論文 / 著書情報
Article / Book Information

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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	Rakhimberdina Zarina		審査員主査： Chief Examiner	Murata Tsuyoshi	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Autism spectrum disorder (ASD) refers to a neurodevelopmental disorder that impacts individuals' communication, learning ability, behavior, and social interaction. The term "spectrum" refers to a range of levels of functional impairment that can occur in people with ASD. Both children and adults can be affected by a disease across all socioeconomic and ethnic groups.

Over the past decade, machine learning methods have been used for automated medical detection of neurodevelopmental disorders, such as autism spectrum disorder. Automated medical detection aims to overcome the limitations of traditional observational methods, which are based on clinicians' subjective observations and are often times costly and time-consuming.

The application of machine learning methods for brain imaging analysis is targeted to develop new automated ASD detection methods. Among different brain functional activity measuring techniques, functional magnetic resonance imaging (fMRI) is widely researched nowadays. Compared to other imaging methods, fMRI is considered to be an advanced tool of clinical diagnosis due to the high spatial resolution of imaging data. With the rapid development of brain fMRI technology, more research is focused on using it to uncover the intrinsic biological markers of ASD. This research aimed to improve classification for ASD, both in terms of the deep neural network framework and the choice of fMRI imaging data. Specifically, the author focused on two fMRI acquisition paradigms: resting-state and visual task-based approaches.

The resting state or task-free fMRI data is a promising tool to investigate functional alterations in the human brain in a relaxed state when a human subject is not engaged in any particular task during a scanning session. Despite the absence of tasks or stimuli in a resting state, the human brain is known to exhibit low-frequency fluctuations in blood oxygen level-dependent (BOLD) signals. Studying the human brain at rest became popular over the past decades and accounts for a large percentage of neuroimaging research. However, the resting-state paradigm has a number of limitations that restrict the amount of knowledge that we can extract from it.

The primary goal of task-based functional MRI is mapping the response of the brain to perceptual, motor, or cognitive stimulation. By measuring how BOLD signal changes between task-stimulated states, task-based fMRI is used broadly to identify brain regions that are functionally involved in specific tasks. Among all sensory perceptions, vision is the human's dominant sense, which also affects cognition. Consequently, this study employed visual task-based fMRI for ASD classification, as it captures the distinctive ways in which individuals with ASD visually perceive and process their surroundings.

Resting-state fMRI and task-based fMRI are the two modalities that can be used to identify individuals with ASD. Given the lack of research analyzing the efficiency and interpretability of the resting-state and task-based fMRI data, this study proposes a deep neural network framework for classifying Autism Spectrum Disorder using both resting-state and task-based fMRI data. First, the author proposed an improved ASD prediction framework based on a graph neural network and analyzed the contribution of the graph structure. The graph-based architecture is capable of integrating different types of input data: brain imaging data and non-imaging phenotypic data. While brain imaging signals are used as features of the individual nodes in the graph, the connection between nodes is reinforced by additional non-imaging information relevant in predicting ASD disorder. The proposed model is a competitive alternative to the current best deep learning methods for ASD classification in the resting-state paradigm. The performance analysis of deep learning methods using resting-state brain fMRI data suggests that graph neural networks can effectively represent the group of healthy individuals and patients. This is supported by high accuracy and AUC results of the proposed framework in predicting ASD. Next, the author extended the scope of the proposed graph neural network to task-based fMRI applications. Studying visual task-based fMRI unlocks valuable insights into the neural responses of individuals with ASD towards visual stimuli. The results from this extension demonstrated the improvement in classification accuracy and AUC scores attributable to the incorporation of the graph-based neural network.

Lastly, considering the unique properties of task-fMRI data, the author focused on diverse neural network architectures tailored for such data. The analysis of task-based fMRI data, in general, can be seen as advantageous compared to the analysis of resting-state data in two ways. First, the task-based fMRI is less noisy because of smaller regions of interest and precise time frames corresponding to stimuli presentation. Second, the presence of the target stimuli allows deep learning methods to learn high quality representations from fMRI through the process of encoding and decoding. The author demonstrated this both on visual stimuli reconstruction and stimuli classification. Furthermore, this study introduced a novel multi-modal framework aimed at integrating visual stimuli information. This approach holds the potential to contribute to the detection of ASD.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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