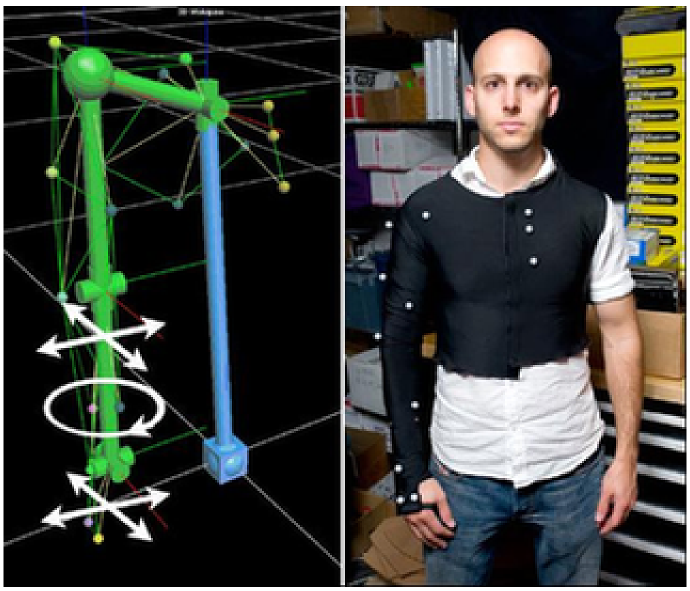
Robot Suit May Help You Achieve a Perfect Golf Swing

October 31 2007, By Lisa Zyga



A robotic feedback suit: markers on the right arm indicate the joints that are regulated by the system. Credit: Lieberman and Breazeal. ©2007 IEEE.

Researchers have developed a vibrotactile feedback suit to help individuals learn new motor skills more quickly and accurately than by mimicking human teachers alone. Besides golf, dance and sports training, the suit may also be useful for individuals undergoing motor rehabilitation after neurological damage, as well as for posture improvement.

MIT researchers Jeff Lieberman and Cynthia Breazeal have published the results of the study in a recent issue of *IEEE Transactions on Robotics*. The study presents a proof-of-concept wearable robotic system that provides real-time tactile feedback over every joint simultaneously.

“Oddly enough, the idea for the robot suit initially came from a dream,” Lieberman told *PhysOrg.com*. “The dream involved people who weren't physically able to express themselves, but who were mentally normal, who used a machine that aided them to get their inner feelings out. This ranged from people with muscular difficulties to even toddlers and 'untrained' people who do not know how to wield a paintbrush. Upon waking and thinking about that idea for about an hour, the idea for this project was born, and I started doing research that day; the overall project was about six months for software and hardware development.”

In experiments with arm motions, the researchers found that the suit increased students’ learning rates by up to 23%, and reduced errors by up to 27%, as well as enabling students to learn movements “more deeply” by affecting their subconscious learning of motor skills. The latter can be especially important for patients with neurological injuries who have lost the ability to form new long-term memories, but can still build new motor skills.

The suit works by optically tracking body markers for the teacher’s movement (or a pre-recorded ideal movement) and the student’s movement with a Vicon motion capture system, which has millimeter accuracy. The tracking data is fed to software that compares the teacher’s and student’s movements, and generates feedback signals to the suit.

“The most challenging part was the human motion tracking system, which needs to function extremely quickly [about 100 hz] and be extremely accurate [about 1mm] to be able to adequately represent complex human motions,” Lieberman explained. “The system we use is a very expensive one for very high-tech applications, and for this to be successful in the real world it has to be much less expensive, and very robust. Tracking systems are typically optical [needing a setup in the room] or exoskeleton-style [wearable] which results in high expense and high weight, respectively. We'd like to solve both those at the same time and are working on new possibilities, although it is not the main focus of the research."

Small actuators against the skin vibrate in proportion to the amount of positional error of the student's joints, giving the sensation of a vibrating "force field" around the correct motion. The suit can also correct for rotational errors of joints by sequentially vibrating individual actuators placed around joints clockwise or counterclockwise, giving the sensation that a rotating signal is urging the joint to rotate.

Because everyone has different physical proportions, the system must first spend 10 minutes calibrating a new user's limb lengths and joint locations, and then match them to the teacher's proportions. Once a teacher's motions are tracked, they can be recorded, repeated, and played at different speeds.

As the researchers explain, the system has the potential to teach a student the precise motions of a teacher in place of the teacher. The system could therefore work well for teachers who are highly skilled, but are not good at teaching, by physically guiding a student who can simultaneously watch the teacher or a pre-recorded motion for visual feedback. However, visual feedback may not even be necessary with the wearable feedback suit, giving it the potential to be used as a training device for blind individuals.

"The biggest initial market is in a sport such as golf, which already spends millions annually on video analysis machines, which tell the student exactly what they need to change," Lieberman said. "But it tells them after they're done, and decades of motor learning research tells us that students will learn much more quickly if the feedback is given immediately with no delay. Imagine how easy improving your swim stroke would be if you didn't need to lift your head out of the water to improve it; after about 100 strokes, you'd be mimicking your teacher almost exactly."

He also explained that the health industry represents an equally, if not more exciting, opportunity. People with neurological trauma might use the suit for remapping their brains, and people with back pain could train their muscles with correct posture.

"We are developing a new system using this technology that will monitor your posture and give you vibrotactile cues to keep yourself sitting properly," Lieberman said. "Typically people only realize their posture is bad once pain starts, so this would give immediate feedback to prevent any pain, and retrain those who have already developed back pain. We should be running tests on this new device early next year. You can imagine having one suit, and 10 people each wearing it one week out of 10, to retrain their posture; the retraining of muscles should have a long-lasting effect, greatly helping those with back pain."

Before some of the complex motions— like a golf swing—are tested, however, the researchers say improvements are needed on the robot suit. These include creating a full-body suit with more than 100 actuators, defining ideal marker placement, investigating the human ability to respond to large amounts of feedback, and finding a less expensive and more mobile tracking system.

"With the golf swing, the difficulty lies not only in the fact that you need to monitor many more joints, but also that the mapping from teacher to student is much harder to clearly define," Lieberman explained. "In our tests, the mapping explicitly told the subject to try to copy the angles the teacher was making. In golf, it is more important that the end of the club contact the ball, and copying normal angles from someone taller than you will result in the club going into the ground, so it's very difficult to map that."

Related information: robotic.media.mit.edu and [bea.st](bea.st).

Citation: Lieberman, Jeff and Breazeal, Cynthia. "TIKL: Development of a Wearable Vibrotactile Feedback Suit for Improved Human Motor Learning." *IEEE Transactions on Robotics*, Vol. 23, No. 5, October 2007.