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Model for Papez Circuit Using Neural Network

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Abstract: **In this paper, we use the modular neural network and recurrent neural network structure to implement the artificial brain information processing. We also select related adaptive learning methods to learn the entirely new input in the existed neural network. With this, a part of information process in brain is implemented as an autonomous and adaptive model by neural network and further more, the entire model for information process in brain can be introduced.**

I. INTRODUCTION

From the 1870, the function of brain was introduced to people by experiments of Germany. The research to make a model for brain has been proceeded from the early 1940 with learning theory and neural network theory. Actually, the brain model is used for expert system in the point of engineering. This makes computer substitute man by doing the several professional tasks. Nevertheless, the expert system is insufficient in the part of inference occurred in the cerebral cortex, thalamus and hippocampus. Therefore, the needs about an artificial model for behavior function implementation based on the information process of biological human brain. As the engineering has been growing the more intelligence for the system is required. One general controller should treat many control inputs and operate various systems. The existed soft computing method can compute many inputs and operate various systems but there must be generous hardware architecture and fast elements. This can cause a growth of price for intelligent controller and make control task be more difficult. The research for artificial brain information processing model is strongly recommended. The brain model can treat various inputs and control system with intelligent method as like that human can feel, think and act.

II. CEREBRAL CORTEX

By the neuro-science, human being uses a part of brain to obtain the sensory information. After analysis and decision of that information human being acts. It is a general process for human to feel, think and speech. As known by the neuro-physiology, the above process is occurred in the cerebral cortex. At the area, called by primary sensory association, which is located in a thalamus of the cerebrum, the sensory information is accepted. The accepted information is transferred to the multiple sensory association area and compared with the past memory. After being compared with the memory, the sensory information is recognized and then, the recognized information is transferred to the primary motor area. In the primary motor area, the arrived information causes the motor of the organism such as leg, eye, arms and so on.

As mentioned above, the information process in the brain is represented with three parts. First, the sensory information is proceeded in the primary sensory association area. In this area, the information is recognized and the recognition about the sensory information is arisen. Secondly, at the multiple sensory association area, the various sensory information that is recognized in the front part, primary sensory association area at first, is treated. The treatment includes comparison with the memory and classification of the information with several pre-defined categories. Especially, if the information can't be found at any memory, the information is handled to the specific area, known as Papez circuit. Papez circuit takes a part of creating new category in the memory to use it in the next time. Once the information was treated in Papez circuit, the information is no more unknown or unidentified. Namely, the unknown information can't be recognized in the multiple sensory association area at first, therefore the information is transferred to Papez circuit. In Papez circuit, the process for the unknown information is performed. The process includes sensory recognition memory update at the primary sensory association area and definition of the information in the point of multiple sensory association at the multiple sensory association area.

This paper shows the artificial model for Papez circuit can be designed by soft computing method. In the proposed model, the adaptive learning method of neural network is introduced and the function of the proposed network is similar with it of brain. The simulation is proceeded to show reaction of the network against the known sensory information and unknown sensory information, respectively.

Biologically, the structure of cerebral cortex is shown in figure 1 [1].

In figure 1, we define modular neural network as sensory cortex (visual cortex, auditory cortex), sensory association area (visual association area, auditory association area) and motor cortex (motor association area). Each modular neural network learns the visual and auditory inputs. In the output layer of modular neural network, the result for motor input is obtained.

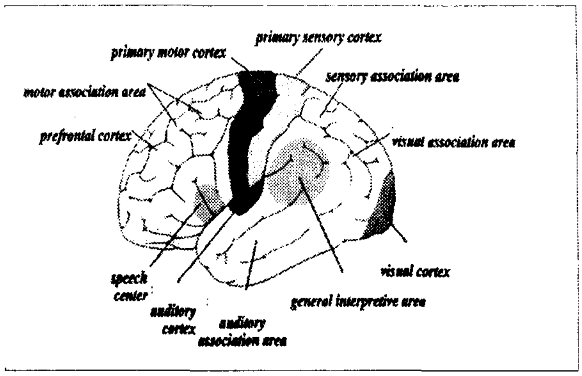

Fig. 1. The Structure of Cerebral Cortex

A. Cerebral Cortex versus Neural Network

The information process in the cerebral is separated 3 functional areas such as sensory information acquirement, behavior inference and decision based on association and motor command.

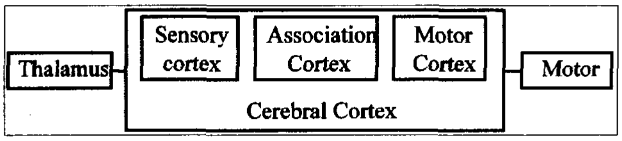

Fig. 2. Functional Structure of Cerebral Cortex

As we know from the figure 2, thalamus is connected to sensory organisms (eye, ear, nose, tongue and so on) and proceeds transfer function from sensory organisms to cerebral cortex. On the other hand, motor is connected to several motor organisms such as legs, arms, neck and so on through motor neurons. Motor area transfers the information about the motor organisms to cerebral cortex and also takes the behavior command from cerebral cortex.

To make a model for them, we use the neural network shaped like module. Each module-type neural network learns the function of thalamus and motor area, respectively. With these neural networks, we make artificial models for cerebral cortex.

In the point of cerebral cortex, it acquires information about the sensory and motor organisms from thalamus and motor. Based on the received information, sensory association area in the cerebral cortex performs inference process after analyzing information from sensory and motor area using linguistic expression. The flow of information process in cerebral cortex likes above. On the middle of flow, if there is a new unknown sensory input, Papez circuit in cerebral cortex can learn it and make cerebral cortex recognize it in the next time. Therefore, we make an engineering model of Papez circuit by introducing information process method and learning method for it.

B. Information Process in Cerebral Cortex

An information process in cerebral cortex is shown as figure 3.

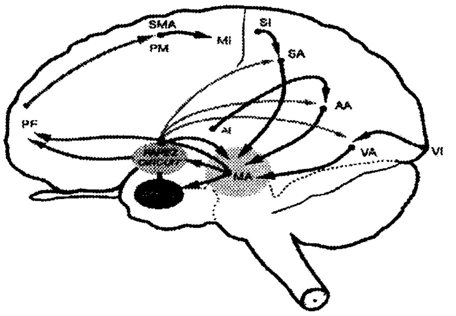

Fig. 3. The Flows of Cerebral Cortex

Each area is defined as follows.

The sensory input is analyzed in the primary sensory area (V1 : primary visual area, A1 : primary auditory area, S1 : primary somesthetic area) at first level. At second level, the analyzed input in the primary sensory area is transferred to sensory association area (VA : visual association area, AA : auditory association area, SA : somesthetic association area). In the sensory association area the information is compared with the past memory and finally decided. After decided in the sensory association area, the sensory is recognized in the multisensory association area (MA). At this point, the sensory input is entirely recognized as a material or sensory source. The recognized information is added by prediction and decision about behavior in the prefrontal cortex (PF). After that, the plan for action is constructed in the supplementary motor area (SMA) and premotor area (PM). Finally, the constructed plan is transferred to reaction for the sensory input in the primary motor area (M1). If the new information arrived at MA does not be recognized by the past memory, it goes to new circuit for memory through Papez circuit in the limbic system. Especially, the stimulation that was important before experience goes to amygdaloid nuclear complex (AMYG) and combines the emotion information. After that, the stimulation comes true as a behavior reaction. Among the cycle for new memory, the important stimulation is add by the emotion in Papez circuit and memorized strongly in the memory. The information passing the memory circuit, Papez circuit, is memorized in the association area.

C. Artificial Model for Papez Circuit

The flow in Papez circuit is explained in figure 4.

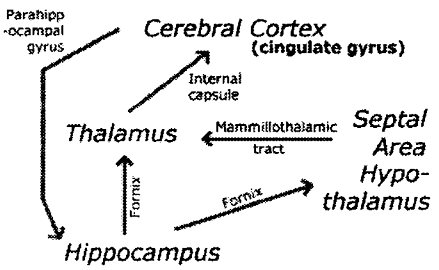

Fig. 4. Information Flow in Papez Circuit

The new stimulation not being in the past memory area at the multiple sensory association area passes through memory circuit, called as Papez circuit, for new stimulation. The information passing through Papez circuit is memorized in the memory circuit and the memorized information is used for process of the new sensory information.

As like above explained, a new and unidentified information can be recognized in the cerebral cortex using Papez circuit. This also makes it possible to learn strange sensory information adaptively.

III. ARTIFICIAL MODEL FOR PAPEZ CIRCUIT

We propose the artificial model for Papez circuit as figure 5.

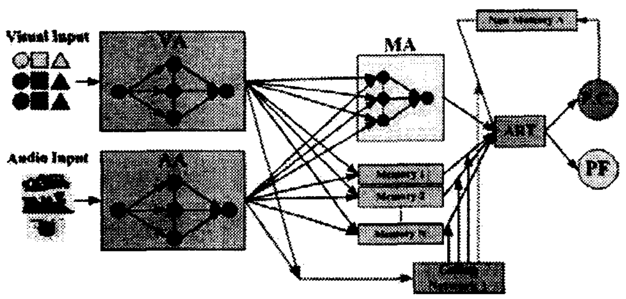

Fig. 5. Artificial Model for Papez Circuit

As like figure 5, we design the functions of brain using module typed neural network and recurrent circuit for information process and memorizing method. The functions in the primary and supplementary sensory association area are designed by 'VA' and 'AA'. The function of multiple sensory association is also designed by 'MA' using multi-layered neural network.

In this paper, we make a model for behavior decision process about unknown sensory input using Adaptive Resonance Theory (ART). By ART, the information input which is decided by the stored information in the memory for the past known inputs is transferred to the area of behavior decision. On the other hand, the information input which is not decided in the memory is designed to be transferred to Papez circuit for new memory.

Consequently, to transfer the new information input toward new memory we separate the information process with the two processes such as recognition of input sensory information and learning process for unknown input information by making a model for Papez circuit that is known as memory making area in the brain.

IV. CONCLUTION

The model for information process in human brain is proposed in this paper. For this model, the learning method with neural network is analyzed as the information process. Especially, Papez circuit known as the organism that makes it possible to memorize new sensory information in the memory is designed with the neural network and ART model. This model may contribute to make whole artificial model of brain information process.

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