A Theory of Robot-Aided Neuro-Recovery

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A theory of human motor control and its recovery after injury would facilitate progress in robot-aided rehabilitation. Despite much slower actuation, communication and computation, human dexterity and agility far exceed modern robots. At the same time, we exhibit surprising (and revealing) limitations: Moving slowly and smoothly is hard for humans; instead, performance ‘breaks down’ into submovements. Human motor control appears to be based on dynamic primitives which emerge from nonlinear neuro-mechanical dynamics. There are at least three classes: submovements, oscillations and mechanical impedances, the latter to account for physical interaction. These primitives may account for striking features of motor learning and recovery: Learning based on rhythmic performance transfers poorly to more general actions; this may partly account for the surprising difficulty of technology-assisted locomotor rehabilitation. Conversely, stereotyped submovements appear in the earliest actions of persons recovering after stroke; their re-organization quantifies the progress of recovery. Saltatory progress—performance plateaus followed by subsequent improvement—is common in recovery; this may emerge as a consequence of

Robot Technology Can Aid Recovery

Older work focused on upper extremities (2002)
Physical collaboration is essential

Strongly endorsed by the American Heart Association in 2010 and again in 2015

More recent work focused on locomotion
Endorsed and supported by the U.S. Veteran’s Administration

See related work by Dr. H.I. Krebs

Bio: Neville Hogan is Sun Jae Professor of Mechanical Engineering and Professor of Brian Cognitive Sciences at the Massachusetts Institute of Technology. He earned a Diploma in Engineering (with distinction) from Dublin Institute of Technology and M.S., Mechanical Engineer and Ph.D. degrees from MIT. He joined MIT’s faculty in 1979 and presently Directs the Newman Laboratory for Biomechanics and Human Rehabilitation. He co-founded Interactive Motion Technologies, now part of Bionik Laboratories. His research includes robotics, motor neuroscience, and rehabilitation engineering, emphasizing the control of physical contact and dynamic interaction. Awards include: Honorary Doctorates from Delft University of Technology and Dublin Institute of Technology; the Silver Medal of the Royal Academy of Medicine in Ireland; the Henry M. Paynter Outstanding Investigator Award and the Rufus T. Oldenburger Medal from the American Society of Mechanical Engineers, Dynamics Systems and Control Division; and the Academic Career Achievement Award from the Institute of Electrical and Electronics Engineers, Engineering