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(SD2020-421) Virtual Electrodes for Imaging of Cortex-Wide Brain Activity: Decoding of cortex-wide brain activity from local recordings of neural potentials

Tech ID: 32602 / UC Case 2020-421-1

BACKGROUND

As an important tool for electrophysiological recordings, neural electrodes implanted on the brain surface have been instrumental in basic neuroscience research to study large-scale neural dynamics in various cognitive processes, such as sensorimotor processing as well as learning and memory. In clinical settings, neural recordings have been adopted as a standard tool to monitor the brain activity in epilepsy patients before surgery for detection and localization of epileptogenic zones initiating seizures and functional cortical mapping. Neural activity recorded from the brain surface exhibits rich information content about the collective neural activities reflecting the cognitive states and brain functions. For the interpretation of surface potentials in terms of their neural correlates, most research has focused on local neural activities.

From basic neuroscience research to clinical treatments and neural engineering, electrocorticography (ECoG) has been widely used to record surface potentials to evaluate brain function and develop neuroprosthetic devices. However, the requirement of invasive surgeries for implanting ECoG arrays significantly limits the coverage of different cortical regions, preventing simultaneous recordings from spatially distributed cortical networks. However, this rich information content of surface potentials encoded for the large-scale cortical activity remains unexploited and little is known on how local surface potentials are correlated with the spontaneous neural activities of distributed large-scale cortical networks.

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have harnessed the rich information content of the local neural potentials recorded from brain surface to infer the cortex-wide brain activity.
By using electrocorticography signals recorded from a small region on the brain surface, the inventors are able to computationally construct brain potentials across whole brain.

APPLICATIONS

This invention may allow large area mapping of neural dysfunctions and neurological disorders without requiring extremely invasive neural surgeries. Virtual implants will use data from clinical ECoG recordings on brain surface that are routinely performed in patients before brain surgeries and compute the brain potentials across the whole cortex. Neural circuit dysfunctions are the cause of most neurological diseases, including epilepsy, Parkinson's disease, dystonia, depression and schizophrenia. For example, when applied to epilepsy, virtual implants will precisely determine the exact coordinates of the neuronal population generating seizures, unlike conventional local recordings resulting in low success rate (50%) for epilepsy surgeries. That will greatly impact the outcome and success rate of brain surgeries. Furthermore, brain-computer interfaces (BCI) have shown great promise for tetraplegia (paralysis), but penetrating microelectrodes cause extensive tissue damage limiting decoding ability and the lifetime of prosthetics less than a year. Virtual implants will enable less invasive long-term BCI by enabling decoding of spike activity from surface ECoG arrays. Virtual Implants will lead us to new findings on neural dynamics that is unattainable otherwise and facilitate development of targeted treatments for neurological disorders affecting one billion people worldwide.

ADVANTAGES

OTHER INFORMATION

KEYWORDS

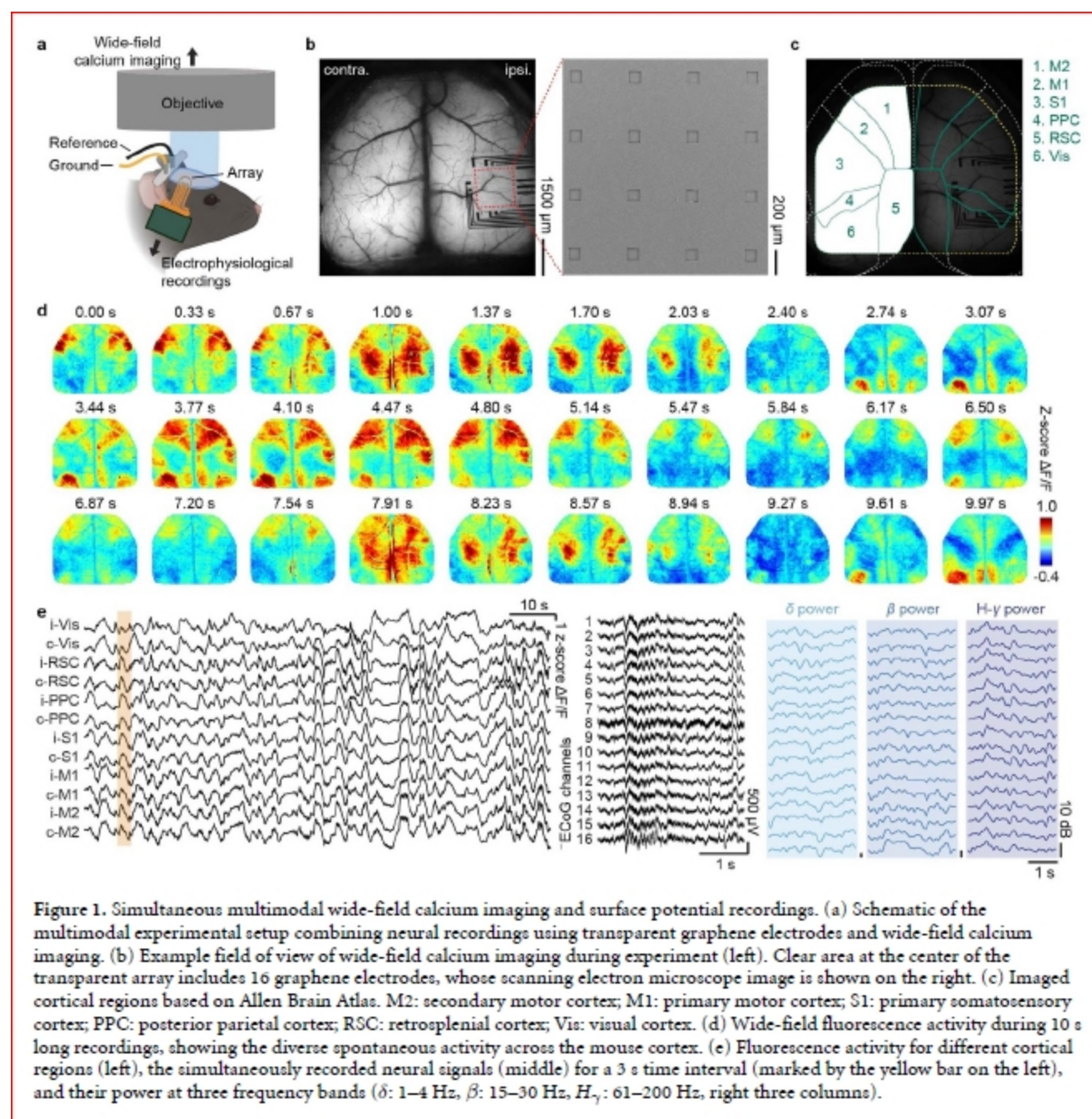neural decoding, large-scale brain activity, neural network, wide-field imaging, electrophysiology

CATEGORIZED AS

▶ **Imaging**
   ▶ Medical
▶ **Medical**
   ▶ Devices
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RELATED CASES

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Figure 1. Simultaneous multimodal wide-field calcium imaging and surface potential recordings. (a) Schematic of the multimodal experimental setup combining neural recordings using transparent graphene electrodes and wide-field calcium imaging. (b) Example field of view of wide-field calcium imaging during experiment (left). Clear area at the center of the transparent array includes 16 graphene electrodes, whose scanning electron microscope image is shown on the right. (c) Imaged cortical regions based on Allen Brain Atlas. M2: secondary motor cortex; M1: primary motor cortex; S1: primary somatosensory cortex; PPC: posterior parietal cortex; RSC: retrosplenial cortex; Vis: visual cortex. (d) Wide-field fluorescence activity during 10 s long recordings, showing the diverse spontaneous activity across the mouse cortex. (e) Fluorescence activity for different cortical regions (left), the simultaneously recorded neural signals (middle) for a 3 s time interval (marked by the yellow bar on the left), and their power at three frequency bands (δ: 1–4 Hz, β: 15–30 Hz, H_γ: 61–200 Hz, right three columns).

STATE OF DEVELOPMENT

Inventors have demonstrated the possibility of inferring cortex-wide activity from locally recorded ECoG signals. The research team implanted transparent graphene microelectrode arrays over the mouse somatosensory cortex and performed simultaneous ECoG recordings and wide-field calcium imaging of the dorsal cortex in awake, head-fixed mice. By developing a recurrent neural network model using locally recorded ECoG signals as inputs, we successfully demonstrated virtual imaging of the averaged spontaneous activity from multiple cortical areas and the cortex-wide activity with pixel-level spatial resolution.

Please see the citation below for the published paper, in which the researchers designed a neural network model to show that both the mean activity of different cortical regions and the pixel-level cortex-wide neural activity can be decoded using locally recorded surface potentials. These findings demonstrated that the locally recorded neural potentials indeed contain rich information for large-scale neural activity and the surface potential responses in different frequency bands and different recording channels provide distinct information about the large-scale neural activity.

INTELLECTUAL PROPERTY INFO

This patent-pending technology is available for commercial development.

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https://techtransfer.universityofcalifornia.edu/NCD/33396.html

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RELATED MATERIALS

▶ Liu X, Ren C, Huang Z, Wilson M, Kim JH, Lu Y, Ramezani M, Komiyama T, Kuzum D. Decoding of cortex-wide brain activity from local recordings of neural potentials. J Neural Eng. 2021 Nov 15;18(6). - 11/15/2021