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Non-Invasive Brain Connectivity Mapping to Guide Precision Neurosurgery

Researchers at Stanford have developed a computational method that uses non-invasive brain MRI to predict how brain regions communicate electrically, enabling personalized connectivity maps without any surgical procedure.

Planning surgeries for conditions like epilepsy or movement disorders requires detailed knowledge of how specific brain regions are wired together. Today, mapping this connectivity relies on invasive intracranial recordings or indirect imaging proxies that do not fully capture electrical communication in the brain. Neither approach is patient-specific, scalable, or easily integrated into pre-operative clinical workflows.

Stanford researchers have addressed this gap with a computational framework that combines non-invasive structural brain imaging with electrophysiological principles to predict electrical connectivity across brain regions. The method also captures patterns in brain electrical activity, providing a richer picture of network architecture. Validated in human patients, the framework offers a practical, non-invasive path to personalized brain mapping that can directly inform treatment planning for a range of neurological conditions.

Stage of Development: Research - in vitro

Applications

- Pre-operative brain mapping software for epilepsy surgery and deep brain stimulation planning
- Personalized network modeling tool for neuromodulation therapy targeting
- Research platform for studying brain connectivity in neurological disorders

Advantages

- Non-invasive: generates patient-specific electrical connectivity maps without surgery
- Broader structural coverage than existing tools, spanning cortical and subcortical brain regions
- Links structural imaging directly to functional electrophysiology, improving neurosurgical targeting precision

Publications

- Shailja, S., Lyu, D., Chau Loo Kung, G., Mortazavi, L., Dai, E., Zeineh, M. M., et al. (2026). Diffusion MRI Tractography Predicts Electrophysiological Connectivity and Explains Spectral Signatures of Evoked Potentials in the Human Brain. bioRxiv.
- Shailja, S. and Lyu, Dian and Kung, Gustavo Chau Loo and Mortazavi, Leili and Dai, Erpeng and Zeineh, Michael M. and Buch, Vivek and Deisseroth, Karl and Parvizi, Josef and McNab, Jennifer A., Diffusion MRI Tractography Predicts Electrophysiological Connectivity and Explains Spectral Signatures of Evoked Potentials in the Human Brain. Available at SSRN: https://ssrn.com/abstract=7467302 or http://dx.doi.org/10.2139/ssrn.7467302. Under review at Neuron.

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