ASSESSMENT OF DAILY-LIFE DYNAMIC INTERACTIONS BETWEEN HUMAN BODY AND ENVIRONMENT USING MOVEMENT AND FORCE SENSING ON THE INTERFACE

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ABSTRACT

The physical interaction between the human body and environment is important in many situations: In physical labor, interactions need to be performed within safe limits of body loading. In rehabilitation, people need to relearn functional motor tasks and interact with mobility support devices. In sports, motor tasks are trained to the ultimate, maximizing force and/or endurance and optimize coordination. The dynamic interaction between the human body and environment can be assessed in terms of forces and movement at the interface. We have shown that power transferred and work done can be estimated using signals from force and movement sensors at the interface [1]. It should be noted that these force and movement quantities also provide information about the dynamic characteristics of the environmental load as well as of the human body. In general, both bodies are physically coupled and therefore interact in a closed loop. Hence, the relation between effort (forces) and flow (velocities) variables gives information about the joint dynamics.

This study describes a method to estimate load dynamics during the execution of daily life tasks. In many motor tasks, the central nervous system (CNS) applies feed-forward control, using learned patterns. The contribution of state feedback (visual/proprioceptive/reflexive) is significantly less when a certain task has been performed multiple times. We hypothesize that force and movement measured at the interface provide information about load dynamics for this class of tasks, since the load is effectively moved under open-loop conditions.

An instrumented handle has been used to measure forces and accelerations on the interface of human hand and a mass and spring load. Both mass and spring loads have been repeatedly transferred between two positions. During the mass load experiments mass was estimated within 4% difference with the real measured value. Estimated damping and stiffness were neglectable. In the case of a spring load, stiffness was estimated within 3% of the actual value.

We conclude that simple load dynamics can indeed be identified during motor tasks that involve learned feed-forward controlled motor patterns. We propose that limited information of body dynamics can be obtained when load dynamics suddenly changes (for example when releasing an object that is thrown). In addition, task performance may be quantifiable from force and movement information.

REFERENCE

[1] Veltink, P. H., H.G. Kortier, et al. (2009). "Sensing Power Transfer Between the Human Body and the Environment." IEEE Transactions on Biomedical Engineering **56**(6): 1711-1718.