MIMICKING THE UNROLL OF A PROSTHETIC FOOT WITH A ROBOTIC GAIT SIMULATOR

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Introduction

Amputees using a transtibial prosthesis often have several complaints regarding their comfort, including pain or tissue damage at the level of the stump due to pressure and friction, unbalanced or abnormal gait as well as muscle and joint pains. Many of these complaints can be minimized by optimally configuring and aligning the prosthesis [Schmalz, 2002; Klute, 2001].

The main objective of a large project is to develop an innovative tool for the prosthetist, in order to optimize configuration and alignment of lower leg prostheses, based on objective simulations with a robotic gait simulator.

In the framework of this project, this study presents a robotic gait simulator that was developed to mimic the kinematics and kinetics of a prosthetic foot during normal human walking.

Methods

Because the desire of amputees is to walk as normal as possible, kinematic input of healthy subjects was used. Ground reaction force and 3D movement of the shank of healthy subjects during walking were recorded simultaneously at 200Hz with an 1m force plate (AMTI, Watertown, USA) and a motion tracking system with 4 CX1 units (Codamotion, Leicestershire, UK). Active markers were placed on 3 reference points (malleolus medial, malleolus lateral, tuberositas tibiae).

Subsequently, the shank movement was recalculated to Euler angles to be used as kinematic input for an industrial robot with 6 degrees of freedom (KUKA Automatisering + Robots, Houthalen Belgium). An AMTI force plate with safety system was placed under the robot in order to register the ground reaction force during the simulation of a unroll of a prosthetic foot. An energy consumption system with spring was placed at the end effector of the robot to adjust the force retaining the desired kinematics.

Forces, moments and motion trajectories were registered real-time and simultaneously.

Figure 1: Robotic gait simulator

Results

Kinematics of the shank and ground reaction forces produced by the robot were similar to measurements in healthy subjects. Both kinematics and kinetics of the gait are adaptable in order to simulate new cases. This allows us to simulate complex, individual and unusual gait patterns.

Discussion

The gait simulator, including a prosthetic foot, has the ability to imitate human walking and running based on realistic speeds and forces. We are able to mimic the unroll of a prosthetic foot with the robotic gait simulator with different alignments.

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References

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