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Automatic EEG Channel Optimization Based on Integrated Gradients for Auditory Attention Tasks

Xue Yuan[1,2], Keren Shi[1,2], Hanbin Wang[3], Ning Jiang[1,2], Jiayuan He[1,2]*

[1]*National Clinical Research Center for Geriatrics, West China Hospital, Sichuan University, Chengdu, Sichuan 610017, China;* [2]*Med-X Center for Manufacturing, Sichuan University, Chengdu, Sichuan 610017, China;* [3]*Institute of Electronic Engineering, China Academy of Engineering Physics (CAEP), Mianyang, China*

*Correspondence: E-mail, jiayuan.he@wchscu.cn

Introduction: Humans have the ability to focus on the specific speaker's voice in a noisy environment, and the attention could be decoded from neural signals, such as Electroencephalography (EEG) [1]. To achieve high accuracy, EEG-based auditory attention decoding studies often employ dozens of electrodes, which increases the complexity of the system and reduces its portability [2]. Previous channel pruning algorithms typically relied on prior assumptions or require additional costs [3]. This work proposed to employ integrated gradients (IG) and directly infer the channels related to auditory tasks without extra training and learning costs.

Material, Methods and Results: EEG data from 16 subjects with 32 channels were collected under an auditory attention paradigm. IG performs Riemann integration on the gradients along the path between the EEG signal and the reference baseline to stably quantify channel contributions, guiding channel pruning. IG significantly outperforms random channel selection (see Fig. 1). The top 20 selected channels achieve similar decoding performance to using full channels. Even with just 5 channels, accuracy remains above 80%. Additionally, the task-relevant channels identified by IG are located in the prefrontal cortex, which is involved in attention allocation and decision-making.

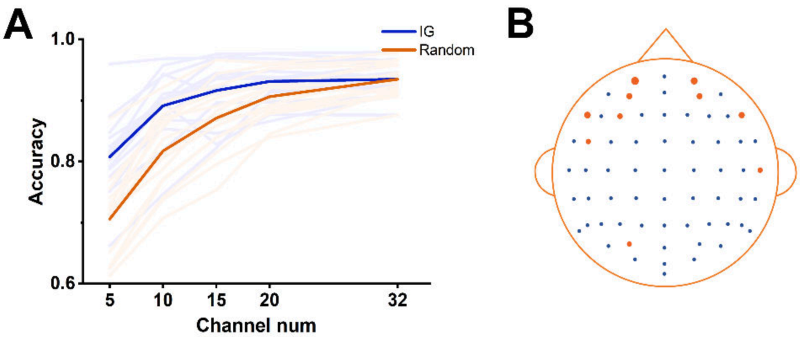

Figure 1: *(A) The impact of channel count on decoding performance. The dark lines show average decoding performance, while light lines represent individual results for 16 subjects. (B) Top 10 electrodes identified by IG, with orange dot size indicating contribution level.*

Conclusion: IG incurs a small causal inference cost, reducing over half the channels while maintaining performance, and successfully identifying channels related to the neural mechanisms of auditory attention. These results support neuro-guided hearing device applications.

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References:

[1] E. C. Cherry, "Some Experiments on the Recognition of Speech, with One and with Two Ears," *J Acoust Soc Am*, vol. 25, no. 5, pp. 975–979, Sep. 1953, doi: 10.1121/1.1907229.

[2] O. F. Kucukler, A. Amira, and H. Malekmohamadi, "EEG channel selection using Gramian Angular Fields and spectrograms for energy data visualization," *Eng Appl Artif Intell*, vol. 133, p. 108305, Jul. 2024, doi: 10.1016/j.engappai.2024.108305.

[3] A. M. Narayanan and A. Bertrand, "Analysis of Miniaturization Effects and Channel Selection Strategies for EEG Sensor Networks With Application to Auditory Attention Detection," *IEEE Trans Biomed Eng*, vol. 67, no. 1, pp. 234–244, Jan. 2020, doi: 10.1109/TBME.2019.2911728.

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