

Activity Transfer Models for Associative Activities in a Brain

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Abstract

This paper describes the paradigm of activity and a network of the programmable and bidirectional digital signal translator that is useful to emulate the brain mechanism. The surroundings ignite activity in a nerve network and the transference accompanies together with forming of circuits. An activity is able to keep in a loop. A neuron laid in upper layer is able to integrate the constituent activities laid in lower layer. The synthetic judgment is carried out by means of pattern matching of plural subsets of activities.

Although each activity is non-linear and it is always on the move, transference of electric charge is able to represent the transference of activity. Since an activity corresponds to a data and a circuit corresponds to a program, the circuit and activity exist concurrently. The concurrently existing subsets of electrons are able to form a MOS decoder. Since transmission of impulse is intermittently, the connecting points of a decoder can be used as the connecting points of the encoder by means of exchanging between inputs and the output.

Keyword: Brain mechanism, Linguistic activity, Understanding, PLD, Dynamic MOS circuit

1. Introduction

Now, researchers from many areas are interested to the brain mechanism, and many reports have been on offer. These movements have been accelerated due to developments of digital computer. Many computational models on brain mechanisms were reported in the field of artificial intelligence (AI) [1], [2]. The program of computer is copied easily and it operates the same function repeatedly. To understand something is to transform it from one representation into another in the field of information.

But understanding is activities of reasoning in a brain. Associative activity in a brain is transference of activity. The synthetic judgment is carried out by means of layered decoders. Linguistic activities are layered activities. The

sense of balance, proportion and harmony is realized by means of a decoder on plural subsets of activities. The plural activities exist concurrently in a hardware system.

On the other hand, the activities correspond to operations in a digital computer. A central processing unit (CPU) is impossible to manipulate plural subsets of operations concurrently. That is, the existence of plural subsets of activities is impossible in a digital computer, because a CPU manipulates only one subset of activities.

To understand something is to transform it from one representation into another in an information processing. But understanding is activities of reasoning in a brain in a true world. Here, we define the true world where phenomena occurs in real time. Origin of intelligence is obtained bottom-up approach in the true world. A newborn baby acquires intelligence through experiences before acquisition of language use. To emulate the imprinting is difficult for the traditional information processing, because the central processing unit (CPU) is operated by means of the program that was pre-installed. Data does not exist concurrently together with the program in software. Some electric charge is able to represent the existence of activity. The hardware system is able to form a new circuit, because the activity exists in the circuit.

The paradigm of activity is powerful tool to reveal the brain mechanisms [3], [4]. The faculty to abstract the information from a true world will be developed by improvements of the hardware. In a future intelligent machine, the implementation of sophisticated hardware will be carried out by the system that is controlled by activities. This paper describes the paradigm of activity for the brain mechanism and the automatic hardware implementation of intelligence.

2. Paradigm of activity for brain mechanism

2.1. Mechanism of synthetic judgment

Each neuron operates the function of a decoder. The decoder upper layered integrates constituents. A synthetic judgment is decided by means of organized plural neurons.

Associative activities counts in the linked activities for a synthetic judgment. The associative activities in a brain are explained by transference of activity where the activity disappears automatically at a point.

The concurrently existing subsets of electric charge are able to form a dynamic MOS decoder, where a pattern of existing electric charge is transferred as the pattern of connecting points on a decoder. By considering the electric charge as the representative of an activity, the dynamic MOS VLSI is possible to emulate the automatic implementation of intelligence.

2.2. Meaning of activity

The scientist seeks re-playable phenomenon. $1+1=2$ is true only in the field of information where the same affair takes place again. But this “Decartes approach” is a top-down approach. Real intelligence became obvious through manufacturing of robots [5], [6]. The activity of a sensor is affected from in the real world. An actuator affects the real world. The meaning of activity on an actuator is able to understand from the effect that exerts on the surroundings. Meaning of the activity is able to understand from the device and the situation.

According to traditional AI, a unit of activity is described by means of an IF-THEN relation. The production system (Newel, Simon 1972 [7]) is realized by means of software such as AI program written by Lisp or Prolog. The description of IF-THEN rule is realized by means of a programmable logic device (PLD). The activity driven system satisfies the conditions of the physical symbol system (Newel, Simon 1976 [8]) that contains a collection of the symbol structures those are composed of a numbers of instances of symbols.

2.3. Representation of activity

The shape of activity shows an impulse. Transference of an activity is expressed by means of transference of an impulse. The impulse indicates the timing of activity. Although each activity is nonlinear and it is always moving, we can express the transference of activity by means of transference of electric charge. It is possible for today’s electronics to realize the model of a nerve system. In the nerve system, a state is changed according to the propagation of activities from present state to next state. The timing of functioning is transferred. Only concurrent activities are able to interact with each other. The operating type of an activity transfer system is a time-sharing operation.

The derivative of digital state is impulse. An impulse is able to represent an activity. The activity of a neuron is expressed by using a McCulloch Pitts model of delta function.

$$o_j = \delta(u_j - \Theta_j) = \delta\left(\sum_{i=1}^n w_{ij} x_i - \Theta_j\right) \quad (1)$$

Here, $\delta(u_j - \Theta_j)$ is the activity that is given by the derivative of a unit step function. The step function $[u_j]$ indicates a state. A digital decoder operates the function of equation (2). Here, value of Θ_j is the threshold value of a weighted linear input combination, and $\Theta_j = 0$ for the digital system. The component of activities matrix w_{ij} is decided by components of an input vector x_i .

2.4. Representative of neuron

A neuron picks up information from the true world with threshold logic. Some incompleteness is inevitable in the recognition. The biochemical reaction is transferred in a body and it changes the state of activity from a present state to the next state. A series of activities is ignited by means of the response of sensor in the circumstances. The trace of transference of activity is able to replay the activity. As a result, the transition of activity will be described by two sets of data. One set is the data on present activities obtained before the change. Another set is the data on activities obtained from monitor on actuator. If we get the “look-up table”, the function of intelligence is able to implement in a programmable logic device (PLD).

The circuit functions not only at the static states but also it functions at change of state. A circuit is able to pass electric current not only continuously but it is also able to pass electric current intermittently. An activity transfer circuit operates combinational logic intermittently. The simplest perception such as figure separation through grouping of perceptual components is expressed by means of a logic function such as the sum of products canonical form. Equation (2) shows an example.

$$o_1 = x_1 x_2 x_3 x_4 + x_1^- x_2 x_3 x_4 \quad (2)$$

The relationship is specified by means of the definition on each activity i.e. x_1, x_2, x_3, x_4 , and o_1 . Here, the output o_1 functions at the input pattern of (1111) and (0111). AND logic circuit decreases constituents of a vector. OR logic circuit increases constituents of the vector.

2.5. Language use as a media of thinking

There are plural activities in a brain. The linkage of activities had explained non-logical feeling of language [4]. Consciousness is one of activities in a brain. If we want to know an image, the time dependency of the image is ignored. The activity must be focused at a point, for a body operates only one action at the moment. If we want to know the time dependency of the phenomena, we must ignore the

change of other phenomena. Human originated communication by words those were defined by human being. Now, many of information are transmitted by means of linguistic expressions. The language is used as a media of thinking. The brain mechanism of a human incorporates language use.

The linguistic activity is serial [9]. The signal of segmentation is necessary for a serial transmission of structured linguistic activities. The nerve is organized by means of existing circuits, and the extension of nerve circuit forms a domain structure. A component possesses pre-conditions less than the whole possesses. There will be a great number of combinations among many components. A layered structure of neurons makes possible to represent a great number of things and affairs. This "principle of extension" economizes circuits.

3. Automatic implementation of intelligence

3.1. A programmable nonvolatile memory

The activity in a nerve system plays a role of data. It constructs the route also. The plural sets of concurrent activities in a brain are able to link by means of a neuron laid on an upper layer. The linkage is intermittent transmission of activities. A floating-gate metal oxide semiconductor field effect transistor (FG-MOSDFET [10]) is used as "flash memory". It is also used in the field of PLD such as, PAL or FPGA.

A FG-MOSFET disconnects between source and drain by injection of channel hot electron into the floating gate. The tunneling of electrons from the drain to the floating gate takes place by the channel hot electron mechanism owing to the electric field between source and drain in the MOSFET. The electron energy distribution presents a tail in the higher energy side that can be modulated by the longitudinal electric field of top gate. This operation needs some amount of current.

On the other hand, electrons in a floating gate are ejected by Fowler-Neordheim tunneling effect through the oxide from floating gate to silicon surface [11]. A strong electric field induces a quantum-mechanical phenomenon of tunneling without destroying its dielectric properties. The current of ejection is very little compared with the injection.

3.2. Activity transfer circuits for intelligent activity

Each activity transfer circuit is made for an individual agent. The circuit for an agent is constructed by means of two kinds of junctions. A type of junction connects from many input lines to one output line. The other junction connects from one input line to many output lines. Since an input accompanies some electric power and the output is

a passive device, we can get logically bidirectional actions by exchanging the inputs and the output. The automatic connections on a bidirectional logic circuit are achieved by using programmable controllable devices of FG-MOSFET.

A decoder transfers some amount of electric charge from many to one. An encoder transfers some amount of electric charge from one to many. The connecting points of the decoder and those of the encoder are the same but the flow of electric charge is opposite direction. By switching from input line to output line and switching from output line to input line, the electric charges are able to transmit reverse direction. Then, a decoder is able to change into an encoder.

3.3. Bidirectional decoder for a unit of intelligence

A logical relationship is represented by the connections from input to output. A decision is made at the turning point from afferent pathway to efferent pathway. Many inputs are connected to one command line and it is connected to many output lines. Here, the meaning of activity depends on each circuit. Since a passive junction is able to function as a logically bidirectional reaction, the connections of many input lines to one output line are able to function as the connections of one input line to many output lines.

In a traditional digital circuit, a digital signal is transferred from the gate to the drain and the signal does not transfer from the drain to the gate. The traditional circuit transmits signal toward one direction only. Here, we can use a FG-MOSFET as a controllable "passive" junction, because the drain and the source in a FG-MOSFET is exchangeable symmetry. By changing the circuit for input side and the circuit for output side, we can get bidirectional logic circuit through the passive junctions.

4. Programmable intelligent MOS circuits

4.1. Automatic hardware implementation

The bidirectional digital signal translator exchanges two kinds of representations mutually. It is able to translate between an array of characters on a word and a registered number of the word. Also it is able to use to translate between an array of registered number of words and registered number of the sentence. A bidirectional digital signal translator is composed of a pair of bidirectional decoders. That is, one decoder is implemented by using inputting digital signal and another bidirectional decoder is implemented by using outputting digital signal on the same item. The connection of these outputs forms a bidirectional digital signal translator.

Fig.1 shows a MOS circuit diagram of a pair of programmable decoders. Since the connections are carried out by

an injection of hot electrons in the FG-MOSFET, the inverted signal is used for the write operation. The H level of inverted digital signal cuts connectable FG-MOSFET individually.

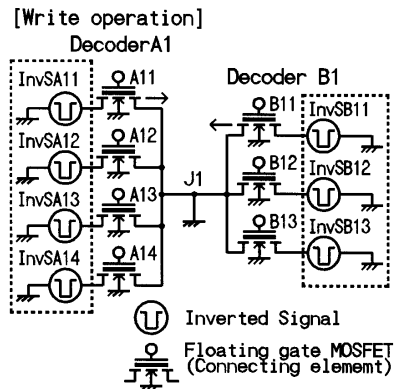


Fig.1 Implementation of a pair of MOS decoders for a bidirectional look-up table

4.2. Operations of bidirectional logic circuit

[Dynamic MOS circuit for an afferent pathway]

AND logic function of the bidirectional decoder is conducted by means of internal resistances inserted at the H level of the signal sources. Here L level of the signal sources are connected to the ground directly. Then, any line with L level state pulls down the voltage on J1 point. OR logic function of bidirectional encoder is conducted by means of high impedance of load resistances.

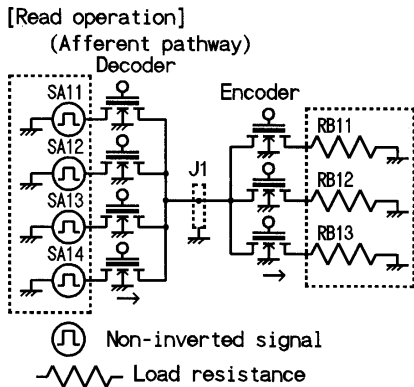


Fig.2 A programmable MOS circuit for look-up table of an afferent pathway

[Dynamic MOS circuit for an efferent pathway]

In order to form an efferent pathway, the output terminals of encoder are switched to the input terminals of translator, and the input terminal of decoder is switched to the output terminal of translator. That is, the same plural connecting

points of decoder located in input side of Fig.1 is able to change into the points of the encoder for efferent pathway.

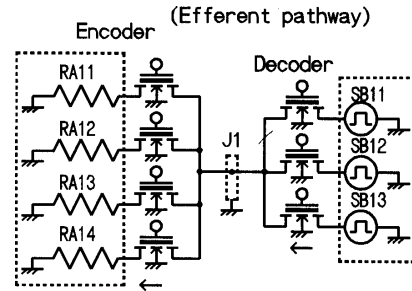


Fig.3 A programmable MOS circuit of look-up table for an efferent pathway

Fig.3 shows the digital signal translator that translate digital signal opposite directions as shown in Fig.2.

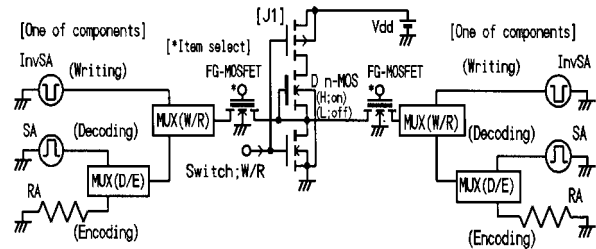


Fig.4 A MOS switching circuit for one bidirectional operations on one of constituent

Both circuits for entrance and exit are implemented at both sides in order to integrate the operations, and the direction of flow of signal is changed by means of switches. Fig.5 shows the switching circuits for one of constituents in a bidirectional digital signal translator. Fig.4 shows the switching circuit for one of constituents in a bidirectional digital signal translator.

4.3. Design of Practical MOS circuits

The practical design of a dynamic MOS IC needs trial manufacturing, because data on a practical device are depend on the fabrication. The bidirectional logic circuit consists of traditional semiconductor devices, and there are many techniques in the field of dynamic MOS IC [12], [13], [14], [15]. The technologies of VLSI are available for the bi-directional logic circuit.

A simulator of PSpice is able to check the operations of a MOS decoder possessed of encoder [16]. The result shows the existence of a delay time and a spike at the end of switching. A stray capacitance causes such storage effects. This problem is solved by means of timing control of the

operation. One of the solutions to remove the needless spike is shorten of the width of impulse.

5. Applications of activity driven circuits

5.1. Bidirectional decoder for linguistic expressions

A register is able to load serial activities according to the occurrences, where the timing of shift is given by the signal of segmentation. The register possessed of bidirectional logic circuits is available to manipulate subsets of activities. There are plural layers in linguistic activities [17]. That is, there are a layer between an array of characters on a word and a registered number of the word, and upper layer between an array of registered number of words of a sentence and registered number of the sentence. The layered registers with bidirectional logic circuits are able to manipulate the subsets of activities.

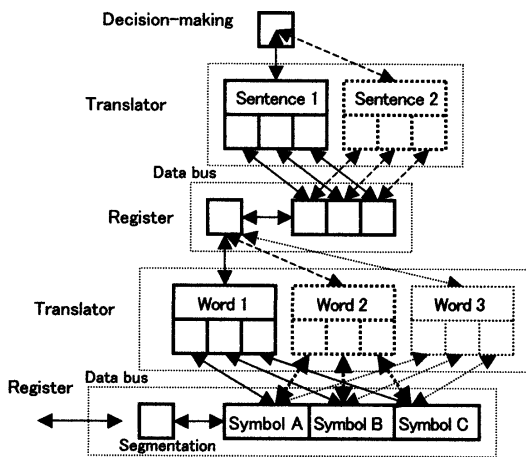


Fig.5 A Network of layered bidirectional circuits for linguistic activities

Fig.5 shows a block diagram of a network of layered bidirectional decoders that is controlled by means of propagation of activities. The linguistic explanation is carried out by means of another network on the same matter.

5.2. Translation between two languages

A pair of programmable bidirectional translators is available as a bidirectional translator between different languages. By exchanging the expressions between different languages on the same affair, a translation of languages is carried out. Since one sentence is expressed by means of a serial series of symbols such as alphabets by using a layer structure. There are two layers of the registers those possess with bidirectional logic circuits in each tree structure.

Two tree structures for two kinds of languages are able to translate the languages.

A VLSI possessed with bidirectional connecting points is able to use as a medium of linguistic activities. The VLSI that translates between the information of letters on a word and a registered number of the word can be used as a medium of linguistic expressions. If one letter is expressed with 8 bits and a word is expressed with 16 letters tentatively, a word is distinguished by means of $8 \times 16 = 128$ bits data. Here, if we use 128 bits of data to distinguish 8,192 kinds of words, the number of connecting points will be points $128 \times 8,192 = 1,048,576$ for the letter data side, and the points $13 \times 8,192 = 106,496$ for registered number side.

The VLSI that translates between a subset of registered numbers on word and a registered number of the sentence can be used as a medium of sentence level of linguistic activities. If one sentence is expressed with the data of 13 bits and a sentence is expressed with 19 words tentatively, a sentence is distinguished by means of $13 \times 19 = 247$ bits data. If we use 247 bits of data to distinguish 8,192 kinds of words, the number of connecting points will be points $247 \times 8,192 = 2,023,424$ for the word data side, and the points $13 \times 8,192 = 106,496$ for registered number side. The 13 bits of registered number on each sentence is implemented as a decoder and those connecting points are used as an encoder.

5.3. Translation from vision into linguistic activities

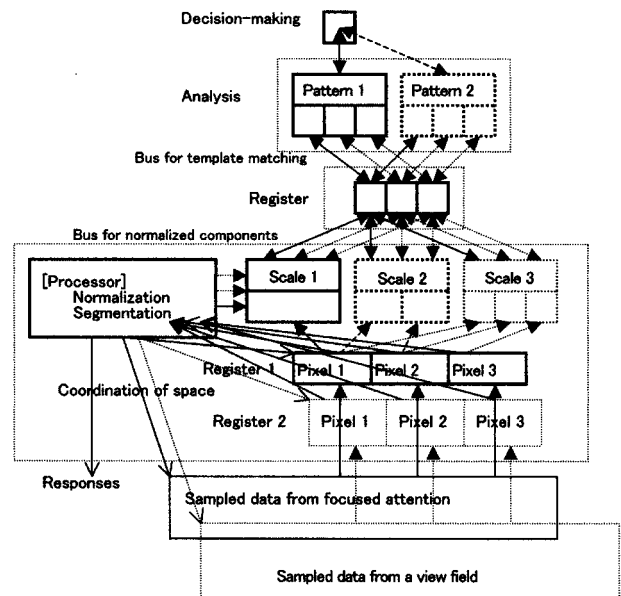


Fig.6 The activity transfer models for a vision where programmable bidirectional circuit is used for a template matching

Fig.6 shows a block diagram of the pattern recognition. Some normalization is necessary for the processing of machine vision. Associative activities are the other subsets of activities interlocked. Such linkages of activities makes possible to explain the structured architecture of human brain. We notice things at the moment of experiences without world modeling that is a memorized world. The dependency on environments provides adaptability for a nerve system. The translation from visual pattern into linguistic expression is achieved by using bi-directional translators where the output of bidirectional decoder on linguistic expression and the output of bidirectional decoders on a visual pattern are connected. When components of the activities are organized, a network of decoder for vision or linguistic expression can be viewed as a tree structure.

5.4. Mapping that depends on the real world

When we close eyes, the image in our brain disappears in our mind. We can distinguish a picture of a friend, but we cannot draw his picture without training. The fact indicates that the recognition depends on the real world. The human vision is not always necessary “world modeling”. The proposing model of vision is performed by the activities those are excited by stimuli from the outer world. By using the data from retina, we can recognize the linkage among the plural things and affairs. The eye is a passing point in a transference route of visual activities. The “frame problem” does not need to solve, if the robot makes decision at each occasion.

Hoffman listed 35 rules of human vision [18]. The activity transfer system will provide those functions. The visual pattern can be used as a media of thinking. Plural images in a view field are mapped by using linkages. A decoder is able to pick up the relation among constituents. Those linkages among those activities are essentials of the brain mechanism.

5.5. Normalization for template matching

The normalization on the number of data bus helps the visual pattern recognition, because a pattern is recognized at the coincidence with connecting points between distributing lines and a decoder. Each pattern of data is discriminated by means of characteristics such as color, and it generates output instantaneously at the data matching. There are a great number of patterns for vision. Since the connections between the register and paralleling decoders are fixed, the data of picture elements on every pattern must be adjusted to the data bus.

By using address data on a target, such as the center, maximum point, and minimum point, the visual data on an image are translated automatically from by fixed calcu-

lations accompanying with the normalization as shown in Fig.6. If we assume the number of data bus is 256 lines for a picture of length for 16 segments and side for 16 segments, and 24 of bits is used for the information of each picture element, $256 \times 24 = 6,144$ bits are necessary for each pattern. Here, the value of 24 bits is 8 bits for each 3 primary colors. The total number of connections for 1,000 pieces of templates will be 6,144,000.

6. Differences between digital circuit and activity transfer circuit

6.1. Impulse driven circuit

A digital system is static. On the other hand, an impulse driven system is dynamic. A real time decision-making machine manipulates data from outer world at every instant. A dynamic MOS VLSI is an impulse driven system. The system is operated moment by moment. The dynamic operation of impulse driven system is able to emulate human vision as follows. Activities on movements of eyes are linked to activities of visual cortex by way of activities of retina [19]. The alignment of two patterns of activities is achieved by changing the direction of eyes. On the aligned point, the depth is measured by using the difference of angle between two visual directions. The data on 3D vision is achieved many such activities.

As for hearing, a direction of sound source is detected by the difference of sound between two ears and we can turn the face to the point of sound source. The target of impulse driven system is such dynamic system.

6.2. Segmentation of operations

Although programmable logic circuits are used for a digital computing system, the operating system possesses a segmentation of operation. On the other hand, things and affairs in the real world are possessed of the segmentation of itself. If a pattern of inputting data is divided into pieces in order to manipulate, there are a great number of combinations due to two kinds of segmentations. Every possible combination of segmentation must be referred in a digital computer. Such pattern recognition must solve a kind of jigsaw puzzle.

In the activity transfer network, a template matching is carried out during the transmission of activities. The hardware system removes the segmentation of operation, and it achieves the difficulty on the recognition. Although an activity transfer is able to realize by using existing digital technologies, there are differences between digital circuit and activity transfer circuit. We can term the system that transfers activities as “impulse driven device” in order to distinguish from traditional digital circuits.

6.3. Focused attention and mapping

The rules on the sophisticated machine depend on the individual machine. The paradigm of activity will help to architect such system. Although plural activities are inputted from the outer world, a body must select one action. A network of decoders unifies these activities. The operation of coordination is the role of a nerve system. The architecture and the data must be provided by means of problem dependent solutions in a bottom-up approach.

There are two ways in a brain. One is looking around outer world and the other is unification of the activities. The focused attention is induced through the activities of sensors. By fixing a focused attention, the data obtained from one small area are analyzed. By changing a point of view, data from the surroundings are checked. Both activities are achieved by means of an activity transfer system.

The concept of "active perception" is considered as a large scale of movement of eyes [20]. Such linkage of body control and signal processing on a vision is an example of activity transfer system. IF-THEN relations for identification of a pattern are obtained by ignoring masses of irrelevant data. Here, the traditional technologies of feature selection or classification are employed together with 1) normalization, 2) digitize, and 3) template detection. The flow-chart of the intelligent machine will be considered by using a) block diagram, b) state diagram and c) timing diagram. The problem-dependent approach requires these specifications.

6.4. Paradigm of activity for computational models

The same result can be obtained by using a software system or a hardware system. The implementation of the system is also possible to carry out by means of CPU system. But the processes of software system and the processes of hardware system are different. To obtain a grate number of data on template matching is hard for a CPU system. The programmable bidirectional digital signal translator was considered in order to implement data easily. The bidirectional logic circuit is designed from the paradigm of activity. The intermittent activities make possible to manipulate such bidirectional flow of signal.

6.5. Paradigm of activity for understanding

In a CPU processing, to understand something is to transform it from one representation into another. But it is not true understanding for a human. We can understand a picture, but it is difficult for us to represent the same picture without a camera. Understanding is activity of reasoning in a brain and it depends on the individual.

The intelligence of a human possesses universal aspect. The generality is the base of language. But a real human possesses many independent aspects. Software system functions in the CPU that is different from the true world. Software is idealistic existence and it has the tendency to express generalities. The base on paradigm of activity is the true world. Since the intelligence is the result of activities in a true world, the paradigm of activity will support the individuality in the information-oriented society.

7. Conclusions

The language sense is a kind of associative activities in a brain. The activity of linkage is interlocked intermittently. An activity can be held in a loop of neurons. Each neuron ignites an impulse at a pattern matching. The concurrent activities of neurons are decoded by means of a neuron that is laid in the upper layer. A layered structure of neurons operates layered activities and those carry out the synthetic judgment. This paradigm of activities makes possible to explain brain mechanisms such as the sense of balance, proportion and harmony.

The operation of a neuron is expressed by means of a look-up table (or truth table). A look-up table expresses a template matching. A network of look-up table will emulates the brain mechanism. The activity corresponds to the data in a software system. A unit of data is manipulated in a digital computer. The CPU is impossible to deal with the phenomenon composed of a pattern of activities. The activity either in a brain or in a computer results in a transition of a digital state. The concept of activity makes possible to combine the technologies of hardware and those of software. The unification of traditional models by using paradigm of activity will reveal the outline of brain mechanisms.

FG-MOSFET has been used as flash memory and PLD. A FG-MOSFET functions as a programmable connecting element. The connection of a FG-MOSFET between the drain and the source is exchangeable symmetry, and MOS circuit is able to "exchange signal source and load". A new logic circuit of "bidirectional logic circuit" is proposed in this paper. The "bidirectional impulse transfer circuit" can be embodied by means of traditional technologies on dynamic MOS VLSI.

The programmable MOS decoder with encoder deals with transference of electric charge as the transference of unit of activity. The intelligent activities are memorized in a network of the look-up tables. Since a combination of bidirectional look-up tables is able to organize transferring activities, bidirectional look-up table is useful for interpreters and intelligent circuits. This new type of VLSI has many uses such as, media of linguistic expression, language transformation circuit, information compression, and translation device into linguistic expression. The operations

of elemental dynamic MOS circuits were confirmed by using a computer simulator of "PSpice". Today's technology on semiconductor electronics is possible to manufacture a VLSI composed of bidirectional look-up tables in a practical level. But, the experimental productions are necessary for the manufacturing.

The point which should be added lastly is that, the model composed of bidirectional look-up tables has good visibility and it is useful for design of highly structured system, and the paradigm of activity will add a new development of highly integrated intelligent system such as a brain computer and it will contribute to developments of brain science and engineering of mind.

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