Characterization and Control of an Assistive Hip Orthosis for the Elderly

Motivation & Objectives

The global elderly population grows at increasing speed. The worldwide percentage of people over 60 years old is forecast by the United Nations to double between 2000 and 2050. Regarding intrinsic mobility difficulties relative to ageing, it becomes a real concern for nowadays and the years to come. Assisting solutions as walkers or wheelchairs already exist but have drawbacks such as the impossibility to climb stairs for example. An alternative technology called assistive orthosis similar to exoskeletons has been developed since the nineties and has proven its capabilities.

The objectives of the project are then to characterize the mechanical design (previous project) of a hip orthosis and to control it regarding future assisting strategies.

Mechanical design

The hip orthosis mechanical design was made during a previous project. The 6 DOF mechanism allows free motion of the hip abduction/adduction and the internal/external rotation. Meanwhile, the flexion/extension motion is actuated by a 60Watts DC motor with a ball screw acting as an electric cylinder which is backdrivable. The parallel geometry is designed to fulfill specifications as a high torque at sit-to-stand angular position while it allows high speed at walking angular positions.

Control set-up

The hip orthosis is powered by a 24volts source with a Maxon® servo-amplifier controlling the motor in current (torque) mode. An encoder measures the angular position and a force sensor records the force of interaction between the orthosis and the human thigh. All the signals are connected with the computer through a multifunction Sensoray® input/output board. The control software was developed at EPFL and is called Flexcom®, it runs in real time with a windows XP operating system and the RTX® real time extension. It can exceed sampling frequency of 1kHz.

Performance analysis

High dynamics are met during walking. An experiment consisting of replicating the walking kinematics at different cycle frequencies with a PID position controller is conducted on the alone orthosis. Results show that at common frequencies (0.6-0.9Hz) a good percentage of assistance (>80%) can be provided based on the motor nominal torque. It also depicts the fact that at 1Hz the dynamic is too high to be followed in terms of torque by the orthosis.

Transparency

The transparency is the concept of erasing the unwanted orthosis effects from the plant. This is realized using a feedback approach based on the model defined. Results are good and are quantified through experiment using the force sensor. Forces of interaction without transparency reach about 20N while in transparency mode it is below 5N.

Conclusion and Future Works

This project sets the prerequisite for further investigations toward assistive strategies implementation. It demonstrates that the mechanical design was good but still could be improved. Future works would be to define precisely the need in term of assistance and develop a following strategy regarding detection of intention and control approach. It is also important to imagine solutions for the quantification of the degree of assistance to be able to precisely compare assisting strategies.

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