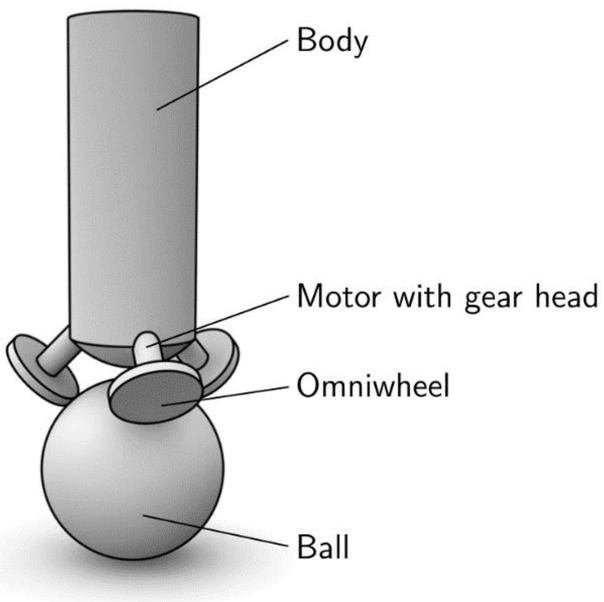
HSLU Hochschule Luzern

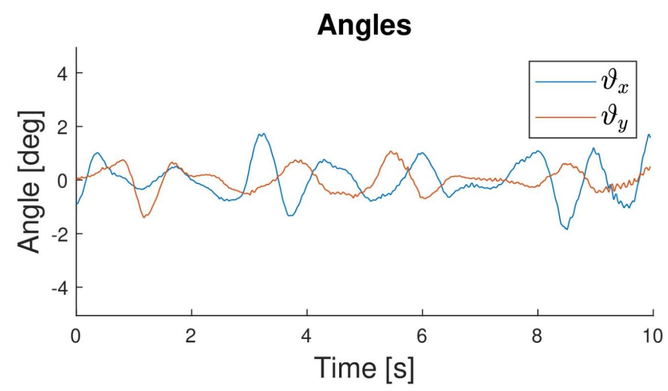
Technik & Architektur
Vertiefung Produktentwicklung & Mechatronik

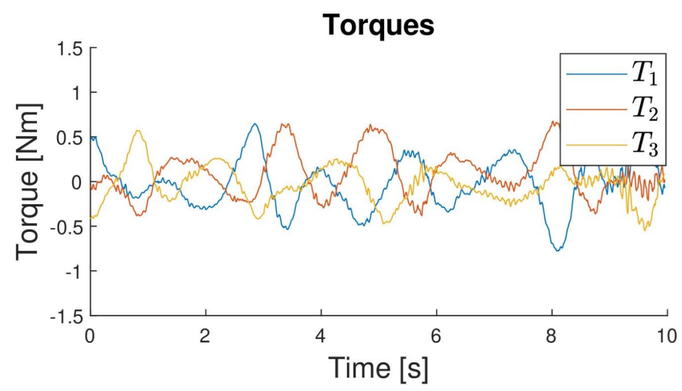
Master-Thesis Mechatronics & Automation

Development of an Improved Ballbot

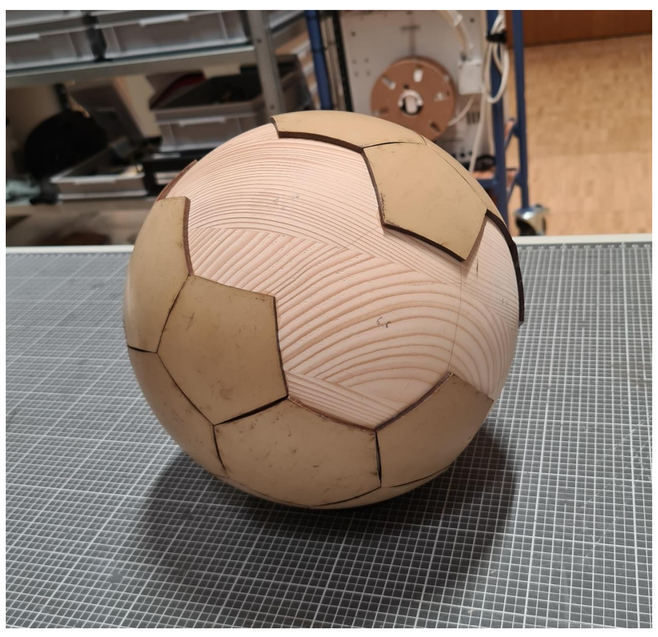


Schematic depiction of a ballbot



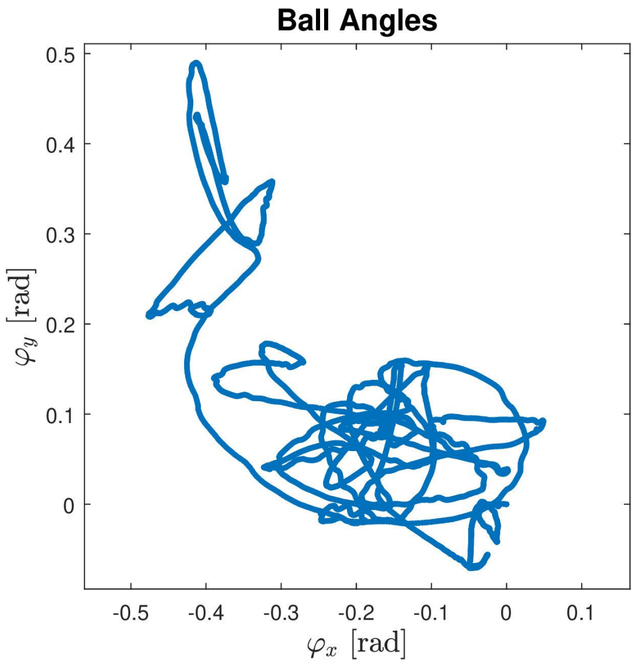


Plots of the angles and the torques of the robot during balancing



Ball made of a wooden core coated with rubber tiles

Ballbot balancing with platform



Position of the ballbot over time while balancing

Introduction

A ballbot is a statically unstable system consisting of a robot balancing on a sphere using a set of three or more omniwheels. The main advantage of this type of robot is its high dynamic movement capability while only having a small footprint. Where other kinds of robots need to restrict dynamic movements with growing robot height because of tipping moments, the ballbot excels with its core function of balancing. This makes a ballbot perfect for navigating environments constructed for humans, as the proportions of height to footprint of both ballbot and humans are similar.

Balancing on a sphere however is a difficult task, requiring a fast and robust control system to keep the ballbot upright. To achieve this goal, a capable hardware platform is needed.

Approach

This thesis documents the process of upgrading a previously existing ballbot to be able to balance on multiple surfaces. To control this unstable system, a linear quadratic regulator in combination with a proportional-integrative controller is used. The upgrades to the ballbot include new motors, a rubber tiled sphere to balance on and a more powerful microcontroller. In addition to that, a platform to carry payloads is also added.

Results

The flaws of the existing ballbot which were identified in the previous project have been successfully addressed. The changed hardware components improve the performance of the ballbot when balancing on various surfaces with a precision that is up to par with other ballbots. It could be shown that the proposed LQR-PI controller structure is able to stabilize the ballbot both on a foam pad and on hardwood flooring.

The added platform at a height easy for humans to interact with offers capacity to carry loads of up to 2 kilograms. With this platform, the ballbot is able to balance on a soft surface like a foam pad. Because of the use of a more common and powerful microcontroller, the ballbot can now also be integrated with other systems.

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