Model design method study of brain functional complex networks based on FMRI

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ABSTRACT

Recent developments in the quantitative analysis of brain functional complex networks, based largely on graph theory, have been rapidly translated to studies of modeling. The brain functional complex network models have features of small-world topology --- such as short average path length, high clustering coefficient and modularity. In this article, we discuss the investigate methods about the modeling to brain functional network in diverse process and provide an accessible introduction to the basic principles of modeling. We also highlight some of the technical challenges and key questions to be addressed by future developments in this rapidly moving field.

Introduction

The study on brain science, both on structural and functional systems, is always a challenge to human science and nature researches, but it is a huge innovation and significance to our life and has the directly effect to neuroscience, medical science, biological science and pathological science with the comprehensive understanding the brain functional network. The study on brain structural and functional networks, also the characteristic of the network systems, has great effect on human cognitive and behaviour, meanwhile, it provides a clinical direction and reference on the remedy in the physical disease and mental illness.

Because of the particularity of the research object, we can not thoroughly obtain the result depending on the experiment. we can select the appropriate design and algorithm to model and emulate the brain functional network. By the modeling and emulations we can have a better knowledge about the brain characters, also it can give a help to analyze the brain structure and provide a feedback or reference to complex network study. Since the mid 1990s, home and abroad developments in the quantitative analysis of brain structural and functional complex networks, based on the complex network theory, have provided many models and algorithms to simulate the brain functional network. In many countries, such as America, Japan, the brain complex network studies have made much progress on neuroinformatics, biophysics, physiology and clinical medicine, also have drawn many important conclusions on brain network with the complex network modelings and algorithms, meanwhile, the outcomes have been verified corresponding with the real-life network. In China, some research centres in colleges and universities have got development on cognitive, behaviour and intelligence even on the clinical practice.

Methods

In the process of our study, one effectual approach to gaining our attempted results or finding significant outcomes is to model. In general, there are two methods usually in our study. The difference is that the modeling is based on the known or unknown knowledges.

Modeling by the unknown knowledges has to analyze the reality examples, then dissect the physical model and analyze itself and its characters by the data, at last corroborate the model and characters by the clinical data. Meanwhile the results are applied into the clinical applications.

Modeling by the known knowledges directly begins with the known geometrical model, then deduces the structures and characters and analyzes the characteristic of the model based on the deduction, at last corroborate the results by the analysis. Meanwhile the results are applied into the clinical applications, also as a method of the verifying.

In the whole modeling, we can select the public data from the Internet or the professional medical database that provided by the research center or the hospital as the corroboration. The clinical data major use fMRI data.

Results

The studies of brain functional networks in the quantitative are based on graph theory, combing the mathematics, computer, statistics, control science with the complex networks theory. To handle the data by the assistant tools of fMRI, EEG MEG MEA and apply a number of models and algorithms to set up the brain networks from anatomical to functional, at last to the utility networks. The functional networks studies on the fMRI, EEG MEG signals and gains the further outcomes.

The research centers home and abroad have put several achievements into the clinical and by the researches of the brain functional networks both the animals and people applied the results to the clinical data analysis, such as the task test with different age groups and comparing the healthy people and patients, Alzheimer's disease and schizophrenia.

The research and the tendency to the brain complex networks put emphasis on the comprehensive exploration on the

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level of molecule, cell and so on, and focus on the modeling and optimization algorithms, meanwhile get help from the brain imaging technologies such as the PET, fMRI to make research about the time and spatial relations of the brain regions. The EEG, MEG and fMRI experimental data play an important role in the test and verify or the confirmation of the brain anatomical networks and brain functional networks corresponding to the reality networks. In the practice the results are more applied to the clinical analysis and remedy, such as the cognitive behaviour, genetic gene, intelligence, psychology and mental disease, further on the research to the relations among the cognitive and behaviour networks and brain functional networks.

Conclusion

In the modeling we begin with the reality complex networks and brain anatomical networks, abstract the definition of the node appropriate and set up the appropriate connectivity mechanism of the edge, next propose the brain functional networks modeling methods based on network modeling algorithm considering the reality and graph theory and information theory, then put forward the new algorithm and compute theory about the important topology character of the complex networks, meanwhile analyze and verify the characters by both theoretical predictions and numerical simulations. The modeling is one of important methods to research and analyze the brain functional complex networks, meanwhile, using this idea one can model other real-life complex networks.

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