Model of Linguistic Activities as Ad hoc Interactive Activities in an Impulse Driven Multi-agents System

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ABSTRACT

The cognition is considered as activities of neurons. A neuron functions as a working memory (WM) of a subset of activities. Transference of activities by means of neurotransmitter is a linkage in a moment. The route through which an activity is transmitted forms a nerve circuit. The formed circuit replays the same activity. A neuron operates as a decoder of activities. The output of activity induces following activities selectively.
A rotating impulse in a loop operates as the kept activity in a short-term memory. A layered network of neurons understands a subset of subsets ・・・of activities. The activities are accumulated to a central nervous system (CNS). CNS induces a new activity according to the whole activity.
A subset of activities is expressed as a pattern of impulses existed. A whole activity can be synthesized by using plural nets of loops on which the common pattern of impulses are included. These activities are able explain the vision. The nerve circuits for language faculty are formed additionally through experiences of language use. The nerve circuits for language use yield grammar.
Language understanding is processed by means of a subset of working memories those are linked to the whole activities intermittently. The language understanding is expressed as existence of activities. The activities are varied with mutual interactions between CNS and focused attention area. This is the model of linguistic activities as ad hoc interactive activities in an impulse driven multi-agents system.

Keywords: Impulse, Brain mechanism, Working memory, Short-term memory, Language understanding, Communication

1. INTRODUCTION

The cognitive activity as an example of brain mechanisms is widely viewed as a feeling, and it has been investigated in the field of psychology. The circuits for cognitive activities in a brain are massively parallel, filled with bi-directional flow of communications. Such activities will explain consciousness, and non-logical feeling in language. Those are becoming subjects of engineering on intelligent systems [1], [2], [3].
We can consider that a neuron decodes a subset of activities, because a subset of impulses is decoded by a neuron formed through the same pattern of activities. The connections of inputs on a post-synaptic neuron are formed by means of a pattern of outputs on pre-synaptic neuron, and the resting potential in a neuron is -80mV and a narrow peak of positive impulse is +40mV.
In this report, the model of brain mechanisms based on the concept of activity is proposed, where existence of impulse is considered as an activity. The activity exists in the circuit and it is able to connect the lines. The activity is able to communicate each other. We perceive our environment through sight, sound and touch. The meaning of impulse that comes from a sensor is able to understand as an action of sensor under the situation. The activity of an actuator is able to understand from the effect that exerts on surroundings.
The element that recognizes things and affairs is a neuron i.e. decoder. A subset of subsets is decoded by means of layered decoders. An intelligent circuit system mode of decoder accommodates control theory, image understanding. Here, intermittent real-time operations of impulses make possible to carry out time-sharing operations of parallel distributed processing [4].
A circulating impulse in a loop is able to keep the activity [5], and a subset of rotating impulses is available to send the impulses to selected direction. Transmitting of impulses along plural lines make possible to operate plural functions concurrently.
The interactions between excited area of CNS and excited area of linguistic activities makes possible to explain the affective aspects of language. The model close to a biological brain has a potentiality to emulate the human intelligence.
Many computational models were considered in order to achieve the brain mechanism [6]. The computational theory of brain mechanism is a solution when the phenomenon is understood.
But the computational solution is poor visibility on the whole phenomenon. The definition of working memory is difficult within concept of information processing, but we can define the function of WM as the function of a neuron within the concept of activity.
The impulsive activity of a decoder is not analytical. But it is able to be computational by using operations of if-then-rule [7].
The function of WM is able to translate to software. LISP for AI programming language is used for production systems [8].
Most of traditional models of brain mechanism have been heavily influenced by the concept of information processing where the information on a state is dealt. The intelligence is not information, but it is an ability of activity. It is not restricted to processing of information.
The concept of activity in cognition, flowchart on activity and mathematical expressions about an impulsive activity, and devices fit for operation are described in this report.

2. SUBJECTS ON A BRAIN TO BE SOLVED BY A CONCEPT OF ACTIVITY OF NEURON

Expression of activity of neuron
Many researchers considered that it was the task to find out the

meaning of transmitting impulses in a brain. The author introduces the model of activity for the brain mechanisms. The system of activity does not need pre-implementation of circuits. In the nerve system, a transmission of impulsive activity constructs a path and the path transmits the impulsive activity. An activity acts not only as a data but also it provides the transmission medium. The activity is able to ignite the other activities. The model where activity is expressed by means of existence of impulses has superior possibilities compared with the model for signal processing.

Externalized language and internalized language

There are two kinds of aspects on language. One is externalized language and the other is internalized language. The former is the common aspect of language and it is the essential for communication. Sharing of thoughts by using externalized language has played an important role to acquire intelligence. The latter is psychological aspect of language. We learn a second language by assistance of linguistics but we understand native language with the non-logical feeling. The functions of internalized language are incorporated in the nerve circuit through the experience of language use in the real world.

The linked neural activities are important to understand the meaning of language. Humans are born with an innate ability to lean language, just as we arrive with the ability to see. Both can be shaped by the real world. After all, the performance of intelligence is achieved by the activity of neuron.

Understanding about activities of understanding

An activity is able to ignite the other activities such as activities of linguistic expression. The linked activities of neurons in a nerve network form temporary linkage at the experience. The psychological aspects of language are caused by the linked activities of neurons in a brain.

We understand the meaning of output of a sensor by the situation where it functioned. We are able to understand the meaning of an output of actuator from the effect that activity of it exerts on the outside. A dog knows the meaning of barking from the effects. As for the activity of the nerve cell that links them intermittently, there is a meaning through the connections [9], [10]. The meaning of internalized language is the associative activities in a nerve network.

First intelligence of a newborn baby

A transferring of biochemical reaction leaves the trace as a circuit automatically in a nerve system. Since a synaptic connection is constructed through transmission of activity by means of neurotransmitters, the first experience and the replay are the same activity in a neural network. Traditional concept of signal processing cannot explain the recognition of first experience.

A newborn baby is able to receive stimuli from outside. It does not know appropriate response at first. It is difficult for a baby to stand and walk at first. The newborn baby must acquire the intelligence by itself through its experiences, for it does not understand a word.

It is difficult even for an adult human to operate paralleling control of the body by using language faculty. We learn the method of walk as a systematic activity on a whole body through the experience in a real world. In a neural network, temporarily linked activities are able to operate plural activities. These functions are brought by the systematization of a nerve cell.

We can recognize a thing at a glance. Since the trace of activity in a nerve system makes possible to replay the same activity, the remembered activity is available for intellectual behavior. The accumulation of experiences makes possible to decide the behavior.

Temporary linkage by means of a neuron

A unit of activity is represented by an impulse. An integrated action is achieved by means of subset of activities. The circuit where connections correspond to the transmission of impulses replays the same activity. The subset of impulses is detected by means of the circuit where every unit of activity is presented by the existence of impulse.

The working memory is the function of a neuron. The reason is as follows. The resting potential in a neuron is -80mV sustained by many biochemical pumps. A narrow peak of positive impulse is +40mV [11]. The connections that input terminals correspond to the points of existing positive impulses may form a decoder on a subset of impulses. A neuron operates the function of decoder in an impulse driven system.

A subset of impulse is packed by means of a neuron at the moment. The function of a neuron is that of WM.

Synthesizing of activities in a central nervous system (CNS)

In the animal that has CNS, the activities of one body are controlled intermittently under the conditions of present state of whole activities. The synthesizing of activities is achieved by means of activities. Here, an activity is represented by means of existence of an impulse. That is, an impulse is the symbol of an activity. CNS is an assembly of neurons that intermittently receives stimuli, and intermittently generates impulses in order to control the body.

The skeletal muscles do not work alone. CNS sends impulses along nerve to all muscles, telling them when and how to contract and make a movement, or to relax and go floppy, so they do not oppose the work of other muscles. The more impulses per second, the more the muscle contracts.

The neuron is the fundamental unit of CNS. The nerve system possesses an immense number of lines for communication provided by the neurons. A number of impulses run through numbers of circuits in CNS.

The activities can be memorized automatically in a circuit where every signal is composed of impulses. This model of activity driven system is operated intermittently.

Mechanism of focused attention and self-awareness

A brain is aroused by certain stimuli. It is influenced by the emotional states. Each part of the activity contributes to the whole activity. The paralleling activities in a brain make possible to emulate a focused attention and this system makes possible to generate another activities such as language use. The traditional AI cannot cover the function of such linkage.

The function of focused attention on a particular affair is useful for the intelligent behavior. The self-awareness is activities in a brain, and the function helps social living of human being.

Those activities can be held in short-term memories made of looped circuits. Although the brain functions to control a certain autonomic body processes are neatly sited in a clearly defined region, the intelligent functions spread across many areas in the cerebral neo-cortex.

Intermittent linkages between the activity that is expressed and the activity that expresses it

The operation in the brain is ad hoc interactive activities in an impulse driven multi-agents system. A linguistic expression is the activity that copied from an activity of focused attention. The existence of a copied activity makes possible to handle the activity by each other. The language faculty is achieved by using of intermittent linkages between the activity that is expressed and the activity that expresses it.
The intermittent linkages among plural paralleling activities make possible to rephrase the activity. The plural subsets of activities in the form of propagating impulses or rotating impulses in loops are able to communicate intermittently within a nerve system. The existence of plural activities in a nerve system raises data processing ability remarkably. The activity of thinking will explained as similar activity as language use in a nerve system.
Although activities in a brain do not stop changing, there is universality in the mechanism of activities. These mechanisms are available to construct a new language processing system.

3. FUNDAMENTALS OF ACTIVITY DRIVEN SYSTEM FOR BRAIN MECHANISM

Understanding that is the activity of end-user
We can see a motion by using a movie film, but it is a copy on a visual image. The movie film is not able to function without a projector. The end user of a traditional signal processing is the human being. A signal processing without comprehension such as a device for telecommunication stays within the world where operations improve expressions.
The activity and the circuit are not divided in a brain. Although the activity driven system is able to cover the signal processing, the signal processing is not able to cover activities of end user. Understanding is activities in a brain that is organized by means of only neurons.

An impulse as a symbol of an activity
An impulse is the minimum signal on activity, whereas a digital state is the minimum information in a traditional signal processing. A serial arrangement of pulses or a waveform of a pulse in a signal processing system carries information. But a pattern of serial impulses in a nerve circuit does not imply the meaning that is similar to speech voice. Frequent generation of impulses only indicates that the activity is breaking out frequently.
A repetition of activity is carried out by an increase of number on impulses. This operation is carried out by means of [OR] circuit for summing of impulses in a delay line.
Since the number of impulses is reduced through AND circuit, the repetition of activities is diminished by means of AND circuit.
A pulse can be used for an impulse in a real system. Even so we term an impulse as the symbol of an activity in order to distinguish the concept of impulse driven system. The activity cannot separate from the substance and it cannot free from real time.
A device driven by impulse is designed in order to make actions where existence of impulse means activity. The information of an impulse is only timing of activity and the meaning of activity is effects those depend on the connections.

Intelligent system without signaling
There are asynchronous transmissions of impulses in a nerve circuit. There is not a segmentation caused by the process of signaling.
Each step of operation in an activity driven system is carried out by a neuron. The function of a neuron is represented by an impulse driven WM. The pre-conditions on functioning of WM are similar to a digital decoder.
But the number of input terminals of a WM is adjusted with the object. The asynchronous segmentation of impulses depends on the object. The intelligent circuits without signaling will be useful for an unmanned device that emulates brain mechanism.
A digital computer deals with the data adjusted to the signal processing, and there is the segmentation in a flow of signal processing. On the other hand, the things and affairs in the real world are possessed of the segmentation of itself. Since there are a great number of the combinations between two kinds of segmentations, the recognition of things and affairs in the real world becomes difficult.

Differences between CPU system and activity driven system
Operations of the computational learning are carried out by a central processing unit (CPU) in a digital computer. Intermittent signal processing in a CPU is similar to an impulse driven circuit. But there are programs and data in a digital computer.
Machine cycle in a digital computer is not signified by the data. The data do not create CPU.
A WM is considered as a kind of circuit that is able to operate in parallel. The back propagation method [12] is a computational method to construct WM. The processes on implementation of a cognitive function in software are different from nerve system.
A nerve circuit constructs biological WM through an experience of activity. If we use the segmentation of the WM for the recognition of things and affairs, the processing of recognition is able to do more easily.

Network of working memories for sophisticated activities
A sophisticated reaction in the impulse driven system is achieved by means of linked activities. These activities are represented by impulses existed in distributed portions.
A subset of paralleling impulses or a series of intermittent impulses are transmitted by means of an impulse driven WM as a representative of a neuron. Connections of WM can be done automatically by making use of the transmission of impulses.
A subset of impulses is decoded by a WM in which intermittent subset of impulses are constituents. A set of subsets is decoded by means of a multi-layered WM. In such case, we cannot understand the meaning of an impulse well when we analyze an impulse that comes from only one nerve cell.
The connections provide a concrete meaning for the circuit. The network of WM is able to realize by using logic circuit for selective transition and delay element for adjustment of timing.

Loop for a short-term memory (STM) on an activity
The function of short-term memory (STM) for an activity is achieved by means of looped delay elements where circulation of impulse represents a continuous activity. Plural paralleling impulses are generated from plural loops.
A neuron selects one subset of activities. The selected activity is kept in a loop of STM. The organized activities yield activities of layers of WM. The STM is necessary for such a layered network of WM. A WM in such network accompanies many loops.
The organized activities on a linguistic expression yield

activities of plural layers of WM for one agent. The meaning of each unit of activity for an agent is different.
Organization of activities by means of WM together with loops makes possible to form the frame of knowledge. The formed linkages are intermittent associative linkages among activities.
Fig.1 show a block diagram of activity for a behavior where a loop of delay elements is used as a STM.

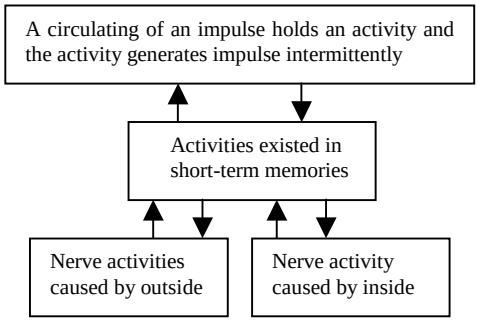

Fig.1 Intermittent associative linkages among activities

Principles of organization
There is higher compatibility in an element of component, because the subset possessing a few preconditions is easy to match. The layered structure makes possible to represent a great many things and affairs, because there are possibility of a great many kinds of combinations among components. The strategy of extension of a system economizes circuits where the organization makes use of existing circuits.

4. COMPUTERIZATION OF AN ACTIVITY DRIVEN SYSTEM

Programs for instantaneous linkages
An impulse is not analytical. But, the phenomenon due to the linkage of impulses is able to be computational.
An agent of activities can be expressed by means of a flowchart. Each step of activity is described by a proposition of "IF A=B, then Y=X". This logic of production system [12] is termed as "if then rule". The precondition of the rule selects a subset of inputting activities and the output of rule connect a route for centrifugal control.
The description of "if then rule" is able to link between the subset of constituent activities and the representative activity at the moment. This operation is the function of a neuron. So the function of a neuron or that of a WM or that of a decoder can be transferred into software.

A chain of WM for a causal chain on activities
So a neuron or a WM or a decoder is able to make linkages between the subset of inputs and the output at a moment. The activity driven system is possible to fabricate as an IC also.
A flowchart as a diagrammatic model for the unmanned operation through transmission of a subset of impulses is useful in order to design a highly developed intelligent system.
The concept of activity will help to construct a semantic network, for a semantic structure is the causal chain of activities. The usefulness of the model will be verified through good visibility.

To A data matching for operation of action
The fundamental operation on an activity is a pattern match. Sometimes the large size of pattern match will be needed in a brain mechanism.
If a pattern of inputs is divided into pieces in order to computerize, the segmentation of signal processing causes the difficulty that processing to seek segmentation on an object becomes a kind of jigsaw puzzle. The special device that is described later may achieve the problem.

Mathematical expressions on an instantaneous change
A state of a post-synaptic neuron $\boldsymbol{u}(t)$ is influenced by activities of pre-synaptic neurons. A model of linear superposition of all contributions is expressed by Equation (1).

$$\boldsymbol{u}(t) = \Sigma \int \delta(t)\, dt \qquad (1)$$

There are integrations with respect to time ($\int$) and connections (Σ). We can use Equation (2) (the derivative of sigmoid function) in order to express the time dependencies of an output.

$$\delta'(t) = \frac{(a)\exp(-at)}{\{1+\exp(-at)\}^2} \qquad (2)$$

Spiking neurons model can be discussed the effects of the integration [13]. But a function of cause and result does not need detailed descriptions of a transition.
The simplest computational model on a neuron is a threshold gate termed as McCulloch-Pitts neuron. The output of McCulloch-Pitts neuron is expressed by means of Dirac delta function $\delta(t)$.

A mathematical explanation of activity a nerve cell
A neuron ignites an impulse at the satisfaction of preconditions. The output of a neuron is given when all pre-synaptic neurons ignite. The preconditions of AND logic are able to represent the instantaneous linkage among all pre-synaptic neurons. Such operation of a neuron (j) is given by Equation (3).

$$\delta''_{Mj}(t) = \prod_{m=1}^{M} \lim_{\alpha \to 0} \{u_{m\,j}(t-d_{mj}+\alpha) - u_{mj}(t-d_{mj}-\alpha)\} \qquad (3)$$

Here, an impulse is represented by means of a pulse with narrow width practically. $u_{m\,j}$ is unit step function, and d_{mj} is a delay time of transmission from neuron (m) to neuron (j).

An adaptation of design technology of state machine
A computer makes action according to the transference of active states according to the software that is programmed by using a flowchart on activities as follows.
"IF present state of activities is B and the inputting activities is C, then the next state of activities is Z." An active state of the subset is transferred to the other state assigned by the activities on conditions sent from monitors of itself and outer world.
The procedures to design such intelligent system are similar to the design of sequential system known as "finite state machine" where one step of operation can be described by a change of the state. But, a design of activity driven system is based on a specification of activities.

5. ELECTRONIC DEVICES FITS FOR INTELLIGENT ACTIVITIES

Automatic implementation of intelligence

Automatic implementation of WM for the recognition on things and affairs in the real world is desired. The target of the activity driven system will be unmanned construction of an intelligent system through experiences.

By counting together with activities inputted and activities held in short-term memories as the preconditions, the system is able to decide the next activity. The operations for communication need to seek the suitable subset of activities. A data matching process achieves the function.

Although plural activities in a system can be dealt by using digital computer, the problem is the data mating process. An adoption of segmentation on each WM as the segmentation of processing in the first stage is a solution, because the number of steps to be checked decreases by the segmentation.

Electronic devices fit for intelligent activities

Electronic device that fits to manipulate a large subset of impulses will be practically implemented in the form of a semiconductor integrated circuit (IC), because the operating speed of circuit becomes very high compared with software.

A programmable logic device (PLD) [14] is a kind of WM. But the number of input terminals of PLD is limited. The LSI for programmable WM with many inputs is desired to manipulate large subsets of impulses in an interface.

Fig.2 shows the device that fits for detection of template matching.

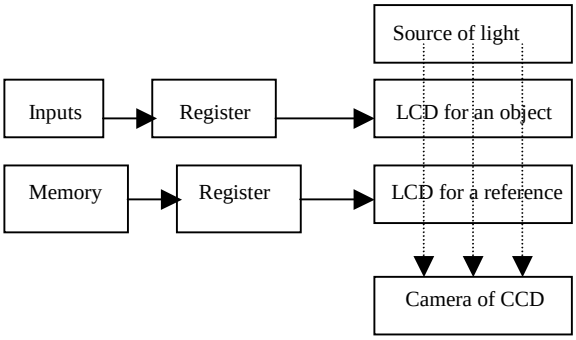

Fig.2. The device that processes a batch of data

Liquid crystal display (LCD) can be used as an element of the device for a large size of WM. A pattern of activities is expressed with the pattern of lighting spots. The pattern of points in LCD activated by means of a RAM can be referred to the images on the other LCD those are inputted one after another successively. The result of AND operation is detected by CCD detector. The common part of two images is able to use as a focused attention.

The circuit in which existing of electric charge indicates a functioning is realized by means of a CCD (Charge Coupled Device) [15], [16]. A dynamic Random Access Memory (D-RAM) consists of capacitances where the charge is stored.

The floatation gate MOS FET (Metal Oxide Semiconductor Field Effect Transistor) is available as an element for a connection [18].

6. LANGUAGE PROCESSING SYSTEM THAT COMMUNICATES

Network of STM with WM for concurrent plural activities

Linked activation of layered loops makes possible to accumulate activities. A focused attention varies with the accumulated activities. The language understanding is carried out by such linked activities.

The parts of accumulated activities induce the activities of speak. The efferent pathway transfers a representative into the subset of components. On the other hand, an afferent pathway transfers a subset of constituents into one output. CNS made of short-term memories is the place where accumulated activities exist. Fig.3 shows a nerve network that is made of STM with WM for concurrent plural activities.

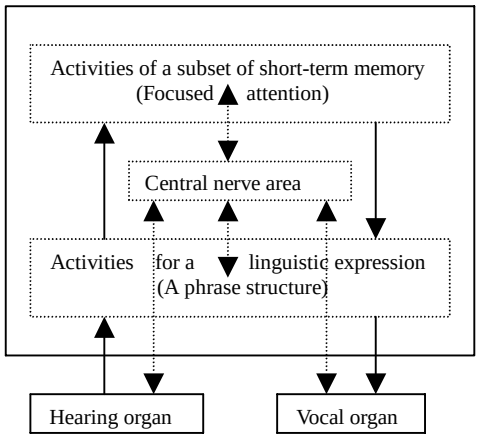

Fig.3 A nerve network that is related with linguistic activities

A brain mechanism; Activities on language understanding are always changed into new state of activities

Language comprehension is the activity induced by language expressions. By manipulating the activities provided by hearing together with activities on present state, both activities can be tidily accumulated. The whole activity is changed, by fixing the focused attention that is reproduced in order to vary the whole activity. The area on focused attention is moved by fixing the whole activities those are reproduced in order to vary the activity of focused attention.

The vision that accumulates whole view is the similar activities, where the point of view point corresponds to the focused attention and the view field corresponds to the whole activity. The activities in the brain are always changed into new state of activities. It is the mechanism of a life.

Language understanding that communicates

By holding the activity of intention, the activity of language expression is carried out. Hearing of language expression induces activity in a brain. The change of nerve activities in a brain through language is the aim of communication.

The activities in the brain are developed and changed by the mutual communication. The conversation is performed with the partner who shares common comprehension on language expression.

7. CONCLUSIONS

The function of language understanding is incorporated in the nerve circuit through the experience of language use in the real world. We understand a speech with non-logical feeling that linked the whole activities of CNS or via CNS. The linked neural activities are important to understand the meaning of language.

Transference of activities in a nerve circuit is an intermittent linkage of activities among plural activities in a nerve network. The instantaneous linkages of activities are held in a subset of loops. The plural areas of short-term memories make possible to communicate among subsets of activities. The traditional concept of signal processing cannot express communications among plural activities in a system.

The proposing concept treats the existence of an impulse as the occurrence of an activity where a neuron operates a unit step of transference of activity in a nerve system. This model for brain mechanisms will be available as a designing tool in a construction of AI. A good visibility of the model is useful in order to design a highly developed intelligent system.

The flowchart on transference of activity can be transferred into software. A digital computer manipulates static signal of states, but CPU makes actions due to intermittent signal processing. The concept of activity in a nerve system will provide deeper understanding of brain mechanism.

The subset of reactions is combined by a WM. A loop of delay elements is able to keep an activity. The consciousness is an activity where a focused subset of activities is interlocked intermittently to the other subsets of activities. These linkages of loops make possible to explain linguistic activity.

A kind of artificial brain that is able to make a conversation in an ad hoc manner is able to construct by means of today's technology. Although the device is possible to realize by using the technology such as language processing, the device is a machine. Experiences of a machine are not the same as those of a human. There are differences between human and machine.

The concept of activity driven system is based on the activity in a real world. The interface that is designed by the concept of a subset of activities will contribute to decrease the gap between activities in a brain and traditional information processing.

The author hopes that the concept of activity for brain mechanism will contribute to developments of science and technology on intelligence.

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