Modeling and Analysis of Biologically Inspired Motor Control

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The Problem: How does the human neural circuitry control posture and voluntary movements? Humans are equipped with an amazing repertoire of motor skills. Despite being outfitted with what by many engineering criterion are noisy signals, slow computation times, devastating transmission delays and marginal actuators, the human system exhibits motor control and motor learning that far surpass our best engineering efforts. We seek a better understanding of how this is accomplished.

Motivation: With a clear understanding of human motor control circuitry the benefits afforded will be widespread. For instance, insight into human motor disorders and their possible treatment, as well as a basis for development of advanced neurological diagnostic techniques should become available. Similarly, this knowledge will provide a framework for implementing biomimetic control systems. In addition, control systems might be had that compliment the aptitudes of natural human motor control with the resources of modern control theory.

Previous Work: Many researchers have investigated both biologically plausible or motivated control systems and human neuro-motor pathways [1, 2, 3]. In regards to the former, many have focused on the role of internal dynamic models, their acquisition and role in motor control and motor learning. In regards to the latter, there exists a wealth of empirical data and hypothesis as to the many neural pathways and cortical areas involved in motor control. Great gains have been made in both approaches, but human motor control awaits a unifying cogent theory.

Approach: Neuroanatomy, biomechanics, engineering control theory, and the theory of neural networks and non-parametric regression are all key fields in the development of a credible model. These mathematical models must be consistent with known neurocircuitry. Therefore, not only should the models exhibit the motor behavior of normally functioning persons, they should also be capable of exhibiting the motor pathologies of persons with deficits when similar ”injuries” are enforced on the model. When the models have progressed sufficiently they shall be physically embodied for further analysis with the anthropomorphic robots of the AI Leg Lab. Not only will this provide a realistic test-bed, it will offer a proving ground for biomimetic control.

Difficulty: Human motor control and motor learning is far more advanced than the current modern control techniques employed to control robotic manipulators and robots in general. This being the case, only aspects of human motor control shall be examined. Specifically, interaction tasks with inertial loads, balance and walking shall all be explored.

Impact: When the questions are properly posed, the models obtained through this research shall be able to offer support for or against relevant theories of human motor control. The consequences for biomimetic control and a clearer understanding of the functionality of the human motor system are far reaching.

References:

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