1. Proposal Title

Therapeutic Robotics: Fundamentally Cross-Disciplinary Collaboration between Clinical Neuroscience and Robotic Engineering

2. Name, affiliation, and contact information

Neville Hogan, Ph.D.
Professor
Massachusetts Institute of Technology
Mechanical Engineering Department
Brain and Cognitive Sciences Department
77 Massachusetts Ave, Office 3-144
Cambridge, MA 02139
(617)253-2277
neville@mit.edu

Hermano Igo Krebs, Ph.D.
Principal Research Scientist and Lecturer
Massachusetts Institute of Technology
Mechanical Engineering Department
Adjunct Assistant Research Professor of Neuroscience
Weill Medical College of Cornell University
Adjunct Professor Department Neurology
University of Maryland School of Medicine
77 Massachusetts Ave, Office 3-137
Cambridge, MA 02139
(617)253-8112
hikrebs@mit.edu

3. Proposal

The demand for rehabilitation services is growing apace with graying of the population. By 2050 the US contingent of seniors is expected to double from 40 to 80 million. With these changes comes increased incidence of age-related disorders. Foremost among them is stroke (cerebral vascular accident) with an accelerating incidence that has already reached about 0.8 million per year. Yet this is merely the tip of the iceberg: the many neurological injuries other than stroke and a plethora of orthopedic injuries also demand rehabilitation services. This creates both a need and an opportunity to deploy robotic technologies to support and enhance recovery.

Unlike prior work, which used robotics as an assistive technology for persons with disability, *therapeutic* robotics uses the technology to facilitate the individual's recovery—in principle, to the extent that no permanent disability ensues and no assistive technology is needed. In an institutional context, therapeutic robotics enables an overdue transformation of rehabilitation clinics from pre-industrial manual operations to technology-rich activities. In short, therapeutic robotics can revolutionize rehabilitation medicine by harnessing technology to assist, enhance, and quantify recovery—and that revolution has already begun.

With NSF support starting in 1989, we pioneered the field of therapeutic robotics by developing what became known as MIT-MANUS. At the risk of hyperbole, therapeutic robotics may well be one of the most important developments in robotics in the last 20 years. It is a first step towards truly integrating humans and robots, a paradigm shift that will move robotics from its “classical” industrial applications (spray painting, spot welding, IC insertion) or contexts considered hazardous for humans (space, nuclear, underwater, rescue) into literally anybody’s living room.

Deploying robots to work in close physical contact and cooperation with humans requires trust. Creating that trust in therapeutic robotics has required 20 years of perseverance. The enormity of our challenge and success cannot be overstated. The effort required is the antithesis of “proof-of-concept” demonstrations, with ultimate deployment entrusted to vaguely-perceived “market forces”. The essential research requires painstaking, careful experimentation, often slow and tedious, to create a large body of reliable evidence to demonstrate what actually works in practice, and why.

Now that the vision and path have been defined, therapeutic robotics has been growing at a remarkable rate with literally hundreds of groups working in this field in academic centers; and the same has been happening in large for-profit enterprises. Yet this growth of activity is not accompanied by a growth in quality, largely because of a lack of “field testing.” Unfortunately, it is not sufficient to recruit clinical collaborators and trust to their knowledge. In our experience, the knowledge necessary to enable this robotic application does not presently exist in the clinical community. This is largely because the tools for quantitative analysis and experimental control of rehabilitation have not hitherto been available. The essential ingredient is fundamental research into how the neuro-biological basis of recovery may be enhanced by robotic engineering.

To guarantee US prominence in therapeutic robotics, we have to create mechanisms to (1) deploy the technology developed in research laboratories; (2) verify that it works in rehabilitation practice; and (3) understand why.

Though therapeutic robotics is presently deployed in clinics, it is not far-fetched to envision the technology finding its way to the home in the near future. Ultimately, the distinction between assistive technology and therapeutic robotics will disappear. Robotics will not only deliver therapy to the individual, but also assist as needed with activities of daily living—literally in their living room. The critical technology required to enable this vision is actuation: despite exciting recent advances, no presently available technology is capable of delivering sufficiently high forces and at the same time is sufficiently non-encumbering to allow free expression of human movement.

To guarantee US prominence in therapeutic robotics, we have to create novel actuator technologies that will generate high forces (up to and beyond the weight of a human) yet be minimally encumbering (compact, lightweight and above all, back-drivable).

Research to address these challenges will have a profound effect on US education and technology infrastructure. Rehabilitation applications and robotics are both powerful magnets to draw young people into science, technology, engineering and mathematics. New actuator technologies will enable physically-interactive robots to become as ubiquitous as cell phones. The new knowledge generated will enable science-based physical medicine and rehabilitation, bringing robotics into the core curriculum of future healthcare professionals.