"How Robotics are Revolutionizing Rehabilitation"

Hermano Igo Krebs, **PhD**

Abstract: Capitalizing on the new understanding of brain plasticity, we introduced a paradigm shift in clinical practice in 1989 when we initiated the development of the MIT-Manus robot for neuro-rehabilitation and deployed it into the clinic. Since then we collected evidence to support the potential of enhancing and augmenting recovery following a stroke, first during the sub-acute and then the chronic phase. Our efforts and that of others led to the endorsements starting in 2010 from the American Heart Association, the American Stroke Association, and the Veterans Administration for the use of rehabilitation robots for the Upper Extremity, but not yet for the Lower Extremity. AHA recommendations were the same in the 2016 revision. Furthermore, it was demonstrated in the VA system that upper extremity robotic therapy has an economic advantage over manual therapy. More recently we completed a pragmatic study RATULS under the auspices of the National Health Service of the United Kingdom and its NIHR Health Technology Assessment Programme, which enrolled 770 stroke patients. Thus, we have developed novel robotic treatment and evaluation tools and have managed to collect the experimental evidence that demonstrates the unequivocal therapeutic benefits stemming from robot-aided rehabilitation for the upper extremity as well as present shortcomings. This talk will present an overview of our past rehabilitation robotics efforts and more recent efforts addressing the identified shortcomings.

"Novel Biomarkers: Robotics and **Machine Learning** "

Hermano Igo Krebs, **PhD**

Abstract: In stroke, we demonstrated that robotic devices promoted upper extremity motor recovery. Those studies raised new questions focused on patients who were mildly or completely resistant to therapy, i.e., patients who did not improve, and prompted the hypothesis that we could predict who are the responders, quasi-responders, and non-responders to behavioral therapy. There have been other attempts to create biomarkers to predict outcomes employing clinical scales such as the Fugl-Meyer assessment, the neurologic sensory exam, functional impairment scales, neurophysiology and neuro-imaging analysis; but these attempts have had mixed results and these measures are seldom used in practice to optimize therapy. To understand the variability of recovery, we examined the data collected with the robotic group on a recently completed studies. We investigated the potential for building a more sensitive biomarker, composed of robotic measurements collected during evaluation and training, to analyze the performance of patients recovering from stroke and to predict who will respond to movement-based treatment and who will not. We hypothesize that kinematic and kinetic measurements can predict the response to behavioral therapy in stroke and also determine how to optimize care for a particular patient. Here we will discuss our attempts to employ both linear and non-linear approaches and ascertain the correlation levels between our robot-based biomarker and clinical scales. We will discuss robot biomarker effect-size and compare it to clinical scales to determine whether there are some noticeable efficiencies in using the robot-assay instead of the clinical scales. We will also present our efforts in developing an expert algorithm that employs data collected during the baseline assessment and during two consecutive training sessions in order to predict patient outcomes as well as to determine patterns of improvement in stroke patients so as to build an alternative machine learning predictor of outcomes.

"Starting a Venture Company"

Hermano Igo Krebs**, PhD**

Abstract: *"Imagine being present at the birth of a new industry. . . trends are now starting to converge and I can envision a future in which robotics devices will become a nearly ubiquitous part of our day-to-day lives. Technologies such as distributed computing, voice and visual recognition, and wireless broadband connectively will open the door to a new generation of autonomous devices that enable computers to perform tasks in the physical world on our behalf. We may be on the verge of a new era, when the PC will get up off the desktop and allow us to see, hear, touch and manipulate objects in places where we are not physically present."*
Bill Gates
Disruptive technology is a term coined to characterize an innovation that disrupts an existing market or way of doing things and creates a new value network. The concept was first described at Harvard Business School by Clayton M. Christensen, who described the concept in 1996 as: "Generally, disruptive innovations were technologically straightforward, consisting of off-the-shelf components put together in a product architecture that was often simpler than prior approaches. They offered less of what customers in established markets wanted and so could rarely be initially employed there. They offered a different package of attributes valued only in emerging markets remote from, and unimportant to, the mainstream." Eventually with improvement, borrowing from Malcolm Gladwell, the moment of critical mass, the threshold, the boiling point is reached and the old practices and existing value network is abandoned in favor of the new one. Here I will discuss my experience as an entrepreneur and whether rehabilitation robotics has achieved its "tipping point."