

Project Title: *Development of a robotic system with an augmented reality interface for rehabilitation of brain injured individuals*

Investigators: James L. Patton, Ph.D. (PI) & Robert Kenyon, Ph.D. (CO-PI)

Other Collaborators: Chris Scharver, MS., Greg Dawe, MS, Ferdinando Mussa-Ivaldi, Ph.D.; Mary Ellen Phillips, MS OT, and Kathy Stubblefield, OT, Rita Bode, Ph.D.

Overview: The goal of this project is to design, develop, and test a new robotic interface for upper-limb rehabilitation of brain-injured individuals. Previously used robotic devices with computer displays have shown great promise in clinical rehabilitation, but these devices were too small and limited for practical application in rehabilitation. We proposed to develop a human-interface robot system that safely operates in three dimensions with a large workspace and an appropriately designed visual interface. Specifically, we proposed to spend the first year on acquisition and implementation of an augmented reality (AR) system. The second year we would interface a robot and develop foundational software. The third year we will develop an easy-to-use interface for therapist operators. The fourth year will be for developing the various therapeutic programs. The final year will be to test and identify the minimum necessary technical parameters (display resolution, display speed, brightness, robot strength, etc.), providing the best possible design specifications for the next generation system.

Progress: In year 1, we acquired and assembled the PARIS display system combined it with the Phantom haptic robot, and implemented basic software that demonstrated the system's capabilities (*right*). This second year has been devoted to developing a foundational library for data acquisition and control. We now have the ability to collect data at up to 10 kilohertz, administer a variety of experimental protocols using flexible text input files. We have implemented an experimenter's interface, a head tracking system that appropriately adjusts the image as the user moves their head, and we can now rapidly turn on/off and distort graphic and haptic objects.

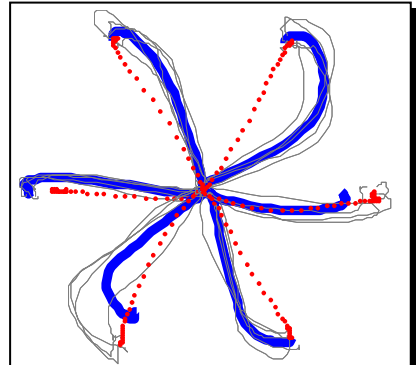
We have begun to collect data on healthy subjects as a precursor to our rehabilitation applications. Our initial test on 4 healthy subjects we found that at the very least, the new system can produce the results we have obtained using our planar robot. Specifically, force field training produced significant after-effects (*right*). We have completed another experimental data collection in on the differences between 2D and 3D training, and analysis is currently underway.

Additionally, in August we hired computer scientist Chris Scharver full-time. There were two podium presentations on our developments at the recent IEEE EMBS Conference, making this development well-known now to bioengineers.

Plans for the coming year: We have finalized plans to begin assessing our programming goals using the help of clinicians, engineers, and patients. This will first involve focus-groups followed by a formal questionnaire process. We will begin preliminary tests on individuals with stroke. Paris-designer Greg Dawe and has been working on a related project at EVL to reduce the cost of the display technology. We plan to integrate other robots into the system. ■



PARIS (Electronics Visualization Labs at The U. Illinois at Chicago) is a large-workspace, three-dimensional system that allows the user to see their own limb as well as virtual objects in space before them. This individual is holding the Phantom Robot (SensAble Technologies, Inc.) that renders programmed forces such as touching these artificial spheres.



Data indicating the efficacy of the system. Shown are the center-out, 10 cm movements (thin lines are individual motions, thick blue lines indicate the average) that demonstrate after-effects of adaptation that cause people to bend their movements away from straight movements they made before training (red dotted lines).