Mechanical and Control Development of a Mobile Rehabilitation Trainer

Degree programme: BSc in Mechatronics and Systems Engineering (Medical technology | Robotics)
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Early gait rehabilitation in weak patients benefits from coordinated arm movements. In this bachelor's thesis, a system for synchronized arm movement is developed. An analysis of the wrist motion while walking has been carried out to identify the mechanical requirements. The mechanical design and then the construction have been carried out. The motor control system has been designed and tested on the newly assembled setup.

Introduction

Existing products aid in walking rehabilitation by unloading the patient's weight or guiding limbs. However, none of these systems currently allows simultaneous weight unloading and stimulation of arms and legs. In response to this need the RehaLab-HuCE laboratory is developing a Mobile Rehabilitation Trainer (MRT) in collaboration with ETH. This project focuses on developing an arm movement system integrated into the MRT.

Method

Arm movement analysis and conception

The arm movement analysis was conducted using a dataset of shoulder and elbow measurements during treadmill walking. With the aid of MATLAB, wrist position, velocity, acceleration, and estimated motor torque were determined. Wrist movements were analyzed across various motion axis to identify the optimal guidance system.

Mechanical design

Mechanical design was performed using the computer-aided design (CAD) software NX, based on the results of the analysis and conception phase.

Motor control

The motors were controlled by EPOS4 controllers, managed by a Beckhoff industrial computer with TwinCAT software for synchronization and real-time feedback. A user interface has been developed.

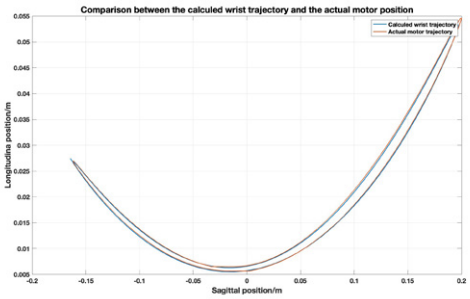

Fig.1: Comparison between the calculated wrist trajectory and the actual motor trajectory.

Results

Arm movement analysis and conception

Fig.1 shows the wrist trajectory of the carried analysis, then compared with the actual motor trajectory. Based on those and results, the mechatronic system was designed.

Mechanical design

All components have been manufactured and assembled. As shown in Fig.2, inside a U-part, a motor drives the belt to move the wrist along the sagittal axis, while a spindle actuated by another motor moves the U-part along the longitudinal axis.

Motor control

The integration of the user interface within the TwinCAT program facilitates the usage of the system. The arm swing is smooth, adaptable to different patient heights, and the speed is adjustable according to rehabilitation needs.

Discussion

The system's ease of use and reliable performance indicate a robust concept with potential for further enhancement, as show in Fig.1 the target trajectory is followed correctly. The mechanical concept can be optimized to be both lighter and resistant, and new functionalities can be added to the program.

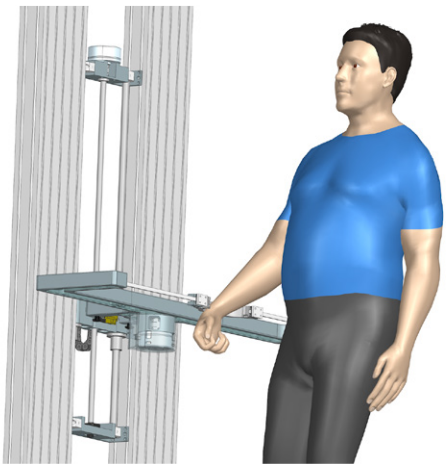

Fig.2: Complete mechanical assembly of the system.

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