June 26, 2008

Internal Model Control and Impedance Control in Human Voluntary Movements

Prof. Koji ITO

Department of Computational Intelligence and Systems Science
Tokyo Institute of Technology, JAPAN

ABSTRACT OF THE TALK

In daily life, humans must compensate for the resultant force arising from interaction with the physical environment. It has been shown that humans can acquire a neural representation of the relation between motor command and movement, i.e. learn an internal model of the environment dynamics. For example, Shadmehr, Mussa-Ivaldi et al have analyzed various reaching movements under velocity-dependent force field (VF) where the hand receives the external load in proportion to the hand velocity. It is then shown that human compensates for the external load by the feedforward control based on the internal model. It is here called <internal model control>. On the other hand, in manipulation tasks, such as opening a door, grasping a cup etc., the dynamic interaction between the human arm and external environment determines the stability of motion. Therefore, it has much important to adjust the arm impedance corresponding to the environment dynamics. Burdet et al demonstrated that the subject employed the strategy to raise the robustness to external fluctuations by the high arm impedance

through the simultaneous activation of the agonist and antagonist muscles, which is called <impedance control>.

We investigated motor adaptation of human arm movements to external dynamics. In the experiment, we examined whether humans can learn an internal model of a “mixed force field” (V+P) which is sum of a “velocity-dependent force”(V) and a “position-dependent force”(P). The experiment results showed that the subjects did not learn the internal model of V+P accurately and they compensated the loads by using impedance control. Our results suggest that humans use impedance control when internal models become inaccurate because of the complexity of external dynamics.