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The Unique World of CerebotiX and Cerebotics

It's perplexing that the radio frequency linkage of biofeedback outputs into true three-dimensional objects capable of moving with 6 degrees of freedom in the x, y, and z axes has not been done before. Now that it has, hopefully this will provoke more applications.

The traditional biofeedback outputs have many limitations. In the past connections have been made to race cars, and of course, to a variety of virtual objects, but true multi-axis control seems to be tantalizingly ignored. The fact that the current cerebotic output is in the form of radio waves creates the potential for a dynamic shift in traditional neurofeedback. By bringing the user interface into the real world through real unconstrained objects an exceptional emotional connection and involvement with the process can be had. Furthermore, presenting multimodal outputs into a single real object opens yet another set of therapeutic possibilities.

Movement in three dimensional space has been described in degrees of freedom. For instance, the direction "up" is one degree of freedom along the Y axis. Each axis has four possible degrees of freedom: along the axis in a positive direction, along the axis in a negative direction, positive rotation around the axis, and negative rotation around the axis. Our algorithm currently allows for 6 degrees of freedom out of the possible 12. This means that complex actions can be described accurately as EEG outputs.

Our algorithms while currently proprietary are indeed our special sauce. Having three inter-related yet independently functioning and controllable EEG outputs that resolve both the hysteresis effect as well as the high variability found in EEG signals is a unique contribution which also opens new doors in the applications of neurofeedback. It's not just about the greater control derived from 3 axes and the fact that the outputs are all fully proportional but also the greater subtlety lends itself to a wider range of potential applications as well as an entirely fresh perspective on feedback modalities themselves.

This link is from Arizona:

http://www.trnmag.com/Stories/2002/061202/Brain_cells_control_3D_cursor_061202.html

This group performed their experimental actions in 3D virtual space, and it was accomplished with surgically implanted electrodes in monkeys. Our work has been accomplished with surface scalp electrodes on humans.

This next link notes several fine pieces of work.

http://www.wired.com/medtech/health/news/2006/04/70568

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The Wadsworth typing method used a full cap electrode system presumably involving all 22 electrodes and produced a reproducible control, but it was linear in nature involving horizontal movement of a cursor. The same article references methods of control using eye-gaze and SMR to produce a variety of psychomotor type outputs. To distinguish our work from these: we use only 2 EEG channels and process the data across the broadband EEG

spectrum. Our output to true three-dimensional space represents a large step forward in the therapeutic impact of biofeedback by bridging the VR gap. The reaction to controlling a "real" object instead of an "imitation" one contributes yet another level to the emotional involvement and commitment that is essential for neurofeedback. Incidentally, we seem to have discovered a new aspect to object control as well, the relationship of emotional identification. This citation, by the way, is entirely about object control with no reference to brain training for anything other than control of the object.

The first article referenced in this next link, Scott Makeig's work, which employs ICA decomposition, redistributes brain wave data into useable packages which he applied to operant conditioning of motor responses.

ftp://ftp.cnl.salk.edu/pub/jung/RehabEng00.pdf

Once again, his entire focus seems to be motor control. Not only is that not our focus, we have discarded the operant model in favor of a more adaptive learning paradigm. One of Makeig's own conclusions in his final statement was, "However, the extent to which ICA-derived spatial filters may actually increase the reliability and speed of brain-computer interfaces remains to be determined." This link also has the beginning of Middendorf's Air Force paper. I have no doubt that this research continues somewhere, but this project failed to yield the motor responsiveness they needed.

The next link is to the brilliant work done at Pittsburgh.

http://www.sciencedaily.com/releases/2008/05/080528140245.htm

This is ground-breaking research, but it's in an entirely separate arena from us. Once again, they used surgically implanted electrodes, non-human subjects, and had motor control as their entire objective. While this research is undoubtedly of great significance, it depends on surgical implantation, and it is not about enhancing the therapeutic impact of biofeedback nor even the overall functioning of mental capacity.

This link refers to the Mind Balance game.

http://news.bbc.co.uk/1/hi/technology/3485918.stm

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This device employs a 6-channel system housed in a full cap to produce a binary output that activates one of two decision squares. This is very far from true 3-axis control of a real object in real space.

This last link sent to me covers the Georgia Tech work using rat neurons to drive a robot.

http://www.gatech.edu/newsroom/release.html?id=125

Once again, this is brilliant work, but it is not doing what we have accomplished.

Other companies such as Emotiv and Nia also make claims to have developed these controls. Both those companies' devices depend on EMG signals.

So here is what we have accomplished.

1) We have, in fact, a reproducible method of controlling an independent unconstrained real object in real space in all three axes with fully proportional movement in 6 degrees of freedom.
2) We have an algorithm that analyzes full spectrum EEG data from 2 channels with these characteristics:
   It is self-adaptive which allows it to adjust itself to any user.
   It is therapeutic which enhances the objectives of neurofeedback.
   It is non-operant which permits greater generalization of the subjective experience.
   It is not motor function derived or driven which, for the first time, creates a type of prosthetic control more closely aligned with emotional intent than mechanical movement.
3) We have developed, also for the first time, 3 usable simultaneous outputs from a single EEG source.
4) Our system also uses special neural net programming and other methods (proprietary for now) that create the learning environment on several levels of consciousness.

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