Modeling on brain functional memory complex networks from module view

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ABSTRACT

Module is an important structure in successfully implementing the complex software system in computer software engineering. Borrowing the module thought in brain functional memory network modeling we put forward the brain memory complex network model from neuron and cortex level. The results of bi-modular network model in brain memory show that it is reasonable to explain the structure and function of the brain memory. We also highlight some of the technical challenges and key questions to be addressed by future developments in this rapidly moving field.

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Introduction

Modeling is an effective method to identify and comprehend the abstract and complex phenomena. The modeling always has the double characters with the prototype, that is, the positive and negative, the right and wrong. But it is a feasible way to recognize the prototype, whether quickly or slowly. Perhaps the model is not corresponding with the prototype thoroughly, we believe that the modeling will provide step towards the truth of the prototype step by step.

Complex network is becoming increasingly popular in our study of the real-life and science research. From the complex network view, many complex difficulties became easier based on the computer graph theory and control science. Moreover, the application on complex networks made itself stronger theory basis.

Brain science is one of the challenges of human being. In the past years, many scientists from different areas contributed to the study of the brain science and gained many useful results for the subsequent study. The researches on brain mainly focused on medical science, psychology, neuroinformatics and so on. Recently, the brain science as an independent branch put their emphasis on the neruoinformatics, especially with the development of neuron image technology and neuron information process. From the clinical anatomy we got the anatomical structure of brain and set up the physical network of the brain. The functional network of the brain is becoming a thorny difficulty that caused the study upsurge.

Brain functional networks are the functional networks that composed of many functional cortexes that interacted and coordinated. Any functional network was not a single neuron or a cortex but the neuron clusters or groups. Brain functional networks focused on not only the structure relations among neurons or clusters, but the dynamic characters of the networks after their construction and the application on the nervous and spirit illness.

Memory is one of the functions of the brain. From the psychology, memory is looked on as an psychological action that presented cognizable behaviors and actions. From the brain science, the memory is an action or behavior of the brain actions. From the neuroinformatics, the memory is the actions of the neurons or clusters. Of course, from above views, we got many useful outcomes, including the memory cortexes, memory networks and memory characters and so on. Especially the memory small-world character made the brain functional memory network on an infusive platform.

However, no study put the memory on the computer system up to now. The computer is so similar with the brain, they all memory and quickly recall. Are there any similarities between them? What is it if we make memory study from computer view?

Based on above, we have done some illustrations in the paper "brain functional memory complex network view as computer system" that submitted to the 4th international conference on modeling, identification and control from the view of the functional network. In this paper, we will continue to discuss the brain functional memory network but from the structure view.

Methods

Module in software engineering

Module is an important concept in software engineering. In a big and complex software, the analysis and design of the software structure is vital for the software implementing efficiently. There are many important concepts to help close to the implementation successfully including the abstract, the precision progressively, the information hiding, the localization and so on. All the concepts implies an idea, that is, module. Further is the module independent or modularization.

Modularization is to divide the whole huge and complex software structure into some different levels modules. Every module that accomplished an independent function can be named and accessed independently, we can integrate different levels modules as a whole software. With the independent module, we can organize any levels and functions software structure easily and simply to fit for the requirements of the users.

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In the software engineering, the module can be small or big, simple or complex, single or integrated by the users' design and function requirement so long as the module can accomplish a relative independent and specific sub-function.

Brain anatomy structure

The human brain is a complex neural network composed of 14 billions neurons from the clinical anatomy. Neuron is the basic unit of the brain anatomy structure and executes the independent or the specific function of the human brain actions. But it is impossible to model every neuron from the structural level whether in the number or in the volume. Many studies divided the whole brain cortex into several regions by different standards, for example, the AAL. So we can also make study on brain functional structure from the cortex level. In general, the brain cortex can be divided into 90 or 116 cortexes in many researches.

Module in brain structure

Memory in brain functional network involves many cortexes and lots of neurons. If we model the memory structure only from the anatomical structure, it is too tremendous and complex to simplify and clarify the memory network, so we get help from the module thought to brain functional memory network.

We can model the memory function from two levels, one is neuron, the other is cortex. In the neuron level, we look on the neuron as the module since they all can express the independent or specific function or information process relatively. We string the neurons who take part in the memory function to a line, and then unites other lines to the memory network, just like the software program language sentences that frame the software by different levels modules. Similarly, we can have a cortex as a module and then shape the memory network by the cortex connection position.(neuron to cortex, three model.)

Results

Using the module concept, the brain functional memory complex network can be constructed from different levels. If we take a neuron as a module, the brain functional memory network will be a huge network just like a kind of global and national software. The network can be organized as a directory tree, or an inverted tree, or a hierarchical tree. The neuron is the node of the tree and the function or the position is the edge that connects the node.

If we take a cortex as a module, it also can be organized as the above trees but the scale is much smaller than the neuron module tree.

In order to close to the memory anatomical structure, we can constructed the memory network based on the neuron unit union the cortex unit, that is, the module can be defined in two levels, the neuron and the cortex level in a network. We called the network as bi-modular brain functional memory network. Previous studies in brain functional network have gained the small-world character outcome, of course, including the memory function. We take the module into the brain functional memory network and also can get the same conclusion with small-world character.

Based on the above module construction, we can look on the neuron module and cortex module as the specific kind of examples of bi-modular module. The detailed process and the small-world character outcome can be referred in our two papers, one is "A novel model of memory network and retrieval algorithm" that has submitted to Neurocomputing journal, the other is "A deterministic small-world model and algorithm of

memory network" that has been accepted by Microelectronics and Computer journal.

Discussion

The excellent software can manage and operate complex users and enterprises requirement. The software engineering is just the aim to satisfy the requirements and the module is one of the excellent ways to solve the complex requirements. Similarly, this solution fits for the complex brain functional memory network difficulty.

The module is an abstract concept and it can be restricted or expanded by the specific surrounding. Benefitting from the module characters, the software can be got to satisfy the requirement of the users, also, we take the neuron and the cortex as the module to set up the network of the brain memory function. The bi-modular model can be got and small-world character of the memory network can be referred by the model.

From the functional view, not only from anatomical view, we look on the neuron as the inner module of the brain, and then look on the cortex as the outer module of the brain to construct the bi-modular memory network. With the responding algorithm, the bi-modular network is reasonable with the anatomy and function of the memory.

Perhaps there are some differences in software and brain in the module, what we have done is not so much fitting for the detailed processing, but the thought and method can bring us to a new way to understand memory function. In the subsequent studies, we will continue to pay close attention to the brain functional memory network in the depth of module and width of memory characters, especially the algorithm in memory information process.

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