BALANCING A BALL TO CONTROL ITS POSITION

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Introduction

Balancing systems are one of the most challenging problems for machines. Understanding the physical response (Figure 3) and being able to model it mathematically enables appropriate control systems to be implemented. This allows us to design and build autonomous machines to perform specific tasks.

Objective

The objective of this project was to balance a ball in a fixed position and to make it track a desired pathway on a flat plate.

System Description

- Figure 1 shows a 2 Degree of Freedom Ball Balancing System. The camera takes images of the plate at 30 frames per second.
- A DAC (Data Acquisition Device) is used to process the control algorithm and also used for the I/O terminal interfaces.
- Two servo motors tilt the plate relative to the horizontal plane to adjust the ball's position to the desired point.
- A voltage amplifier is used to drive the two servo motors.

Methodology

- Using the camera images, an algorithm determines the ball's current position as X and Y coordinates in relation to the plate (Figure 2). The ball's current position is used for the control system (Diagram 1).
- A desired set position is compared with the current ball's position on the plate (Diagram 1). This produces the position error that needs to be corrected.
- An encoder provides feedback to determine the current angle position of the plate (Diagram 1).
- A simple proportional and velocity controller (Diagram 1) is used together with a proportional servo control to correct the ball's position on the plate by tilting the plate relative to the horizontal plane.

Results

The reading of the desired and current ball positions shown in Figure 4 demonstrates how the ball is attempting to follow the desired path position. However, there is a slight difference in position due to the speed and accuracy of the controller. The desired and current angles of the servo motors response are shown in Figure 5. This demonstrates how the servo motors are trying to match the desired angle to reduce the angle error.

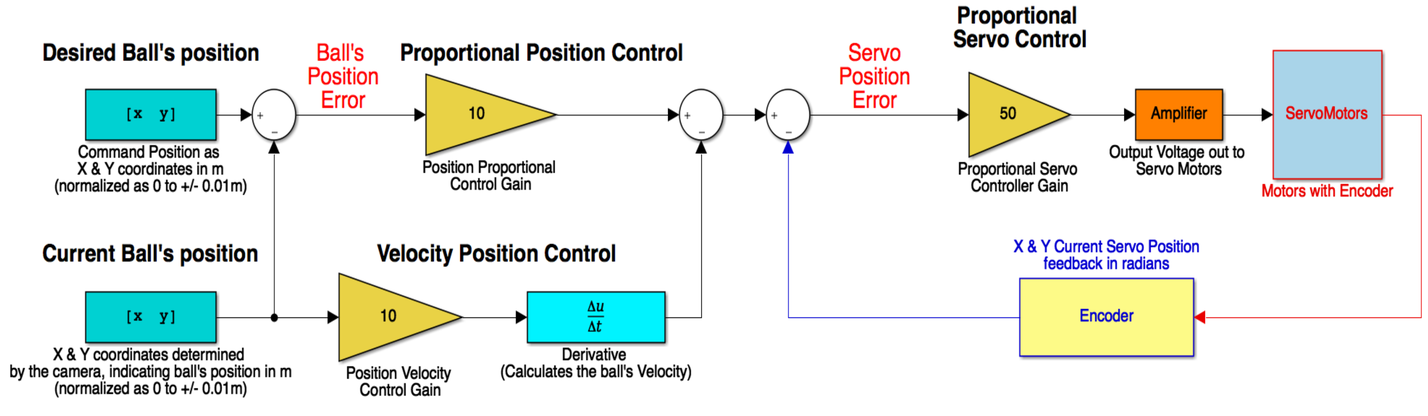
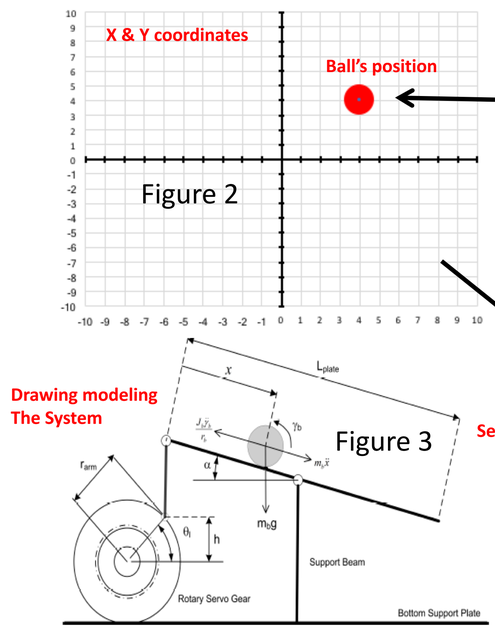
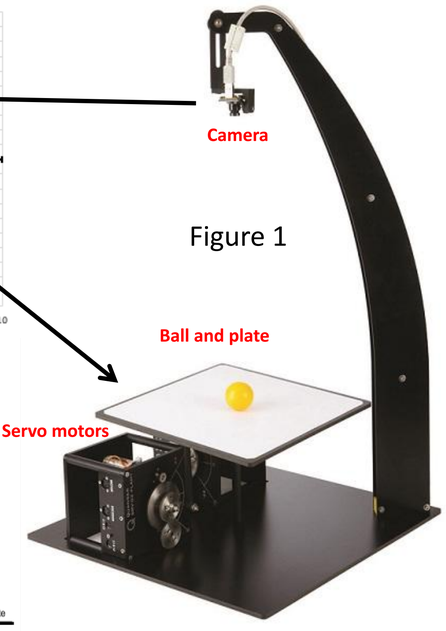


Diagram 1 - Implementation of a Control System





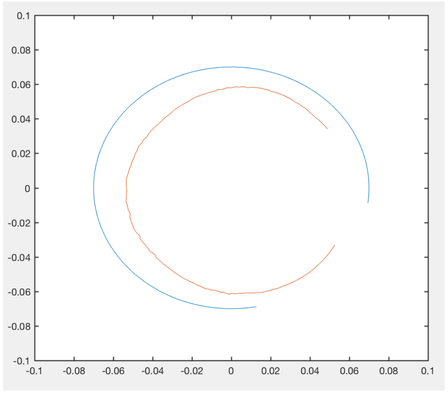


Fig 4 - Desired (blue) and current (red) ball's position

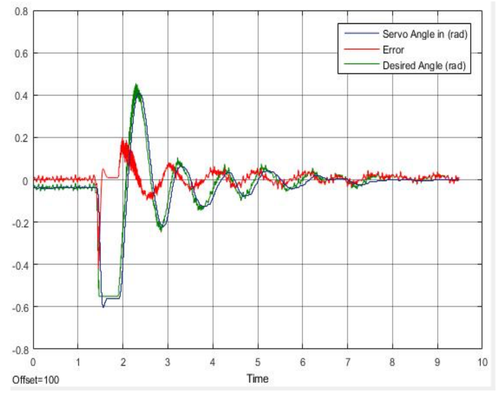


Fig 5 - Desired and current servo angle to adjust ball's position

Conclusion

The objective of this project was successfully achieved by implementing a control program that uses a camera to determine the actual position of the ball on the plate and a control algorithm which commands the two servo motors to tilt the plate relative to the horizontal plane and adjust the ball's position to the desired point.

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