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Research Ideas

Related to training and rehabilitation, the study of augmented feedback (visual, haptic, auditory, multi-modal) and its ability to improve robot-mediated skill transfer and rehabilitation. For example, haptic interfaces enabling interactions in virtual environments can be designed to provide a virtual practice medium that matches the targeted physical medium, or to behave as virtual assistants to improve training effectiveness, providing feedback that is not realizable in the physical world. Emerging innovations may center on new approaches to human-robot haptic interaction including (but not limited to): (1) haptic assistance for performance enhancement and improved training effectiveness; (2) shared control to augment motor learning; and (3) skill transfer in human-robot and robot-mediated human-human interactions. The neural mechanisms for acquisition of sophisticated motor behavior in humans are complex. There exists evidence in the literature that the human nervous system may utilize internal dynamic models of the external systems with which they interact. We may seek to accelerate the formation and/or adaptation of the human internal model to achieve desired performance for a given task in order to facilitate motor learning of these dynamic tasks. This can be useful for teaching purposes (pilots learning to control new aircraft or unmanned vehicles, or medical students learning new surgical procedures), but can extend to rehabilitation applications for stroke or spinal cord injury.

Not directly mentioned in the call for proposals, but relevant on a number of fronts, is research on robotic systems as they apply to the development of 'smart prosthetics'. Specifically, the prosthetic device can be viewed as an external system to be controlled by the human, for which there are internal channels of sensing and/or actuation. Through studies of human motor skill learning, we may be able to train those receiving prosthetics to develop adaptable internal models of their new limbs to enable more precise control, thus improving quality of life. Relevant research questions include*

- What kind of information should be acquired in order to provide enhanced performance of the smart prosthetic? Smart prosthetics for various levels of dysfunction might require different degrees of feedback, and upper extremity applications might be considerably different than those in the lower extremity. What sensory information is necessary and sufficient for each clinical application?
- How will sensory information be provided to the user, and how will he/she not be over-taxed by interpretation of the information to provide true sensory-motor integration in the control functions?

* These research questions were raised at the NAKFI Smart Prosthetics workshop in 2006 (Task Group 7, Sensory Restoration of Perception of Limb Movement and Contact) where I was a participant, but I believe are relevant to the discussion for this workshop.