**Rehabilitation PhD Qualifying Exam** (Kamper)

**Exam Details**

The exam will consist of two components:

i) Closed-book exam (2 hours). Time and location: 9/29/21, 10:00-12:00, Wed. morning.

* Students may bring a calculator.
* Students may bring the papers listed below with their own annotations.
* Questions will require qualitative and quantitative answers.

ii) Take-home component involving Simulink (project with code must be submitted

electronically within 24 hours of receipt of assignment).

* This will be open-book, but the student is expected to work entirely independently.
* Familiarity with Simulink will be assumed.

**Introduction**

Increasingly, rehabilitation technologies are being developed and implemented to help individuals regain function following neuromuscular injuries such as stroke, spinal cord injury, or limb loss. These technologies introduce a coupling between the user and device. This involves not only mechanical coupling, but motor planning and execution as well. The user, for example, must characterize and incorporate the properties of the device to perform motor planning, while the ideally the device would learn the properties of the user to provide customized assistance. Furthermore, devices can provide users with knowledge of external objects, both real and virtual.

This exam will explore issues related to the human-machine interactions that are fundamental to functional utilization of rehabilitation technology. For the in-class portion of the exam, students are expected to be able to discuss concepts from these papers both qualitatively and quantitatively. For the take-home portion, students will be expected to create a specified model using Simulink. Topics may include:

* Internal representation of self
* Representation of wearable devices
* Forward and inverse kinematics
* Haptics
* System response

**Suggested References**

Questions and concepts will be drawn from the following papers:

* Lambercy O, Metzger JC, Santello M, Gassert R. A method to study precision grip control in viscoelastic force fields using a robotic gripper. *IEEE Trans Biomed Eng* 2015; 62: 39-48.
* Ranzani R, Lambercy O, Metzger JC, Califfi A, Regazzi A, Dinacci D, Petrillo C, Rossi P, Conti FM, Gassert R. Neurocognitive robot-assisted rehabilitation of hand function: a randomized control trial on motor recovery in subacute stroke. *J Neuroeng Rehabil* 2020; 17: 115-127.
* Dingwell J, Mah C, Mussa-Ivaldi, FA. Manipulating objects with internal degrees of freedom: evidence for model-based control. *J Neurophysiology* 2002; 88: 222-235.
* Maimon-Mor RO, Makin TR. Is an artificial limb embodied as a hand? Brain decoding in prosthetic limb users. *PLOS Biology* 2020; 18.
* Nabeshima C, Kuniyoshi Y, Lungarella M. Adaptive body schema for robotic tool-use. *Advanced Robotics* 2006; 20: 1105-1126.
* Debaraba HG, Bovet S, Salomon R, Blanke O, Herbelin B, Boulic R. *PLOS One* 2017; 12: e0190109.
* Chen YF, Napoli D, Agrawal SK, Zanotto D. Smart crutches: towards instrumented crutches for rehabilitation and exoskeletons-assisted walking. *Proceedings of the 7th IEEE International Conference on Biomedical Robotics and Biomechatronics* 2018; 193-198.