Motion Trajectory Control of a Ball on the ”Ball balancing Platform”

Degree programme: BSc in Micro- and Medical Technology | Specialisation: Mechatronics
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The „Ball Balancing Platform“ (BBP) is developed, and currently used in practical training, in the „Feedback Control“ course within the study program Micro- and Medical Technology of the BFH. This thesis aims to expand the current set of applications of the BBP with the implementation of dedicated algorithms to balance a ball in the centre of a plate, and follow randomly generated paths, with the ball.

Introduction

The „Ball Balancing Platform“ (BBP) consists of three motors that enable the tilting of a plane via arms (see figure 1). The BBP allows students to implement and test velocity or position controllers on DC motors. This thesis aims to extend applications with the BBP by introducing a more complex control problem: balancing a ball in the centre of the plane, automatically or manually. Additionally, a control algorithm is implemented, making it possible for the ball to follow a user-defined trajectory. This allows to expand problem definitions for future student labs and to use the BBP as a reliable demonstration object.

Goals

- Derive the equations of motion of the ball in an inclined plane.
- Derive and simulate a state space model for the ball on a plane.
- Design a control algorithm for the BBP to balance the ball.
- Generate random paths and follow with the ball.

Methods

The model representing the dynamics of the ball on a plane is created by studying the equations of motion of the ball. The model is verified by measurements of the position of the ball at different inclinations of the plane. The second part is to develop a control algorithm for the complete system to balance the ball. To make the simulation of the complete system possible, it is necessary to calculate the motor positions from the desired inclination of the platform, which is described by the inverse kinematic. A complete model of the subsystems used to balance a ball on the BBP is then implemented in Matlab/Simulink, allowing for the investigation of various feedback control algorithms.

Results

The verification of the model yielded the following results: for a small inclination of the table (5 degrees) the maximum error (difference between measured and simulated position) is 5.2 mm, while for a larger tilt (15 degrees) the maximum error is 8.66 mm.

Discussion

Using the controllers and the developed algorithm (see figure 2), it is possible to balance the ball in the centre, despite intentional disturbances (such as moving the ball with a finger or system inaccuracies). In addition, various geometric figures (like a square, a circle or a figure eight) can be simulated and traced by the ball on the plane.

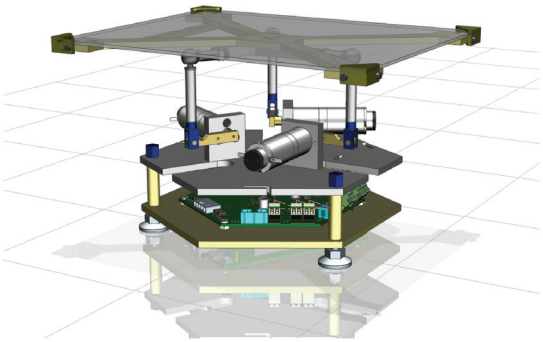

Figure 1: Ball balancing platform (BBP)

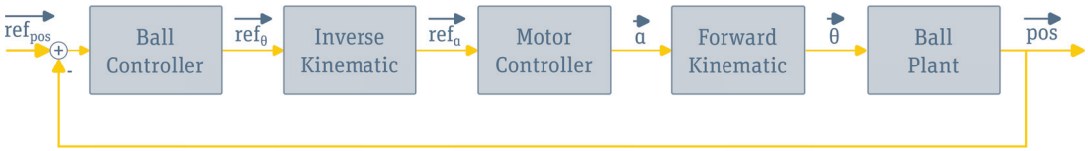

Figure 2: Diagram of the system

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