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From Eating Behavior to Dialogue Using Language; Evolution of Neural Network

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Abstract: In this paper, logic is developed based on the view that the brain nerve circuit is composed of a combination of neural circuits with the same function. The subject of logic is animal's action; from early evolved animals that only perform feeding to more evolved animals that have ability to act as groups. In Chapter 2, reconstructed and outlined the previously published papers described about Basic Unit. Using category theory, Basic Unit is defined as an object in neural network (defined as category). By setting functions between categories, behavior of multiple categories express imitation behavior not only eating behavior. These functions enable collective actions and are the basis of individual communication. Chapter 3 describes the essential functions which human communication make superiority to non-human communication. First, a new neural network is placed on the top level of the existing neural network. The new neural network operates asynchronously with the existing neural network directly involved with the senses and motile organ. Next, a process to share events that are recognized by new neural networks among companions is presented. In other words, dialogue deploys individual knowledge to group knowledge. It is clear that the spreading of knowledge from individuals to groups is one of the most value of language. On dialogue session, there is no guarantee that the listener understands the content with just one explanation of the speaker. Speakers guess the understanding level of the listener from listener's actions and expects the following content. The contents of next dialog are opposition, misunderstandings, corrections, supplements, and etc. Ordinary, after resulting trial and error, both speakers become satisfied situation. But sometimes the dialogue ends without satisfied situation. These dialog processes are represented as changes in dialog content according to the internal state of high -level neural networks related to the reception of time series data.

Keywords: Context Corresponding Neuron layers, Getting Knowledge by Dialogue, Category Theory, Dialog Between Persons, Descriptive World in Brain, Real World in Brain

1. Introduction

How can animals in the early stages of evolution, which can only food behavior, get evolution manipulating languages like humans? In this paper, it is discussed on neural network the evolution of animal's recognition and action ability.

The basics are the combination of neural networks that recognize and generate time series data. The simplest circuit is the embodiment of eating behavior, which is essential for animals to live. Next, the circuit expands its function to acquire imitation and learning abilities. This feature leads to a language ability that only humans can manipulate. The circuit configuration is a hierarchical connection of units with a similar function that recognizes and generates time series data composed of a combination of finite elements. The finite limit of elements in series data is led from the resolution of the sensory motile organs and the accuracy of the motile organs, but the series data are recognized and treated using context structure by the hierarchy connection of the unit, so structure is logically unlimited. In other words, the presented neural network has expandability to a universal machine while being conditional. The idea that any system can be constructed by hierarchical connecting similar function units is familiar to the knowledge of the brain of neuroscience (gradual theory), that is, brain neural circuits consist of similar structures. On the other hand, if the similar circuits are assembled by electronic circuits, it

realizes self-repairing circuit using redundancy and learning function.

In Chapter 2, reconstructed and outlined the previously published papers described above. The proposed Basic Unit is a essential part that constructs a neural network, and has a time -series data recognition and generating function. Using category theory, Basic Unit is defined as an Object in neural network. By setting functions between categories, multiple categories behavior express imitation behavior not only eating behavior. These functions enable collective actions and are the basis of individual communication. [1, 2]

Chapter 3 describes the essential functions which human communication make superiority to non-human communication. First, a new neural network is placed on the top level of the existing neural network. The new neural network operates asynchronously with the existing neural network directly involved with the senses and motile organ. Related events include not only non-restrictions on location, but also past events and prediction events.

Next, a process to share events that are recognized by new neural networks among companions is presented. In other words, dialogue deploys individual knowledge to group knowledge. For example, if anyone belonging to the group knows the appearance and the location of the foreign enemy's beast, the group get knowledge from him and can develop a survival plan. It is clear that the spread of knowledge from individuals to groups is one of the most value of language.

On dialogue session, there is no guarantee that the listener understands the content with just one explanation of the speaker. Speakers guess the understanding level of the listener from listener's actions and expects the following content. The contents of next dialog are opposition, misunderstandings, corrections, supplements, and etc. Ordinary, after resulting trial and error, both speakers become satisfied situation. But sometimes the dialogue ends without satisfied situation. These dialog processes are represented as changes in dialog content according to the internal state of high -level neural networks related to the reception of time series data.

However, it is not possible to confirm only by the dialogue contents whether the both target image obtained from the dialogue is the same. Furthermore, the reliability that the same image were obtained will not be a problem immediately among companions. Feelings such as fear and joy have similar problem because that are not displayed in shape. It may be a kind of philosophical problem.

2. Basic Unit: As Universal Parts of Neural Network

Eating behavior is characterizes animals even if in an early evolution stage. Animals get the situation by the sensory organs, if judged eatable is there, capture the food and move to the next place. This process can be explained using Turing Machine. The operation of the circuit that combines logic elements is deployed to a computer with built-in operation programs then supporting today's society. On the other hand, the instinctual behavior of animals evolved enough to be recognized as intellectual behavior, not because the brain had built-in operating programs. To explore the evolution process of intelligence, isn't significant to develop another universal machine that is consisted of different principle from computer? [3, 4, 5].

There is a view point that the brain of the animal in the early stage of the evolution and the human brain are based on the similar structure of the same neural circuit. Taking above view, this paper based on an opinion that the evolution of the ability must be depending the complexity of the combination of neural circuits. The neural network to be presenting is corresponding to the whole brain and recognizes the environment in which it is located, and depending on the results of the perception, rewrite the environment and take the best measures for the system self in which the neural network belonged. [6].

The target of the neural networks featured in this paper is time series data. First, above mentioned eating behavior can be shown by the movement of the muscles connected to the nerve cells equivalent to AND circuit as shown in Figure 1.

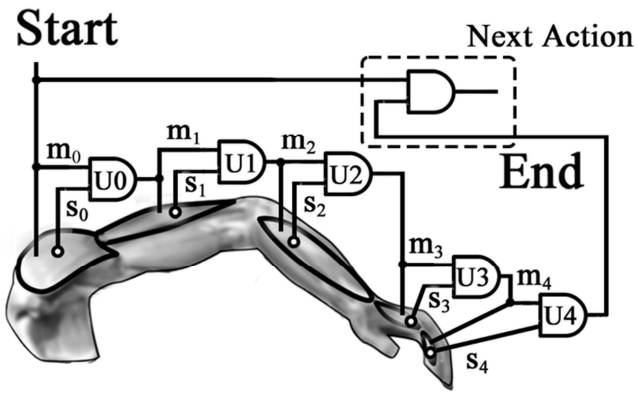

Figure 1. *Eating action as a basic behavior of animal.*

When signal m_0 is given, shoulder muscle moves. The muscle continues to move until receiving the signal s_0 which indicates the load and movement limit of the muscles. When signal s_0 is received, signal md1 that moves the next upper arm muscle is activated. As following, the movement of s_1, s_2, s_3, and s_4 to the signal m_1, m_2, m_3, m_4 is also the same, and a series of end signals are issued by the reception of m_4.

Figure 2 is an illustration in which the same functions as Figure 1 is rewritten in expressions that are closer to neuroscience. In the cylindrical form, a randomly arranged nerve cells and axon sets gathered in bundles, and the input / output of the information is performed from the exposed axon placed top and the bottom. This cylindrical structure may be not so much different from the structure of a fictitious module called in neuroscience such as mini column, macro column, barrel, stripe, or blob [7].

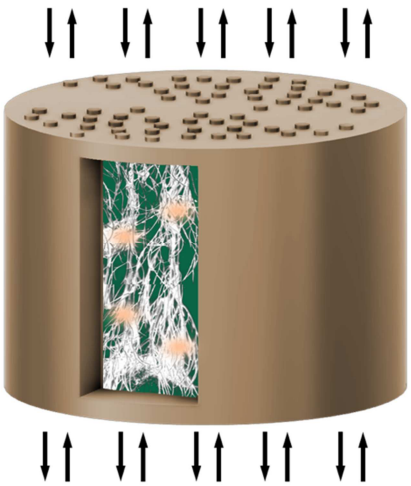

Figure 2. *An image of mechanism of Figure 1 from neuroscience side.*

Figure 3 is a diagram shown by emphasizing the essential part of Figure 2. Some signals such as temperature or brightness are not necessary to the movement of the voluntary muscles, but the essence of the operation is the same processing in time series data.

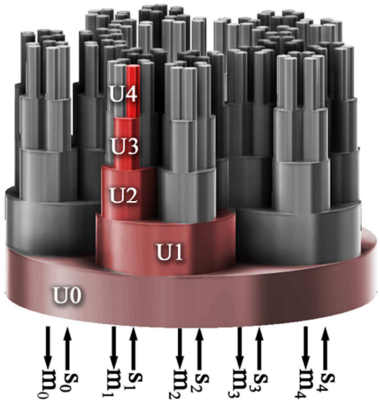

Figure 3. *Image of emphasized the essential part of Figure 2.*

First, as a start signal, some cells that are randomly connected to data m0 are activated. When the following data m1 arrived, by the first data m_0 some sets of cells in U0 are still active, then the sets are additionally activated. Additional activated area become narrow as the data receives m_2, m_3. When the last m_4 is received, the array of the elements that maintained the activity, that is, replaced with an electronic circuit, the array of the linked AND logical elements is corresponding to the time series data $m_0m_1m_2m_3m_4$. If the start signal is given from the top, such as eating behavior, the time series data is generated. Conversely, the time series data $s_0s_1s_2s_3s_4$ receiving from the lower part will be the time series data recognition operation, and the end of the U4 will be the recognition finish signal.

The operation listed in the example consists of 5 steps, but if a circuit is set up as shown in the Figure 1, the desired operation can be completed only by one start signal. The next action, such as putting to mouth the food already gotten can be started by the completion signal from lower circuit. In other words, multiple processing with context structure is possible by adding the circuit to the top. In the following, above mentioned operation are more generalized, formatted, and bridging to the universal machine.

In the early stages of evolution, animals grow using the predation as instinct, and many of them end their life in a born environment. Evolved animals move in search of richer foods, safer residence, and fight other animals. In other words, how to deal with events caused in a new environment is an important ability to win the survival competition. There is no need of intelligence for the neural network that only performs the processing required at the production site given by humans. It can be said advanced neural network that can build a processing method even if the situation encountered first time. First, the time -series data intended in this paper is not the time -series data for the specified operation as shown in Figure 1. The target are general strings. This leads to the versatility of the proposed neural network.

As shown in Figure 4, arbitrary time-series data can be divided into multiple subsequences in which the same element does not appear more than once if it consists of a finite number of types of elements. Since divided subsequences can be considered as elements of new time series data in the upper hierarchy, it can be said that any time series data contain hierarchical contexts.

$$c_1c_7c_4c_6c_6c_0c_6c_5c_1c_3c_7c_8c_9c_9c_9c_7c_5c_4c_1 \quad (1)$$

$$\downarrow$$

$$|c_1c_7c_4c_6|c_6c_0|c_6c_5c_1c_3c_7c_8c_9|c_9|c_9c_7c_5c_4c_1| \quad (2)$$

Figure 4. *Time series data can be divided subsequences.*

A neural network that performs serial/parallel processing of subsequences is the basic module, and is called Basic Unit. The limit of finite number of elements is derived from the resolution of the sensory organs and the accuracy of the motile organs. But neural network constructed by Basic Units is logically unlimited expandable then the data strings are recognized and processed using the syntax structure by hierarchically connecting. In other words, the proposed neural network is conditionally expandable toward universal machine. It may be said that there are quantitative and qualitative limitations in the ability of animals, including us, to recognize and process time-series data.

The activity of n-cells ($a_1\ a_2\ \cdots\ a_n$) is represented according activity of the surrounding cells.

$$\begin{pmatrix} 0 & w_{12} & w_{13} & \cdots & w_{1n} \\ w_{21} & 0 & w_{23} & \cdots & w_{2n} \\ w_{31} & w_{32} & 0 & \cdots & w_{3n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ w_{n1} & w_{n2} & w_{n3} & \cdots & 0 \end{pmatrix} \begin{pmatrix} D(t)a_1 \\ D(t)a_2 \\ D(t)a_3 \\ \vdots \\ D(t)a_n \end{pmatrix} \quad (1)$$

Here, w_{ij} is binding coefficient between cell i and cell j, and $D(t)$ is activity decreasing coefficient at time t. When new data arrive to cell, activity of the cell become maximum, $D(t)$ sets maximum value 1. And w_{ij} indicates the degree of connection between cell i and cell j, and the value depends on the activity

of both ends shown as follows:

$$w_{ij} = d(t)c(i, j) \quad (2)$$

Here, $c(i, j)$ presents connectivity between cell i and j. Between high activity cells c generates high value, conversely between low activity cells, the value is low. In both case staying in low activity, connectivity become closer to unrelated by decreasing coefficient according time $d(t)$. Decreasing changes in the connection coefficient are slower than the changes D in case of cells, but in the long term they are involved in the construction of neural network functions such as learning and oblivion.

N(k) is subset of neural network and consisted of cells that are connected each other by coefficient w stronger than constant k, is expressed as follows.

$$N(k) = \cup_{j=1}^{n} \left\{ \cup_{i=1}^{n} c_{ij} \{ w_{ij} | > k \} \right\} \quad (3)$$

By properly selecting k, a set including all the Basic Units in N is selected. Rename N(k) as N, and the Basic Units contained in N are defined as Objects. An ob(N) refers set of Objects in N. That is $\{u_1, u_2, \ldots, u_n\}$. The set of mappings for each u_i and u_j belonging to ob(N) is written as hom(i, j). Furthermore, by adding definition of associativity and identity, Category N is defined. Mapping shows information transmission between the adjacent layers of Basic Unit, and the coupling of mapping corresponds to exchanging information beyond layers. The time series data moves in the Category N while modifying the activation area and continue processing such as serial parallel or opposite parallel serial conversion.

The image of the brain's work, which has been described in neuroscience so far, changes into a more theoretical target by using the category theory. As an example, description by Graziano about changes in consciousness while picking up an apple is presented. [8]

When you pick up an apple, you can process the color, the shape, the smell, the smooth feel, the sound as you bite into it, the taste, your emotional response, and many other related aspects. Each of these features, in isolation, could be processed in your brain without engaging awareness. Even an emotional reaction can run subconsciously. But when consciousness is brought to bear, the components click together into a single, rich understanding.

This kind of observation has led to a consensus view-one of the very few — that consciousness is related to the massive integration of information throughout the brain.

The description above explains that the activated area is integrated and creates a "consciousness" (integrated information theory). In this paper, while avoiding to mention the theme of the presence of "consciousness" or the process of occurrence, etc., show the deformations of activation area by concrete examples. And in later chapters, considerations of the themes such as using of languages and dialogues are more mentioned.

Let S be a category in which the activation region is deforming. S includes not only the extending of images caused by stationary objects such as the apple shown in upper example, but also changes in time-series data linked to sensory and motile organs, such as eating behavior and scenes of fruit falling from trees. The S has the meaning of sequence of event.

S is a category that deforms while processing time series data. The Object in S in the category theory is not the nerve cell itself, but the Basic Unit as Object. Figure 5 shows the deformation of S. This development uses a comprehensive and bird's -eye view of the object, which is a characteristic of category theory.

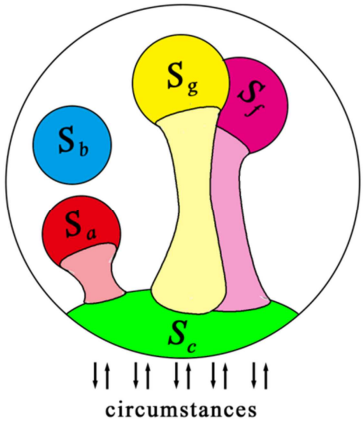

Figure 5. *Illustration of activated area changing in the brain.*

Figure 5 shows the S_a, S_b, S_c, S_f and S_g, where the sets of Basic Unit tied with strong connection. The S_c illustrated in bottom is a part that is linked to the sense of the at motile organs from the familiar situation, and moves the muscles from the shoulder to the fingertips while monitoring a signal showing the load and movement limit. Eating behavior is an example. Hereinafter, the function of S_a, S_b, S_f, and S_g placed at the top of the S_c is described. The transmission of information with S_c is shown in both directions, but specifically, it can be considered a axon or a Basic Unit connection.

The S_a is an image caused by the S_c that the senses obtained when picking up the apple quoted above and eating.

The S_b is a memory of scenes, such as the faces of people nearby, and is not connected to S_c, but may be activated by some situation.

The S_f gets the image of a tree branch with ripe apple from the S_c, and when it is activated, S_c starts to eat.

S_g has the same function as S_f, but the difference is that S_f is activated by apple fruits only, but S_g is activated by pear fruit only. The common thing in S_f and S_g is to start eating S_c. Therefore, even if the apple and pears are not distinguished, S_f or S_g activate S_c to eat. Such a relationship between S_f and S_g corresponds to the concept of “compatible” defined in the category theory.

This development uses a comprehensive and bird's-eye view of the object, which is a characteristic of category theory. Furthermore, the method can be expanded. A new expansion is the concept that regard a category as an object and define mapping between the categories as functor. Figure 6 shows two categories N_1 and N_2 composed of Basic Units, and a

mapping funtor connecting the two. As shown by arrows let map $F(f)$ in N_2 correspond to map f in N_1. It is important that the definition includes for $f, f' \in N_1$, $F(f \circ f') = F(f) \circ F(f')$ as associative law.

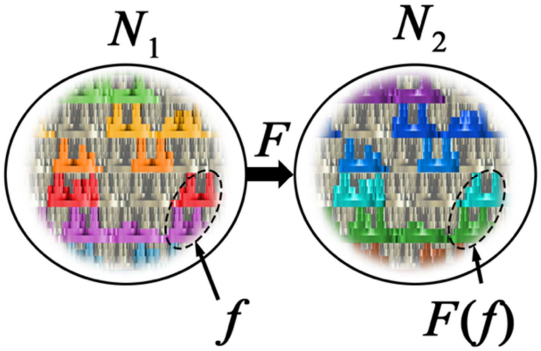

Figure 6. *The functor F between category N_1 and N_2.*

More specifically, although N_1 and N_2 are separated from each other and have different structures, there are interconnections between Basic Unit in N_1 and Basic Unit in N_2, so that similar time-series data behaves similarly in both N_1 and N_2.

There is an experiment that showed that there is a region called “mirror neurons” in the brains of primates and above [9]. Category theory can express the experiment.

In the Figure 7, when the monkey extends his hand H_m to food, the neural network N_1 that observes H_m and the neural network N_2 that controls the movement of H_m are activated. This is because the muscles that move the hand are voluntary muscles, so the movement and the feeling of the result are always paired to perform a series of processes. When the experimenter moves the hand H_p to food in front of the monkey's eyes, it happens that N_2 is activated along with the neural network N_1 that is observing the Hp. As mentioned above, basically N_2 is activated only by observing moving of the monkey's own hand. But the behavior of N_1 is very similar to the behavior of N_2 (both areas are connected by functor). As a result, even if the monkey does not move his hand, N_2 is activated via N_1.

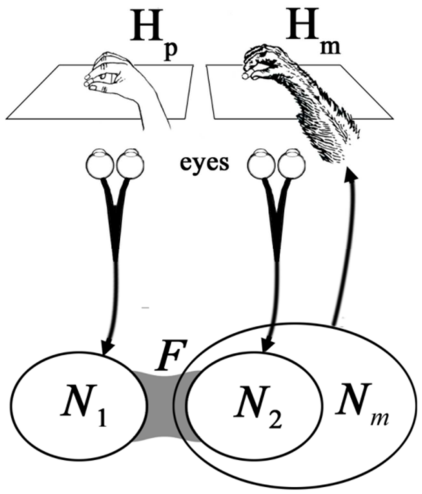

Figure 7. *Illustration of mirror neuron using category theory.*

Copying the binding structure of mapping in the category to other categories is natural phenomenon not artificial. Because that the binding between highly active nerve cells become strong (Hebb law) and definition of Basic Unit is correspondingly compatible. The function of mirror neuron is imitation, but beyond the function various categories connected by functors may encourage associations and analogy etc. Mapping and functor in the category may be considered separately from the neuroscience side. Functor has a long information transmission distance and has no branching or merging. It may be involved in the function of glial cells, etc. [10]

3. Getting Knowledge by Dialogue

What is the essence of the intelligence that characterizes human beings? Let's think in comparison with other animals. As a familiar example, let's take a look at putting some tricks on pets. Pets understand the owner's instructions only when there are pets on the spot. If we scold or praise about what the pet did the previous day, it would not be understood to the pet, and it is impossible to promise to do the next day. By documents and hearings, we know that some types of mushroom and fish have poison and do not collect them. How can be gotten this sharing knowledge without a language? Is there any animal except humans who can explain to their friends as "The XX I just ate was bad, must not eat" while suffering from poisoning? In the cave where anthropoid apes lived, even if any tool or murals cannot be found, if a polished stone that is not in the area is found, the stone is evidence that a language -based culture were existed. Because the type of stone that is not in the area means that it was transported from the production area by trade, there are tools to polish the stone, and that is an indispensable tool for some kind of rituals to be kept without being lost. This is, it indicates that such values were added and transmitted beyond generations. Only language can perform such a society. [11, 12]

The neural network already shown targets the "real world" that can be operated by voluntary muscles based on the information from the sensory organs. The proposing new neural network targets "descriptive world” and is connected on the conventional neural network that targets "real world". [13].

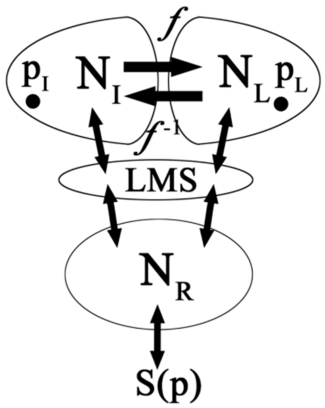

Figure 8. *A processing scheme of the brain oriented neural networks with long-term memory and language ability.*

In this chapter, Figure 9, which is simplified figure the lower part of figure 8 in order to focus on the dialogue process. In short, the following theme are the dialogue process in the "descriptive world". Assuming that there are neural network N'_L and N'_I, which is equivalent to N_L and N'_i, which is equivalent to the dialogue partner. Figure 8 is presented in previous paper. [14] The simple explanation as is follows.

The N_R drawn at the bottom is the neural network already shown, and is a model of the basic part of the animal's brain that lives by manipulating events in the area that can be recognized by the sensory organs using limbs etc. Long-Term Memory Synthesizer connected to the N_R take out essential information in the various "reality" handled by the N_R at the bottom. The information is transmitted to top arranged neural network N_L and N_I. N_L can be considered a language processor, and N_I is a neural network like image processor.

The neural network N_L is simplified from the original figure, but is tied to the ear and mouth, and exchanges information with friends through voice. The neural network N_I is connected to N_L, and when a category in N_L is activated, the corresponding category in N_I is activated. In short, it is a symbol and an image correspondence, and it is bidirectional.

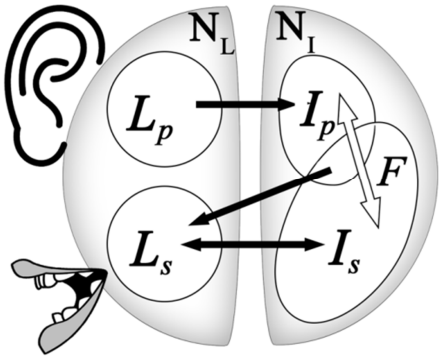

Figure 9. *Simplified figure the lower part of figure 8.*

The corresponding relationships are generated by conditional learning or the microscopic view that binding between high activity nerve cells become strong by the Hebb rule. In Figure 9, L_P is an area that was activated after hearing the remarks of his fellow. I_P is an image activated by L_P, L_S and I_S are the activated part of the words and images in the own neural network N_L and N_I. When I_S is activated, the corresponding L_S is activated, but it does not necessarily speak out. Because L_S can be activated by the inner muttering.

When a friend says, "Cosmos blooms in autumn," the areas corresponding to Cosmos, autumn, and flowers are activated in N_I. In this case, it is not necessary to return words to friends because it matches the area that has been activated many times in N_I. However, if a friend says, "Cosmos blooms in the spring," the inclusion of areas that is corresponding to cosmos, spring, and flowers will greatly different from the area where the previous remarks activated. The final situation of the dialogue is that the two people are convinced, and the discrepancy in the inclusion is settled. In that case, the own image I_S is equal to I_P activated by a friend's remarks. At that time, appears the mapping F shown as f in figure 9. This mapping F is a functor between the categories, and is a mapping used in the previous chapter to explain the imitation function.

Specifically, it is necessary to share any of "Cosmos blooms in the fall" or "Daisy Bloom in the spring" as knowledge. In order for both sides to be convinced, it is necessary some message exchanges while trial and error.

The exchanges are time-series data containing cosmos, daisy, spring, autumn, blooming and negative words of them. By reforming the data such as replacing order of words data have various formats such as questions, negative sentences, and supplements. The motivation to start dialogue is the inconsistency of the inclusion. Sometimes the words that stir the emotions of others are mixed.

The example mentioned above is an object that can be recognized in the shape, but the "descriptive world" is wide. The world includes past events, events that may happen in the future. As well as mind or soul cannot be recognized in the shape. We know that the feelings of joy and anxiety are different for each person. It is not possible to obtain shared knowledge simply by resolving the above inconsistencies in inclusion relationships. Research into neural networks may be close to the realm of philosophy. [15, 16, 17]

4. Conclusion

The beginning of my idea of Basic Unit was around 2004, I thought that the function of nerve cells is not only image processing. There are many ways to embody. One of significance of incorporating the characteristics of the nerve circuit in an electronic circuit is a self -repair function using redundant structure. The function is a mechanism in which not only changing logical element unit, but a dormant circuit learns the necessary functions and changes into a circuit that accepts alternative functions. Humans will be able to recover functions lost due to cerebrovascular disorders by rehabilitation. The micro technic of the semiconductor circuit has contributed to such as miniaturization and power saving. The future development may be the addition of self -repair functions that improve safety and reliability. The idea of replacing in a function unit, not a logical element unit, is based on the mathematical perception of time series data. The category theory that captures the subject in a comprehensive and bird's -eye view seems to be suitable for the development of this field. Although the subject of categories theory contains the field of mathematics, such as intuitionistic logic, the definition of the category theory is flexible, and ambiguity set's deforming can be subject of theory. It can be said that it is a tool suitable for research on neural networks.

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