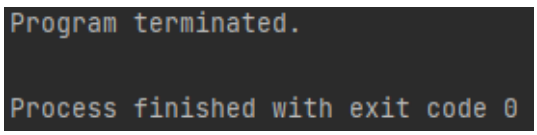

Figure 8. Terminating Program

The user can now enter stop time input for data plotting. That allows the user to specify a desired duration for the real-time data plot. The user can enter a stop time in seconds, and the program will continue plotting the real-time data until the specified stop time is reached.

Figure 8. Stop Time User Input

For example, if the user enters 5 as an input, data plotting will end after 5 seconds. The example is given in Figure 9.

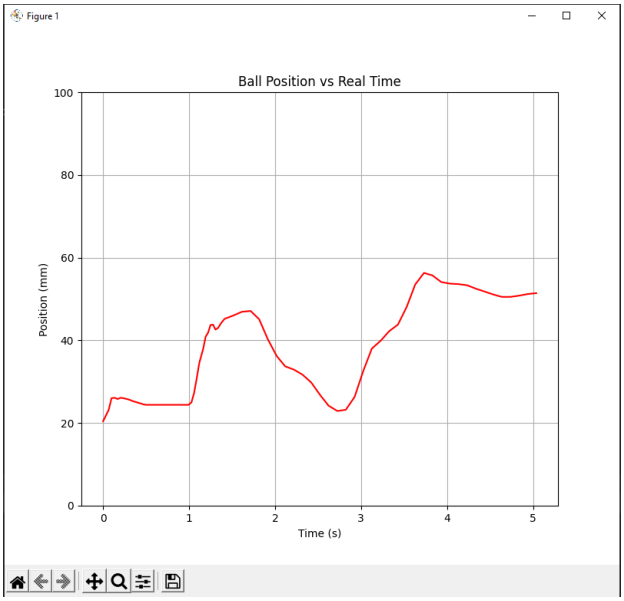

Figure 9. Data Plotting for 5 Seconds

Incorporating Acrome's logo as both the GUI icon and the Windows taskbar icon adds a touch of visual perfection and professionalism to the application. By featuring it prominently as the application's icon, users are immediately greeted with a visually appealing and recognizable symbol, leaving a lasting impression.

Figure 10. Acrome's Logo as an Icon

3 CONCLUSION

The Python Graphical User Interface for the Ball and Beam system offers an efficient and user-friendly platform for controlling and visualizing the Ball and Beam system's behavior. Its intuitive layout, PID control capabilities, and real-time data plotting make it a valuable tool for control system analysis, education, and experimentation. With this GUI, users can explore different control strategies, fine-tune PID parameters, and gain valuable insights into the dynamic behavior of the Ball and Beam system.

4 REFERENCES

1. Acrome Robotics Ball and Beam System: https://www.acrome.net/products/ball-and-beam

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