Technology-Mediated Telepathy: A Natural Language Brain-Computer Interface

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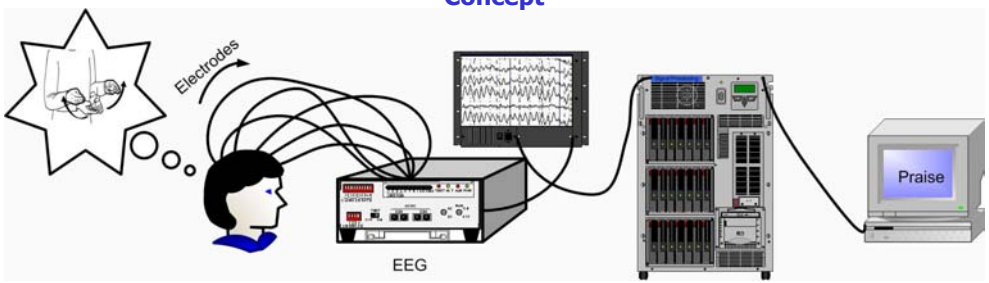
Our Goal

- Since the inception of brain imaging technology, researchers have tried to develop new ways to utilize the signals in the brain for external communication.
- Recently, developments in signal processing have improved real-time analysis of these signals, allowing for a viable interface between the brain and a computer.
- These advancements, while significant, still lack many qualities which make an interface effective, notably, ease of use.
- Our goal is to provide a proof-of-concept for a brain-computer interface using natural human language as a basis for communication. Specifically, we hope to utilize the signals associated with imagined sign language to enable silent translation of thoughts into digital information via electroencephalography (EEG).

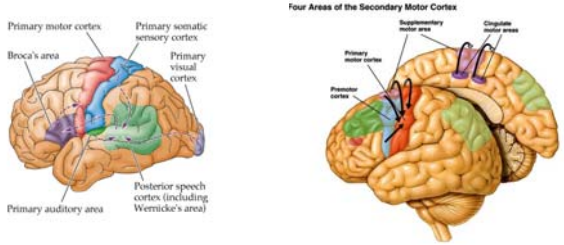
Concept



Timeline

- Background research and exploratory work has been going on since the summer of 2003. Design of the system and development of a viable protocol occurred over the past six months.
- We are currently in negotiations to obtain lab space for implementation of an initial proof-of-concept. We expect to complete extensive testing with human subjects to establish a usable vocabulary range and set up the translation system by July 2004.
- Ideally, completion of the final proof-of-concept system is expected to occur by the end of summer.
- Development will proceed simultaneously with user training and selection of a small number of usable signs, and work with Matlab to develop the corresponding recognition and translation algorithms.

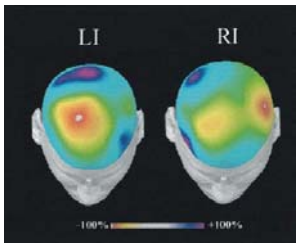
Signals in the Brain



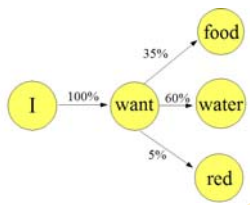
- Silently spoken speech (thinking to oneself) generates activity in Wernicke's area. The signals here, however, are not easily recognizable with noninvasive techniques because they are generated far from the surface of the brain.
- The motor cortex, however, is close to the surface and significantly easier to access. Even signals coming from imaginary motion can be detected in this region. Various groups have successfully used these signals as a means of communication, but present interfaces focus on imagined motion of entire limbs, which has no intrinsic meaning to the user.
- These interfaces attempt to solve this problem by creating an intermediate menu, and arbitrarily associating the motion of limbs with a choice on this menu. Sign language, however, uses both the language and motor regions of the brain, providing signals in the motor cortex which afford a window into the thoughts of the user.

Signal Processing

- Signals in the cortex will be recorded during imagined sign language through the use of non-invasive EEG technology, providing patterns of activation across the entire scalp.
- Because the use of sign language in this context is a novel paradigm, there is no established methodology to guarantee accurate identification of intended signs.
- Prior research has shown the potential applicability of a variety of signal processing methods, including FFT and frequency analysis, spatial pattern extraction and wavelets.
- We plan on exploring these signal processing techniques alone and in concert in order to determine which is best suited to sign language.
- In addition, we eventually hope to utilize the emergent properties of language (syntax, word frequency) in order to more accurately predict intended signs.



Caption: Analysis of Imagined Left & Right Hand Motion using the Signal Space Projection method (Babiloni, et al, 2000)



Application & Impact on Future Research

- The immediate application of our technology goes toward improving the lives of severely disabled patients suffering from total paralysis, or "locked in" syndrome. As they are unable to speak or move any part of their body, but retain consciousness and brain activity, our interface would provide them with a natural way to communicate.
- In addition, this technology presents itself as useful in any situation where one might desire to communicate without any vocal or physical manifestation. Given a sufficiently robust technology, the impact could be vast – from soldiers on the front lines giving a status report without making a sound, to writing text messages on a cellular phone without lifting a finger.
- Our research presents a new paradigm for brain-computer interfacing research, one based on natural language. Even if we are unable to read more than a small number of signs, this limited success would open the door to other, more advanced language-based interfaces. It also suggests a number of research questions regarding advanced issues in signal processing, pushing the limits of what can be obtained from EEG signals. In essence, this work is the starting point for a new model of communicating, limited in scope only, quite literally, by the power of the imagination.

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