Control of an Unstable Platform for Strength and Coordination Exercise

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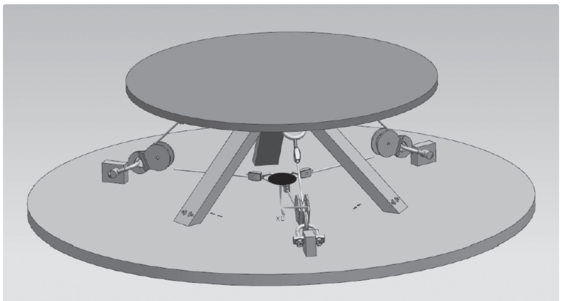
Strength training on vibrating plates as well as balance exercises on different types of unstable platforms are commonly used for practice and rehabilitation. Further the effect of stochastic vibration impulses in strength and coordination training is an innovative research field. The assumption is that a device with a combination of stochastic motion impulses and balance exercise would lead to an effective application which combines the benefits of both principles.

The aim of this thesis is to implement position and force control for fluidic muscles, which are the actuators of a prototype of an active balance board. Another aim is to describe the existing kinematics and to implement a control system where the therapist can control the device via a tablet computer. The costs of the device should be kept low as it is intended to enter the market of therapeutic devices in the future.
The prototype included the mechanical part of the device and a first control system. The concept of the mechanics is shown in Fig. 1. The idea was that the platform performs a defined motion by moving the node (red dot) in plane.



Original concept of the foregoing prototype.

Materials and Methods

The actuators are three fluidic muscles by FESTO. Force and position sensors were evaluated and integrated into the application for every muscle to be able to set up the closed-loop controllers for the position and the force.
The control system consists of an Arduino Due microcontroller board and an Android App. These two components communicate over Bluetooth.
An electrical circuit allows the pressure of the three muscles to be set and amplifies the force sensor signal to be read in by the microcontroller.
The closed-loop controls were implemented on the microcontroller using an interrupt timer loop and PI-controllers.

Results

The original mechanical concept was disproved after a proper mathematical investigation. The problem is that the upper platform position is not uniquely defined by the node position.
The new mechanical system has a well defined kinematics. The final outcome of this thesis is a prototype with a properly functioning mechanical concept and a control system which enables the communication via a tablet computer and which has the required closed-loop controllers implemented.

Discussion

The aim of implementing the closed-loop controllers could be met. The required description of the kinematics led to a new mechanical construction. Further a cost-effective and user-friendly control and sensor system which is independent of expensive software was realized.
Tests are required to characterize the acceleration abilities and limitations of the system. It is also a task for the future to implement functionalities like impedance-control of the system, a human-in-the-loop-mode with biofeedback and stochastic motion; however the whole framework is now available.

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