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Нейронные сети и их интерактивная реконструкция (фМРТ – ЭЭГ исследования)

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Нейропластичность – основа приспособительного характера деятельности мозга, способности к креативной работе. Измеряемым параметром нейропластичности оказывается функциональная коннективность – сила «связности» различных структур мозга и внутри них статистическая зависимость между отдаленными нейрофизиологическими событиями. Пути интеграции в иерархически выстроенной системе реального мозга определяются эффективной коннективностью, корреляционной и векторной составляющими потока информации между областями мозга. Визуализация этого феномена в томографе обеспечивается технологией функциональной МРТ (фМРТ), физиологическим сигналом, которой выступает BOLD (blood oxygenation level dependent signal) – изменения интенсивности которого отражают степень насыщения крови кислородом конкретного церебрального образования. Появляется возможность визуализировать функции реального мозга. В томографе удается измерить электрическую составляющую мозговой деятельности – ЭЭГ. Созданная таким образом «бимодальная» нейроплатформа представляет собой уникальный инструмент, реализующий основные характеристики мозговой деятельности. BOLD и ЭЭГ, встроенные в контур обратной связи, создают новый класс нейротехнологий – интерактивную терапию (стимуляцию) мозга. Процесс нейропластичности становится доступным для когнитивной реконструкции нейросетей с лечебно-восстановительными и научно-исследовательскими целями. Доклад – попытка анализа возможностей вновь созданной платформы и результатов ее работы при исследовании мозга человека любой степени сложности. В нашем случае речь идет об острых нарушениях мозгового кровообращения (инсультах) и аффективных расстройствах широкого спектра. В докладе предлагается семантическое сравнение роли нейросетей, как элементов программного кода в «лексике» искусственного интеллекта, и реальных визуализированных «территорий» мозга, претерпевающих естественную и интерактивную реконструкцию в процессе креативной деятельности. Аберрации нейросетей – основа патологии психической и нервной деятельности – демонстрируются на примерах депрессивных расстройств и симптоматики инфарктов мозга (инсультов).

Литература

1. Shtark M.B. Neurofeedback: A scarce resource at the mental market, Neurofeedback the first fifty years, 2020, P 353 – 358. ACADEMIC PRESS

2. Melnikov M.Ye. The Current Evidence Levels for Biofeedback and Neurofeedback Interventions in Treating Depression: A Narrative Review, Neural Plasticity, 2021, P 31.

3. Mel'nikov M.Ye., Bezmaternykh D.D et al. Real-time fMRI neurofeedback compared to cognitive behavioral therapy in a pilot study for the treatment of mild and moderate depression, European Archives of Psychiatry and Clinical Neuroscience, 2022, https://doi.org/10.1007/s00406-022-01462-0.

4. Khruscheva N.A., Mel'nikov M.Ye. at al. Interactive Brain Stimulation Neurotherapy Based on BOLD Signal in Stroke Rehabilitation, NeuroRegulation, 2022, Vol. 9(3), P 147–163.

Neural networks and their interactive reconstruction (fMRI – EEG research)

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Neuroplasticity is the basis of the adaptive nature of brain activity, and of its ability for flexible, creative work. The numerical (measurable) characteristic of neuroplasticity is the so-called functional connectivity (FC) – the controlled strength of "connectivity" between and within different brain structures. FC is a statistical relationship between distant neurophysiological events.

Integration paths in a complex hierarchically built system of the real brain are determined by effective connectivity (EC). EC is a correlation and vector component of the information flow between brain regions. The visualization of this phenomenon in a tomograph is provided by the functional MRI (fMRI) technology based on BOLD (blood oxygenation level dependent) physiological signal. The changes in BOLD intensity reflect the degree of blood oxygen saturation at a particular area of the working brain depending on its current activity. Therefore, it becomes possible to visualize the functions of a real brain. In addition to tracking the BOLD phenomenon in the tomograph it is also possible to measure the electrical component of brain activity through electroencephalography (EEG). The "bimodal" neuroplatform created in this way represents a unique tool that implements the main characteristics of brain activity. BOLD and EEG signals built into the feedback loop create a new class of neurotechnology, that is interactive therapy (stimulation) of certain brain formations. The process of neuroplasticity becomes available for the cognitive reconstruction of neural networks with therapeutic, restorative, and research aims. This report is an attempt to analyze the possibilities of the newly created "trimodal platform" (which is an independent interest) and the results of its work in the study of the human brain of any complexity degree. In our case we are talking about acute cerebrovascular accidents (strokes) and affective disorders of a wide spectrum. The report provides a semantic comparison of the role of neural networks as elements of the software, in terms of artificial intelligence vocabulary, and real visualized "territories" of the brain undergoing natural and introduced interactive reconstruction during creative activity. Aberrations of neural networks, which are the basis of the pathology of mental and nervous activity, are demonstrated on the examples of depressive disorders and symptoms of cerebral infarction (stroke).

References

1. Shtark M.B. Neurofeedback: A scarce resource at the mental market, Neurofeedback the first fifty years, 2020, P 353 – 358. ACADEMIC PRESS

2. Melnikov M.Ye. The Current Evidence Levels for Biofeedback and Neurofeedback Interventions in Treating Depression: A Narrative Review, Neural Plasticity, 2021, P 31.

3. Mel'nikov M.Ye., Bezmaternykh D.D et al. Real-time fMRI neurofeedback compared to cognitive behavioral therapy in a pilot study for the treatment of mild and moderate depression, European Archives of Psychiatry and Clinical Neuroscience, 2022, https://doi.org/10.1007/s00406-022-01462-0.

4. Khruscheva N.A., Mel'nikov M.Ye. at al. Interactive Brain Stimulation Neurotherapy Based on BOLD Signal in Stroke Rehabilitation, NeuroRegulation, 2022, Vol. 9(3), P 147–163.

神經網絡及其交互重建（fMRI – EEG 研究）

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神經可塑性是大腦活動的適應性及其靈活、創造性工作能力的基礎。
神經可塑性的數字（可測量）特徵是所謂的功能連接（FC）——
不同大腦結構之間和內部"連接"的受控強度。 FC
是遠距離神經生理事件之間的統計關係。
真實大腦的複雜分層構建系統中的集成路徑由有效連接（EC）決定。 EC
是大腦區域之間信息流的相關和矢量分量。 這種現像在斷層掃描儀中的可視化是由基於
BOLD（血氧水平依賴）生理信號的功能性 MRI（fMRI）技術提供的。 BOLD
強度的變化反映了工作大腦特定區域的血氧飽和度，具體取決於其當前活動。
因此，可以可視化真實大腦的功能。 除了在斷層掃描儀中跟踪 BOLD
現像外，還可以通過腦電圖（EEG）測量大腦活動的電成分。
以這種方式創建的"雙峰"神經平台代表了一種實現大腦活動主要特徵的獨特工具。
反饋迴路中內置的 BOLD 和 EEG
信號創造了一類新的神經技術，即某些大腦結構的互動療法（刺激）。

神經可塑性的過程可用於具有治療、恢復和研究目的的神經網絡的認知重建。
本報告試圖分析新創建的“三模態平台”（這是一個獨立的興趣）的可能性及其在任何復雜程度的人腦研究中的工作結果。
在我們的案例中，我們談論的是急性腦血管意外（中風）和廣泛的情感障礙。
該報告提供了神經網絡作為軟件元素的作用的語義比較，在人工智能詞彙方面，以及在創造性活動期間經歷自然和引入交互重建的大腦的真實可視化“區域”。
神經網絡的畸變是精神和神經活動病理學的基礎，在抑鬱症和腦梗塞（中風）症狀的例子中得到了證明。

文學

1. Shtark M.B. Neurofeedback: A scarce resource at the mental market, Neurofeedback the first fifty years, 2020, P 353 – 358. ACADEMIC PRESS

2. Melnikov M.Ye. The Current Evidence Levels for Biofeedback and Neurofeedback Interventions in Treating Depression: A Narrative Review, Neural Plasticity, 2021, P 31.

3. Mel’nikov M.Ye., Bezmaternykh D.D et al. Real-time fMRI neurofeedback compared to cognitive behavioral therapy in a pilot study for the treatment of mild and moderate depression, European Archives of Psychiatry and Clinical Neuroscience, 2022, https://doi.org/10.1007/s00406-022-01462-0.

4. Khruscheva N.A., Mel’nikov M.Ye. at al. Interactive Brain Stimulation Neurotherapy Based on BOLD Signal in Stroke Rehabilitation, NeuroRegulation, 2022, Vol. 9(3), P 147–163.

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Systems Theory, Algebraic Biology, Artificial Intelligence: Mathematical foundations and applications

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It remains challenge in bioinformatics to uncover underlying relationships between biological entities such as protein-protein interaction (PPI) or diseases similarity prediction tasks. Traditional methods use handcraft features to calculate the distance or similarity between different entities, which can be largely biased and may failed to capture the non-linear dependency.

However, the emergence of deep learning frameworks has allowed for the development of sophisticated models to predict complex biological relationships. We develope DeepTrio, a sequence-based model using mask multiple parallel convolutional neural network, for the task of PPI prediction. DeepTrio is significantly better than other state-of-the-art (SOTA) methods in terms of various metrics and can be extended to provide additional insights into the contribution of each input neuron to the prediction results. On the issue of disease similarity prediction, we present CoGO, a contrastive learning framework based on gene network and ontology structure, which incorporates the gene interaction network and gene ontology (GO) domain knowledge using graph deep learning models. We propose an inter-view graph neural network to encode the network structure information and a cross-view contrastive loss to mix up the representations learned from the gene network and GO graph. CoGO outperforms the SOTA on different evaluation metrics and extracts credible similar diseases which are significantly comparable with other disease similarity studies.

The above deep learning frameworks demonstrate the potential of deep learning in accurately predicting complex biological processes and provide insight into the development of future models. The use of deep learning frameworks has the potential to greatly advance our understanding of protein-protein interactions and disease relationships.

References

1. Hu Xiaotian et al. DeepTrio: a ternary prediction system for protein–protein interaction using mask multiple parallel convolutional neural networks. *Bioinformatics* 38.3 (2022): 694-702.