The architecture of device that manipulates image in which each set of activities is ignited through transference of impulses

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Abstract The nerve mechanisms of vision are represented from a viewpoint of engineering in this paper. Those are the separation of dynamic image by retina, the unification of activities by thalamus and the associative activities by neocortex. The activities of vision are associated with the real world, i.e. the next activity of vision depends on the results of former activity. Such operations of the human vision are realized by means of digital technologies together with the design concept of "open system via the real world" in which a package of impulsive activities is operated intermittently. Here, the concept of "transmission of activated portions" was used as a tool to describe a fusion of plural activities for the visual perception.
Key words Vision, Endless world modeling, Brain mechanism, Neuroanatomy, Retina, Thalamus, Neocortex

1. Introduction

The lack of today's technology is the mechanism that communicates with the real world in which unpredictable events happen. The device of vision that is able to quickly understand events in the real world is desired in many fields i.e. unmanned vehicle [1].

Since 1985, "Behavior-based artificial intelligence" has emerged in a field of robotics [2]. The behavior-based intelligence is opposed to the main stream of knowledge-based intelligence. For, a behavior changes the situation, but the information itself does not change.

The traditional design concept of computer vision is objective, and it is characterized as "world modeling based on the results". Although the digital technology deals with "static state", every operation is carried out by an activity at the transition [3]. The intermittent impulsive reaction is able to associate with the real world, because intermittent reaction is able to change the behavior and it is able to adapt to the changing environment.

We focused our attention on ad hoc reactions in the real world, i.e. the present situation causes the next action. As tools for ad hoc reactions, many modules of reactions are necessary. There are plural functional areas in a brain as measured by PET (Positron Emission Tomography) [4].

The neuroanatomy has revealed nerve structures of a brain [5]. But depending on its individual experiences, the accepted theory of the brain mechanism does not exist yet.

The concept of activity that deals with intermittent activities is a powerful tool to investigate the behavior producing mechanism [6]. The transmission of activated portions is able to add structures to an already existing working system. These functions of brain can be materialized by means of digital technologies [7]. The category of activity is also a powerful tool to adapt traditional technologies to the engineering of mind i.e. one agent corresponds to a file, and a network of agents corresponds to layered structure of distributed file system

of a digital computer.

This paper presents the impulse transfer mechanism on human vision based on the nerve structure in a brain. These mechanisms can be used as reference models for a communicating real-time decision-making machine.

2. The retina that associates with the real world

2.1 Functional localization of retina

The sensing is an important part of perception. The image in monocular zone does not cover with the other monocular zone in human vision as shown in Fig.1. [8].

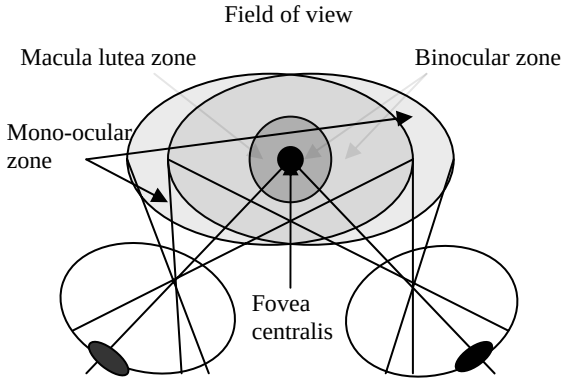

Fig.1 The functional localization of retina in which there are field of view and focal view: The structure is able to control of view point.

Each area of retina is connected to a specialized portion of neocortex. By making use of these plural routes in a brain, processing of vision is carried out one by one.

The eye movement is used as scanning of the view. The binocular alignment of eye axis can be carried out via the focused attention. If the excitations on two layers coincide, the activations will be emphasized, and the depth between the face and a view point is measured at the state of adjusted eye axis.

2.2 Small involuntary eye movement

The size of "receptive field" of a ganglion cell that is situated in the central area of the retina is much smaller than those of situated at the periphery [9].

A reason of small involuntary eye movements at a fixed view is considered as follows. The receptive fields in the fovea are moved, but the receptive fields at the periphery are not moved. Different reactions provide information. The periphery area can be used for positioning. The central area can be used for analysis of an object.

2.3 Separation of the dynamic images by retina

Bipolar cells and horizontal cells in the retina respond with membrane potential and these cells do not generate impulses. There are two kinds of pathways from cone to bipolar cell. One is depolarizing, the other is hyperpolarizing. These pathways make chemical synapse with ganglion cells. The synapse from bipolar cell to ganglion cell is excitatory.

Here, the amacrine cell generates the impulse that modifies the visual signal of membrane potential on bipolar cell [9]. By way of bipolar cell with delayed interactions via amacrine cell, visual data are transmitted from photoreceptors to ganglion cells.

The modification of amacrine cell on two kinds of routes is illustrated in Fig. 2.

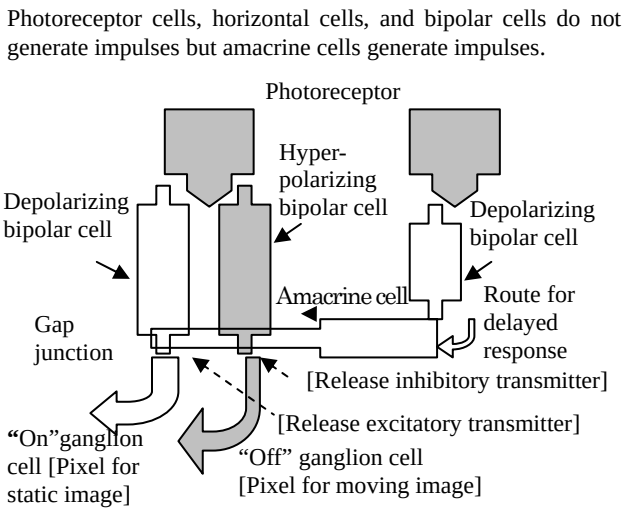

Fig.2 The mechanism that extracts moving image in a retina, i.e. the visual signal of potential on bipolar cell is modified by the neurotransmitter via amacrine route.

According to physiological, biochemical, and anatomical criteria, there are 10 to 20 types of amacrine

cell [9] in a retina. This structure has the meaning that was formed during evolutions. The authors propose the explanation that many kinds of amacrine cell operate as many kinds of delay elements to separate dynamic images. The operation is illustrated in Fig.3.

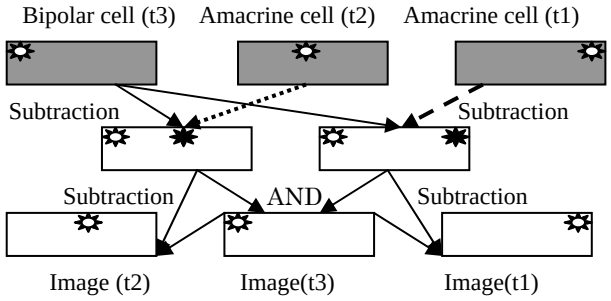

Fig.3 A model on separation of dynamic images: the functions of many kinds of amacrine cell cells operate as many kinds of delay elements for the separations.

3. Organization of nerve activities

3.1 Representation of action

The decision-making is an important part of intelligence. It is carried out by neuron. The impulse in a nerve network is transmitted along one direction by an after-effect of neuron. Every control is one direction. Such impulsive reaction has been treated by means of dynamic MOS technologies. A functional model on a neuron as a programmable logic device (PLD) that transfers a set of impulsive activities is shown in Fig.4. The movement of data is controlled by signal on the gate.

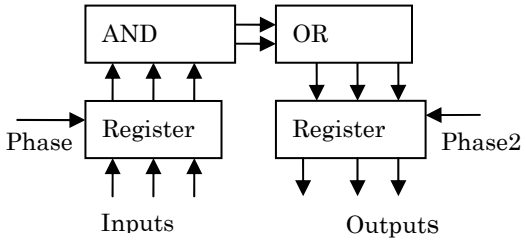

Fig.4 A model of a neuron as a PLD: An impulsive reaction represents a set of activities in a brain.

The register-to-register transfer structure is used as an element in a finite-state machine. The circuit in which a part of outputs is used as a part of input for the next step is shown in Fig.5.

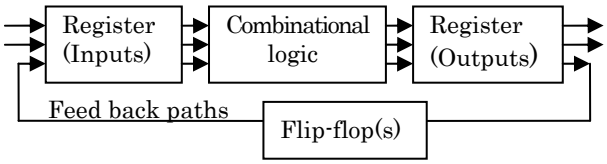

Fig.5 An element of a finite-state machine that includes feedback path

3.2 Manipulation of a set of impulses by a nucleus

A neuron makes action of recognition through a process of data-matching. The process of data-matching depends on the segmentation. Then, meaning of the reaction depends on the segmentation. The share of elements economizes the system. So, the neuron that operates similar function is linked together. The linkage forms a module and a layered structure.

On the other hand, a line of delay elements is able to handle a sequence of impulses. A connected line of neurons in a nucleus is able to operate as a shift register.

3.3 Control of plural activities by thalamus

There are many concurrent activities in a brain. It is necessary to coordinate as self-consistent activities. The input will be changed by the unit of activity as the results.

If each operation is carried out quickly, the plural activities are managed by means of an algorism of winners-take-all. The winner-take-all among activities of nuclei is carried out by mutual inhibition in the thalamus.

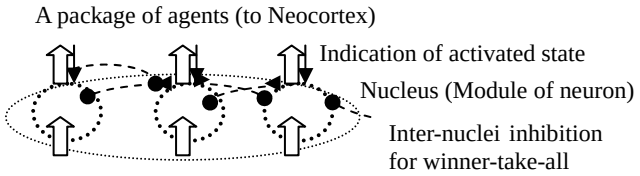

Fig.6 Unification of activities by lateral inhibition among nuclei: Since results of a unit of activity change input, the winner-take-all manages plural activities.

Thalamus is a module of nuclei and there are mutual inhibitions [10]. The functional model of thalamus that manages pathways to neocortex shows in Fig.6.

The operation of thalamus is considered as a control center of asynchronous sequential network. Fig.7 shows the model of asynchronous sequential network.

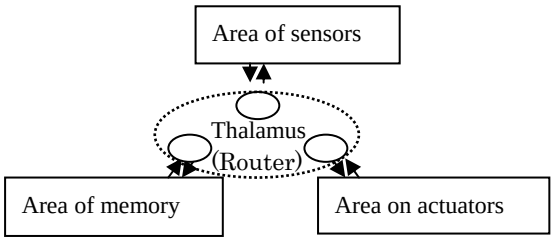

Fig.7 The serial control on a distributed autonomous system: the functional is carried out by a thalamus

In case of fixed task, the timing of processing on each of nuclei can be controlled as a synchronous system such as a central processing unit (CPU).

4. Nerve mechanisms for intelligent behavior

4.1 Modules of impulsive activities for human vision

By using joint ownership neuron, a network of plural serials of neurons for similar function is economized. A set of neurons with similar function form a module of circuits. The network for a module forms a structure.

In a cerebral cortex, there are many little mini-columns of about 100 neurons. The mini-columns are organized into macro-columns [11].

After implementation of circuits, the recognition will be the operation of selection on elements in the network. It is known that similar columnar organization in the visual cortex appears generally in neocortex.

As for columnar structure of the primary visual cortex (V1), the address of column is connected to the address of retina. The data are sent from retina. The recognition is a selective activation. The reactions of V1 are transferred to the second visual area (V2) via connections.

Fig.8 shows a columnar structure of the visual cortex [12] and Fig.9 shows the functional model that manages plural activities on a vision. Here, every cell makes decision individually at the action. The outputs of neuron can be linked to actuator.

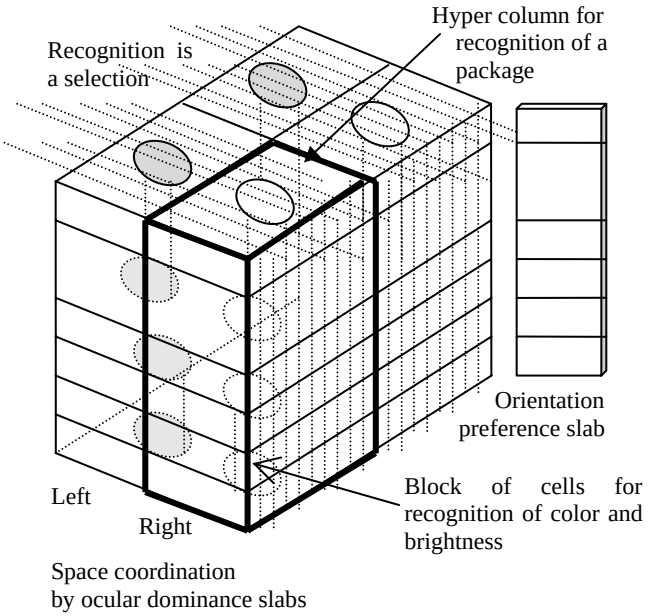

Fig.8 Columnar structure on V1: the selection of action for a set of visual data through pre-condition

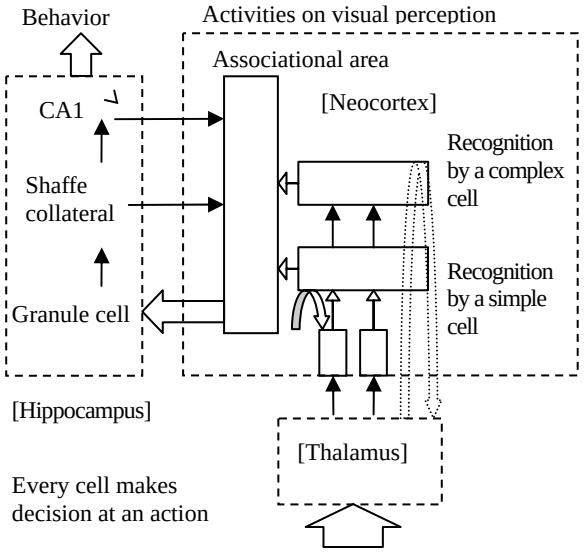

Fig.9 A model of visual signal processing in a brain

4.2 Associative activities by the neocortex

The network of neuron is able to deal with a packet of serial activities. But indication of operating state is necessary in order to manage plural packets of serial

activities by the thalamus. A circulating activity of impulse is able to generate impulses during the period of operation. This circulation must stop at the end of agent.

Fig. 10 shows plural sets of short-term memory that is made of a serial route together with the loop.

The combination of circuits, in which circulation and a series of agents function in parallel concurrently, is able to manipulate plural packets of serial activities [13].

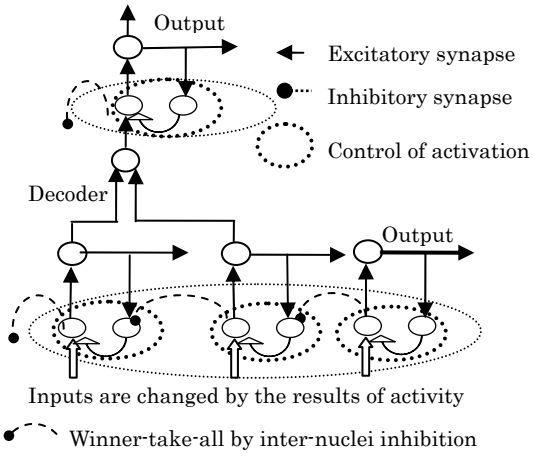

Fig.10 A model of short-term memories in which neocortex and thalamus form a loop memory

4.3 Repeating of transitory activity for memory

A series of poses is able to assign a behavior. Each pose is assigned by a pattern of data. The speed of motion is assigned by transitions of activities. This type of control is carried out by a network of neurons in cerebrum.

There are loops of neurons through neocortex via hippocampus in a brain. So, a transitory activity is repeated in the loop and it helps to construct the circuit. Fig.11 shows the diagram that repeats transitory activity in a neocortex through hippocampus. This configuration is similar to Mealy type of PLD.

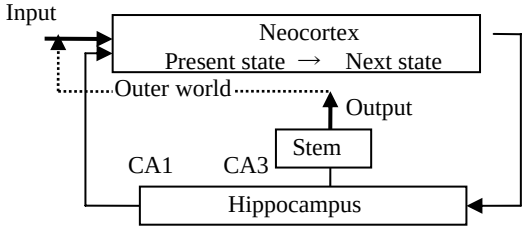

Fig.11 The circuit that repeats transitory activity in a neocortex through hippocampus

4.4 Memory of timing on output by the cerebellum

The intelligence must produce effects. The cerebellum is the organ that controls muscles.

Fig.12. shows a main nerve circuit of cerebellum.

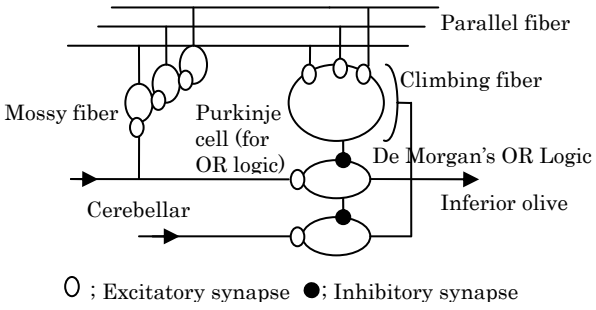

Fig.12 The mechanism of cerebellum that memorizes timing control of agent for a muscle

The timing control of a muscle is memorized as a serial line of connections as follows. The cerebellar cortex receives input from two sources: mossy fibers and climbing fiber. Both inputs make excitatory contacts. Mossy fiber inputs end on granule cells. The axons of granule cells form a parallel fiber. The parallel fibers form excitatory synapses on Purkinje cell. The Purkine cell axon that outputs to the deep nuclei, being inhibitory, can only modulate ongoing activity [9].

Transmitting impulse in granular layer generates timing impulses in a layer of parallel fibers. The time interval is memorized in the connections between Purkinje cell and a set of parallel fibers. Here, the impulses from climbing fiber are used at implementation.

The synaptic inhibition of Purkinje cell is achieved by holding the membrane below threshold. The effect of inhibitory transmitters is to active channel permeable to anion (Cl^-). The inhibitory impulse is generated at absence of excitation [9]. The modification of inhibitory transmitters for continuous impulses operates OR logic according to De Morgan's theorem [13]. Thousands of OR connections do not function due to existence of noises.

5. Conclusions

In this paper, the mechanism of human vision that associates with real world has been represented from a viewpoint of engineering. The vision has subjective activities according to a focused attention. The intelligent activity is described by plural interactions among modules of activities. Here, the category of activity simplifies descriptions of the interactions.

The immutable purpose of action in a creature is the supply for necessary. But a human associates with real world in which unpredictable events happen. The activity of a creature has some meaning owing to result of evolution. The satisfaction depends on the state of supplies and demand. The human vision has many kinds of reactions compared with processing of knowledge.

Following architectures are proposed in this paper to improve the today's computer vision.

1) There are binocular zone and monocular zone in a retina. Each area of retina is connected to a specialized portion of neocortex. By making use of these plural routes in a brain, processing of vision is carried out one by one.

2) Many kinds of amacrine cells play as delay elements in separation of many kinds of dynamic pictures in retina.

3) There are loops of neurons through neocortex via hippocampus in a brain. The loop is considered as a set of decoders together with a function of register. It is able to generate impulses during operating state of a set of serial activities.

4) A unification of plural sets of activities is carried out by a function of winner-take-all in the thalamus in which lateral inhibitions exist among nuclei, because every reaction will be changed by results of action.

5) Every activity is memorized as a trace of transmission of impulsive activities. The recognition is considered as a response of neurons. Since the meaning depends on the connections, it depends on the segmentation.

6) Joint ownership neuron economizes a network of plural serials of neurons. The circuits those operate similar function are organized. The system can be realized by means of a layered structure of distributed file system for a digital computer.

We have learned many kinds of fundamentals on the intelligence from creatures. The authors hope that those mechanisms will contribute to the engineering of vision and the engineering of mind.

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