WHITE PAPER

ECoG based Brain-Computer Interface Research

Brain computer interfaces measure brain activity and analyze the data in real-time in order to control external devices. About five years ago, over 80% of all BCIs relied on the EEG to measure brain activity. However, more cutting edge BCIs have instead relied on ECoG. ECoG based systems have numerous advantages over EEG systems, including (i) higher spatial resolution, (ii) higher frequency range, (iii) less artifacts, and (iv) no need to prepare users for each session of BCI use, which usually requires scraping the skin and applying electrode gel.

Recent research has demonstrated, over and over, that ECoG can outperform comparable EEG methods because of these advantages. For example, for over 20 years, researchers have published work with EEG-based P300 BCIs, which allow users to spell or select other items from a matrix. Despite dozens of major papers describing improvements to every component of the P300 BCI, these systems are still fairly slow. However, in the very first P300 BCI using ECoG, the authors broke the speed record for BCIs with the first BCI to break the 100 bit per minute barrier. A critical reason for the speed improvement is the improved signal quality. Subjects could accurately spell based on only one target flash, whereas EEG-based P300 BCIs typically must average together the P300s resulting from 3 or more flashes before the signal is clear enough for accurate classification.

Other work showed the ECoG methods can not only improve BCIs but also help us address fundamental questions in neuroscience. A few efforts have sought to map "eloquent cortex" with ECoG. That is, scientists have studied language areas of the brain while people say different words or phonemes. Results revealed far more information than EEG based methods, and have inspired new ECoG BCIs that are totally impossible with EEG BCIs. Other work explored the brain activity associated with movement. This has been very well studied with the EEG, leading to the well-known dominant paradigm that real and imagined movement affects activity in the 8-12 Hz range. ECoG research showed that this is only part of the picture. Movement also affects a higher frequency band, around 70-200 Hz, that cannot be detected with scalp EEG. This higher frequency band is more focal and could lead to more precise and accurate BCIs than EEG methods could ever deliver.

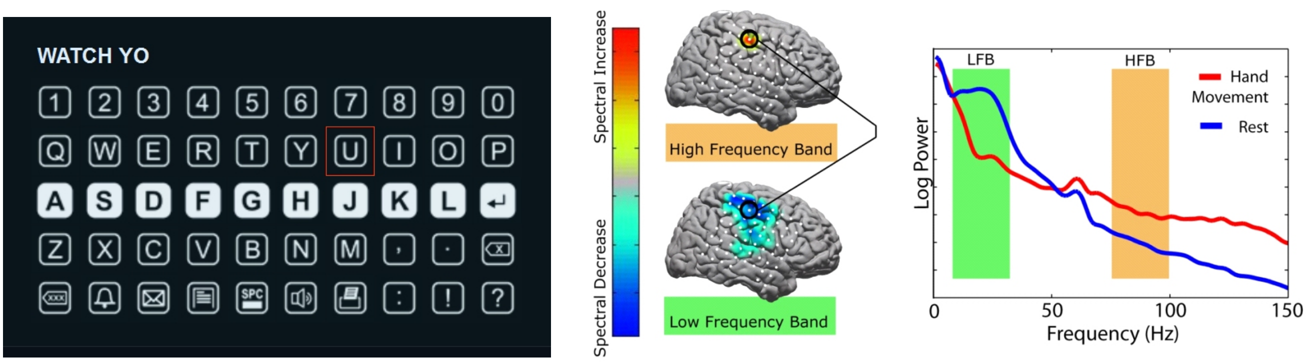

Figure 1: The left panel shows a P300 BCI used to spell, called intendiX. The right panel (picture from Kai Miller) shows high frequency band activity recorded by ECoG, which cannot be detected with EEG.

Newer ECoG systems are also very promising for epilepsy surgery. ECoG is often used to facilitate epilepsy surgery. New systems could reduce cost and recovery time while providing a more accurate and localized picture of the patient's brain. As a result, surgeons can avoid removing unnecessary tissue and reduce the opposite problem of failing to completely remove brain tissue that causes seizures.

Overall, ECoG is a very promising technique that can overcome many of the drawbacks of EEG systems. ECoG is rapidly gaining attention in BCI research, basic science, and medical applications. g.tec offers a complete line of ECoG products, including electrode connectors, amplifiers, software, and documentation, as well as an exceptional support staff. Our systems are compatible with Matlab Simulink, BCI2000, and other established platforms.

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