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# A sEEG-based BCI for Brain-to-Chinese Language Decoding

**Jie Yang[1*], Lu Cao[2], Yifei Jia[1], Di Wu[1], Yue Zhang[2], and Mohamad Sawan[1*]**

[1]CenBRAIN Neurotech, Westlake University, Hangzhou, China, 310030
[2]Natural Language Processing Lab, Westlake University, Hangzhou China, 310030
*E-mail: {yangjie, sawan}@westlake.edu.cn

*Introduction:* Decoding language from neural signals can greatly improve the quality of life for individuals who have lost their ability to speak, such as those with ALS or stroke. Although significant progress has been made in brain-language decoding [1], relatively few studies have focused on Chinese—a representative syllabic language spoken daily by over one quarter of the global population. In our previous work, we introduced a decoding framework based on syllable elements [2]. In this study, we present our latest advancements in developing a Brain-Computer Interface (BCI) platform for Chinese language decoding, leveraging a medical sEEG system. This system demonstrates high performance processing with low latency, high inference speed, and competitive accuracy, showing great potential for both clinical and research applications.

*Material, Methods and Results:* A custom neural signal processing platform was developed to stream signals from a medical device intended for advanced epilepsy monitoring and research, specifically for long-term sEEG data acquisition. The platform can simultaneously process up to 1024 channels of streaming sEEG signals while recording and playing multimodal voice and video data, with automated marker labeling. With GPU acceleration, the platform performs numerical statistics, frequency processing and neural network inference. In our language decoding experiments, two epilepsy patients who had undergone sEEG electrode implantation participated during their inter-ictal periods. Chinese characters were presented to them sequentially on a screen, and they were instructed to read aloud after receiving a cue. The corresponding sEEG signal and voice signals were simultaneously recorded and processed by the platform. A short time window of sEEG data, with a margin to capture brain activity before and after sound production, was selected for processing.

The signal processing pipeline includes channel differential, filtering, standardization and frequency domain processing. The processed data was then fed into a neural network model for predicting the Chinese Pinyin initials corresponding to the sEEG signals. The network contains five convolutional for feature extraction and followed by a fully connected layer for the final classification decision. Causal convolution is adopted to prevent data leakage from future time steps. The experiment results showed that the top-1 accuracy for the initial prediction exceeded 50% and the top-3 accuracy achieved over 90% on the best performing subject, using an experimental corpus that contains 407 words with 23 distinct Chinese Pinyin initials. The platform is capable of performing over 200 inferences per second, with a processing delay of less than 20 ms.

*Conclusion:* This study demonstrates the feasibility and potential of a high-performance Brain-Computer Interface (BCI) for Chinese language decoding, we achieved promising results in real-time, low-latency, and high-accuracy predictions of Chinese Pinyin initials from neural signals. It lays the foundation for future research on extending the decoding capabilities to full words or sentences.

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