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Research Article

Knowledge Exchange Between Neural Network Toward Dawn of Language

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Abstract

In this paper, the nervous system is composed of a combination of common structure components, indicating that the hierarchical structure may lead to a great evolution to cognitive function extending eating behavior. The common component (basic unit) is a set that combines neural circuits to cylindrical forms, and the basic unit has an affinity with the structure of pillars, barrels, or blobs in neuroscience. Use multiple input and output to achieve a variable value function. By connecting a basic unit in a hierarchically, it can be done more complex time -series data process and can be add almost unlimited. Time series data is saved by repeating judgment and action. Save data includes not only food and other objects, but also surrounding situations. If the new situation resembles the elements of the time that is already recorded, the approximation element becomes active and the activation spreads throughout the past time series data. Time series data is constantly updated with processing. As example, reality turns into a new cause, and prediction turns into a new reality. If the two areas are often active at the same time, even if only one area becomes active, the corresponding areas will also change. This learning function corresponds to Hebb's law in neuroscience. This feature is the basis of imitation and conditional learning, enabling people to communicate with fellows and enabling collective actions. This ability is an indispensable ability to build a society and is the beginning of a language. Languages can express events not only in the past or future events, but also in places where sensory organs cannot reach. It has been inherited for generations as a culture. In this paper, a new layer is proposed at the top of the neural network that has evolved from eating behavior. The processing of the new layer is asynchronous with the lower layer, but it performs a complementary process and enables event communication with friends. This ability is the basics of language. The process of forming common knowledge exchanging questions and teachings between two neural networks is shown a simple example.

Keywords

Context Corresponding Neuron Layers, Getting Knowledge by Dialogue, Basic Unit, Dynamically Recognize the Object, Dialog Between Fellows, Descriptive World in Brain, Real World in Brain, Modal Logic

1. Introduction

Neural network research aims to build an intelligent system. However, it is difficult to define what intelligence is. The act of creating and evaluating art works such as literature and painting is an intellectual act that only humans have. But the behavior of monkeys and birds they eat using branches may be not called as intellectual. It is thought that the origin of cognitive science begins with the consideration of Plato in B. C. After that, for a long time, the subject of consideration was

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expressions based on personal thoughts such as philosophy and psychology. However, from the second half of the 20th century, experiments and measurements of brain structure and behavior have been added to consideration. In addition, software with a combination of modules corresponding to the thought process participates in the realization of intelligence. Today's stage of cognitive science can be seen this way.

When multiple fields come together, it becomes an inter-disciplinary as a natural course. Because of the wonderful combination position, there are some different areas that shake each other's claims. Even if discussions in each field are logical and systematic, it may be an understanding of the area cultivated only in the field. It is subtle, even if such an unexpected situation cannot be said to be illogical from other fields, and the thesis is regarded like prose. Terms such as "target", "reward", and "penalty" come from psychology, and each has a brain -related part. However, we cannot make sure in detail how individual nerve cells work due to our emotional fluctuations. The system can be assembled by combining software modules that imitate the behavior of each part of the brain by imagination. But can it match the knowledge of neuroscience obtained by equipment such as fMRI: Functional magnetic Resonance Imaging? Another example of contradiction between software and neuroscience is the backpropagation method often used in the learning process. Neurology has not confirmed the existence of the corresponding algorithm. Even if the system based on imagination is highly evaluated by the industry side, not the neuroscience side, it is inevitable that the belief and personification of researchers are involved in the construction of the thought process. As a result, the common understanding of each field becomes ambiguous. In other words, “each field are jostling for position in a coalescence that may illusory” [1].

Looking back on the development of science, in all academic fields, the common understanding of the early stages that lacks clarity shakes with each other, but when a theory that integrates various theories and speculation is presented, the degree of completeness increases. Let's consider the path of discussion of the astrodynamics, which created the universal theory of gravity and relativity. What is clear there is that even phenomena that are recognized as extremely local phenomena may change their worldview if there is a clear logic supported by the experimental results in the explanation of the phenomenon.

Let's return the explanation object from space to the neural circuit. If the object is basically built with a unit with similar functions, the results will be spread throughout the units, even if the initial state transition of the unit that makes up the object seems to be small and local. More specifically, when animals accept changes in the environment through sensory organs, changes in the macro state of the brain occur due to changes in the microstate of sensory organs. In other words, a world -class movement, a world described in the astronomical example of astronomical physics described above, corresponds to the recognition process that progresses in the animal's brain. The more logical the cognitive process, the more it can be called "scientific" knowledge. The act of manipulating tools with motor organ such as limbs and changing the environment based on accurate knowledge may be called “technology."

In the discussion of cognitive science how much detail is needed about objects? Neuroscience explores the behavior of nerve cells in general organisms, but what cognitive science pursues are the actions of sensory and motor organs of animals. Among them, eating behavior is an essential ability even for animals in the very early stages of evolution, and the basic movement may be realize by junior high school students by combining electronic circuits that mimic sensory organs and motor organs. Therefore, it is not unnatural to think that the ability of more evolved animals is realized by the combination of the above -mentioned eating behavior mechanism. This paper indicates that basic behavior, including eating behavior, is realized by connecting a general component (de-fined as a basic unit). The hierarchical connection of the unit is logically unlimited, indicating that it can be deployed to advanced functions beyond eating. The target is time -series data, is not still image only. Animals live surrounded by moving objects. The chased animals are not in the same form by always changing their direction or hiding behind the scenes. Even static objects such as fruits have various images depending on the viewing angle and light conditions. In the proposed neural network, not only changes in the object itself, but also the surrounding sensory information is stored in time -series data. The active area is growing like a branch and produces a tree shape as the processing of time series data. The data arranged in the shape of the branch is a past result, which can be obtained from prediction and analogy. When multiple areas become active at the same time, the connection between units contained in each area is enhanced, and one of them is eventually active, and one more active. This action not only helps imitation and conditional learning, but also leads to basic language functions.

The logical scheme is a generalized configuration of cell automaton. Neuroscience knowledge based on Hebb's law can be reflected in the format of status transition functions without inconsistencies. Even if the number of possible conditions is limited, the logic can be advanced if the resolution is comparable to the accuracy of animal sensory organs and motor organs. The length of time series data is limited to the complexity of the neural circuit, but there is no logical restriction by hierarchical processing. The previous papers does not define the operation between the set of negative operations of the basic unit. [2-5]. In this paper, the introduction of a negative coupling can apply to a series of nerve circuits. By applying this function to the new layer at the top of the neural network, the recognition process can be expressed in the form of modal logic. Development in modal logic may be the entrance to the most intelligent field of cognitive science.

2. Dynamically Recognize the Objects

This section first shows the importance of handling time series data in object recognition using examples of familiar natural phenomena. Neural networks dealing with time series data have an affinity with the knowledge of neuroscience. It can be extended to the general logic of perception and action by hierarchical connection.

Animals of very early evolution take action by feeling hungry and go into standby mode once satisfied. This level of operation may be achieved by combining sensors, logic circuits, and actuators (Figure 1).

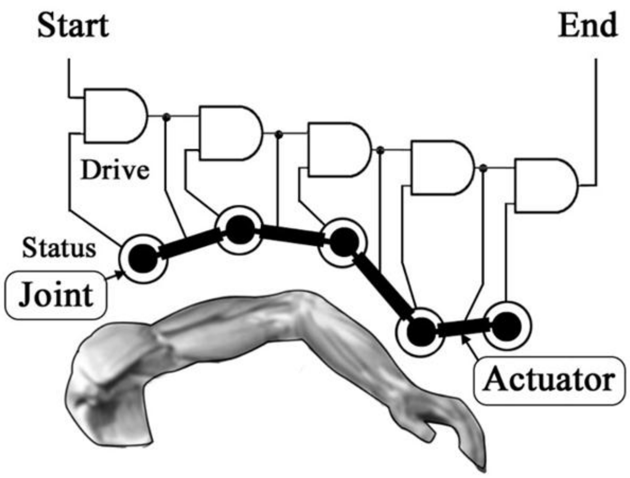

Figure 1. *A simple machine imitating predation behavior.*

However, more evolved animals recognize the situation from the sensory organs, predict the next event from similar situations in the past, determine what actions should be taken, and direct the results to the motor organs. The success rate is increased by trial and error. The system with the built-in program to simulate this cognitive process has much higher processing power than the circuit shown in Figure 1, and its applications are expanding from industry to daily life. However, it was the computer that brought about the evolution of the system, and it is the result of incorporating a different kind of mechanism from the evolution of the sensory and motor organs that animals have. Was there such a leap in the history of animal evolution? Computers may just be running programs that are built according to human desires and fantasies. A similar problem is called uniformitarianism evolution vs. radical evolution in biology and is being discussed especially in relation to the origin of language.

The purpose of this section is that the function of the neural network, which can be logically shown, can be realized by combining the known function of the nerve, that is, a circuit with basically equal functions as a common component. Therefore, this method belongs in the direction of affirming uniformitarianism evolution, but in the process may be fall into a situation that is rather better to assume some radical evolution. And the situation will may trigger research and development.

The upper part of Figure 2 is an image of leaves falling. Each leaf has almost the same shape and moves in almost the same direction due to the action of wind and gravity. Most animals living on land recognize that they are not animals because each object does not move independently in this situation. The shape of the leaves instigated by the wind changes every moment, so there is no representative shape. However, if some of the new time series data is similar to some of the past time series data, each time series data will be activated, and a new situation will be created. The most active is the time series data S (B) corresponding to the latest image, but the next active is the time series data S (A) and S (C) saved by the past leaf flow A (displayed in green) and C (displayed in brown). S (B) is also activated from both S (A) and S (C). This state (displayed in a circle) is activated based on past state transitions and may function as a prediction.

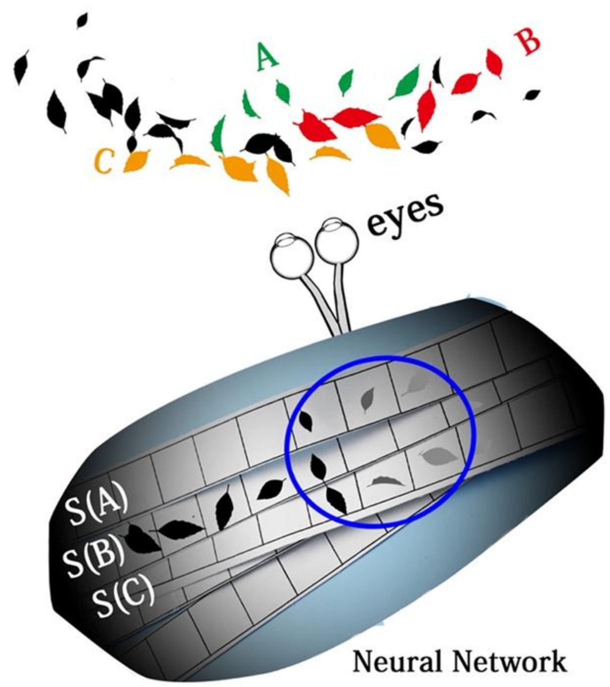

Figure 2. *Neural network capturing the moving objects.*

The time series data of moving things such as falling leaves is a huge amount. Functions used in methods such as pattern matching, and the Markov process need to assume logically possible patterns. However, only a small part of what you need for a normal life. For example, the number of strings within 10 characters that can be obtained by using one of the 26 letters of the alphabet only once is 3,268,760, but in our daily life there is no inconvenience if thousands of words are known. Parrots and parakeets often imitate human spoken language, but their abilities are not fully used among their peers. Just by combining 5 types of pronunciations, 153 kinds of messages can be marked, but their abilities are not fully utilized among their species. In animals, the species that have achieved maximum functional improvement with minimal instrumental evolution in the process of evolution will win the competition for survival. The evolutionary path of animal cognitive ability and the path of industrial technology development are different. The idea that any function of a neural network can be realized by a combination of components with equivalent structure is not derived from the anatomical knowledge of neuroscience, but from considerations of the logical generality and integrity of neural circuits. Before talking about the configuration of the above neural network, lets define the basic columns included in the time series data. The basic column is a sub-column of general time series data and corresponds to the neural circuit construction that processes the sub-sequences. The type of elements that make up the time series data are limited, but the lower limit of the type's number is not concerned to the essence of the discussion if it is comparable the resolution of the sensory organs and accuracy of the motor organ's movement.

For simplicity, let the elements of the time series data be 10 from a_0 to a_9. The example shown in Figure 3 shows that any time series data (1) can be divided into series of sub-column.

$$c_1c_7c_4c_6c_6c_0c_6c_5c_1c_3c_7c_8c_9c_9c_9c_7c_5c_4c_1 \quad (1)$$

$$\downarrow$$

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

Figure 3. *Dividing series data into series of sub-column.*

The dividing is done by the following procedure.

1) Let the first element be the beginning of the sub-column.

In the given example, the top element is c1, followed by c7, c4, and c6 are included same sub-column. In addition, when the next condition holds, the new element becomes the first element of the next sub-column.

2) If the element is same as the element that is already in-clouded in the sub-column, the element is regarded the first element of the new sub-column. In this example, that is c6.
3) If the maximum length（relating to the length of the nerve）is specified in the sub-column, the next data that reaches over the maximum length should be the first element of the next sub-column.

By naming each sub-column as an element of new time-series data, the new time-series data became one level higher time-series data. The hierarchical structure obtained by this iteration is reflects of the syntactic structure inherent in time series data. The neural circuits in the neural network corresponding to each subsequence are easy to construct and have an affinity with the anatomical knowledge of neuroscience, as described in the next paragraph. That is, the contextual structure of time-series data is reflection of the activation transition in the neural network. The basic circuit that makes up the hierarchical structure is called a Basic Unit and has bidirectional function that is serial-to-parallel conversion and its inverse conversion.

The neural circuit shown in Figure 4 is not a newly devised circuit to realize the basic units described above. A similar structure is a cylindrical set of nerve cells connected by axons branching from the bottom to the top. These are modules called mini-column, macro-column, barrel, stripe, blob [6, 7], etc. in neuroscience. In addition, similar structures can be seen not only in the neural circuits of the brain, but also in the spread of blood vessels, branches, and plant roots. This is familiar to the idea that the evolution of animals consists of the accumulation of gradual evolution and not because radical change (catastrophism) occurred (uniformitarianism).

The Basic Unit is a neural network with multiple inputs and outputs. The part that contains the element that received the first data c_0 and became active is U_0. When U_0 receives c_1 following c_0, the element activated by c_0 is further activated. The elements that are additionally activated by c_1 are not all elements of U_0, but that is the set of elements already activated by c_0 and called U_1. The activated area become narrow as receiving c_2, c_3, and c_4. The fact that U_4 became active after receiving c_4 indicates that the time data $c_0c_1c_2c_3c_4$ is recognized. The U_4 output is called d_0. In general, multiple regions are output the same as d_0. The binding between the elements of the Basic Unit is strengthened by repeatedly receiving data, and the corresponding region is activated only by receiving the top part of the time series data. In other words, the basic unit learns the time series data. As shown in Figure 4, after the learning progresses, the basic unit recognizes the signal from the bottom as time series data and outputs the result above. Furthermore, when it receives a signal from the top, it outputs the time-series data corresponding to the signal downwards. That is, it acts as a two-way converter. Meanwhile, the activation level of other parts without new activation coefficients decreases and returns to the initial state.

The time -series data of the flows of leaves in Figure 2 may contain flow patterns that have characteristics such as vortex and turbulence caused by nearby disorders. They are unnecessary patterns called noise. When developing a system that determines whether the necessary patterns are included in time series data, the conventional engineering approach includes the following steps: First, collect data that contain the necessary patterns and collect data that do not contain. Next, develop a means to easily achieve both set classifications. However, natural animals are born with the ability to classify the data required for survival. In addition, they grow up this ability from parents and friends and win the battle for survival. Why do animals have the innate ability to classify data? This is be-cause, as shown in the example of splitting time-series data, hierarchical structures are inherent, and bundles of nerves with many branches correspond to a certain kind of hierarchical structure, which triggers cognition. Changes of areas with high activity in neural network are affected not only by the movement of the sensory organs and motor organs, but also by nearby areas with high activity.

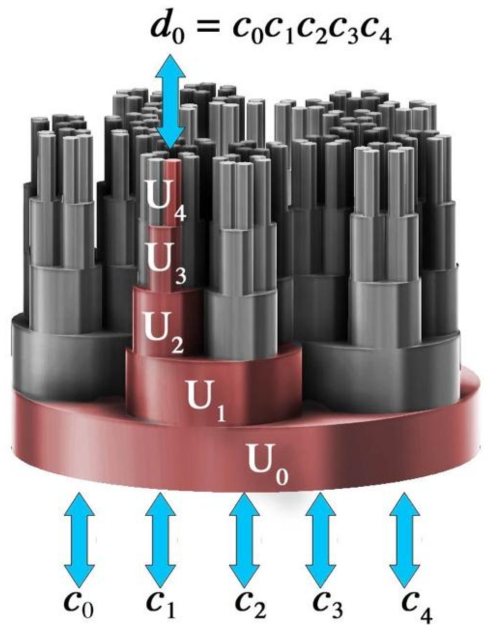

Figure 4. *Concept of bidirectional conversion by neural circuit.*

The following describes the mathematical representation of the macro movement of the activated area in the neural network, including the Basic Unit.

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

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

Here, w_{ij} is the coupling coefficient between cell i and cell j. If the activity of cell i at discrete time t is $a_i(t)$, then the activity at time $t + 1$ is expressed by (2).

$$a_i(t+1) = \sum_{j=0}^{n} w_{ij} a_j(t) \quad (2)$$

The coupling coefficient changes depending on the activity at both ends. If the activity of the cells at both ends is high, the coupling will be stronger, and if the activity of both ends is low, the coupling will decrease. If the state of low coupling continues for a long time, the coupling coefficient will approach zero, essentially resulting in no coupling. Although the change in the coupling coefficient is slow compared to the cell activity, the change in the coupling coefficient is related to the learning function.

$$S(k) = \bigcup_{j=1}^{n}\{\bigcup_{i=1}^{n} c_{ij}\{w_{ij}| > k\}\} \quad (3)$$

As shown in (3), a set S of cells with inter-cell connection strength of k or more is defined as a subset of the set N of cells. There are multiple S-like areas in the brain, each connected to different sensory organs, motor organs, and even digestive organs that signal hunger. The state of S can be thought of as the situation of a part of the brain.

By appropriately selecting k, each S can be made to include cells that make up a Basic Unit. Basic Units in S are treated as objects in category theory and are denoted as ob(S) = {u_1, u_2, …, u_n}. The set of mappings between each u_i and u_j in ob(S) is defined as hom (i, j) in category C by defining the associative law and the identity law. Mappings between categories have the function of transmitting the processing of Basic Units, and specifically, they may correspond to the functions of axons and glial cells in the brain. Time series data moves through N while changing the activated area, and processing such as serial-parallel and inverse-parallel-serial conversion is performed. If the coupling coefficients between cells change during the processing process, the number of elements in S increases or decreases. The Figure 5 shows how the results of processing in the Basic Unit in S_1 below affect the activity of S_2, S_3, and S_4 above, and how the results of processing in each Basic Unit are returned to S_1.

Neural network capturing the moving objects is a characteristic of category theory, is suitable for expressing cognitive functions. As an example, Graziano's explanation of the change in consciousness when picking up an apple is shown.

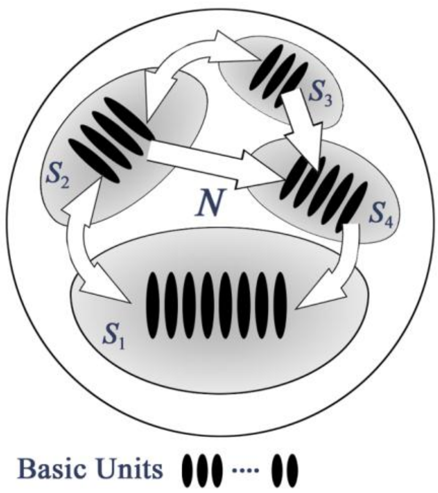

Figure 5. *Activated areas move with the process of BASIC UNITs.*

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. [8]

The above explanation shows that picking up an apple activates various areas, and then these areas are integrated to create "consciousness" (Integrated Information Theory). The following next example is concerning to recognition process for the scene (Figure 6).

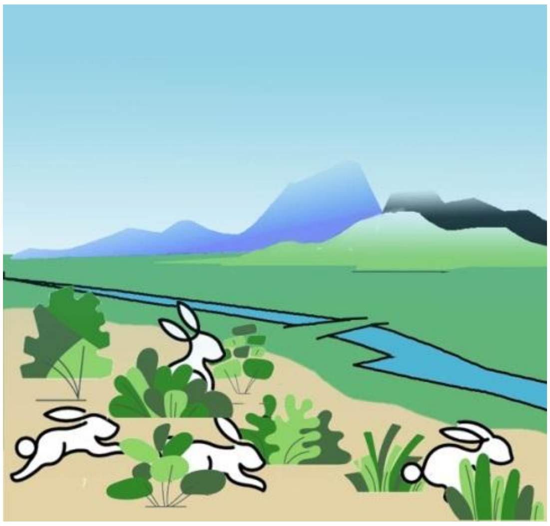

Figure 6. *The image of the hometown that animals might have.*

The example in Figure 6 is about the recognition process of the scene. In this example, the target time series change is incorporated. Although the existence of "consciousness" and the process of developing are not mentioned, the use of alignment may express various aspects of the recognition process. The target animals encountered in the scene in Figure 6 move between the plants in the foreground, hide in the shadows of the plants, and change their posture in various ways. However, the target animal that is paying attention from time series data is recognized as rabbits. For animals that have lived in this area for many years, the river that catches the fish and the mountains beyond it should be engraved in the brain as an unforgettable landscape of their hometown. However, it cannot be expressed and communicated to friends. Only humans who can use language can do that.

3. Dialogues between Neural Networks

This section describes the movements of the activity area in the neural network in the category theory following the previous section. In the first half, a neural network with the ability to imitate and conditional learning is explained. In the second half, the neural networks that expand the learning system described in the first half and add new layers to enable dialogue between neural networks is explained. At the bottom of Figure 7 is a group of birds that escape by carnivorous beasts. And at upper side a neural network for bird brain is indicating. Block 1 is a neural network that responds to images and sounds captured by sensory organs that recognize beasts and bird songs. Block 2 is connected to the motor organs those are preparing to escape and shouting of the warning.

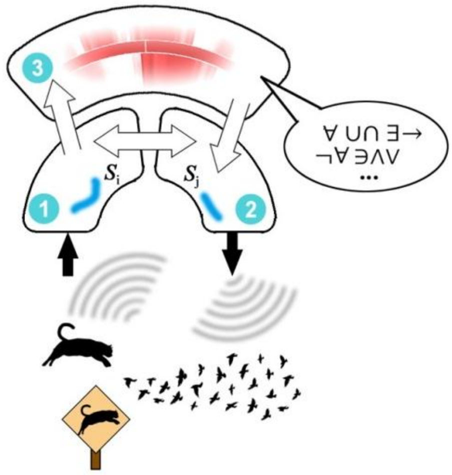

Figure 7. *Animal's condition learning.*

The mapping which connects block 1 and 2, has the role of sending information about the movement of the motor organs, such as the degree of load obtained by the sensory organs. In our daily words, it plays the role of reflexes. When the statue of the beast is captured in the retina of the bird's eyes, the time series data from the visual nerve is transmitted to the block 1 and activates the area SI. The activating trigger is come from sensory organ, so the active state does not last long. But next, in block 3, the area corresponding to SI of block 1 is activated and makes the copy of Si. (See figure). The active status of block 3 lasts longer than block 1 and holds by long -term memory. In block 3, if there is already similarity between the time -series data activated by block 1 and the time -series data that already exists in block 3, the bond between highly active elements will be enhanced. The newly active part can be considered as joint of two time series data, and the next time series data is executed by this new neural circuit. These are conditional learning and imitation functions. The flow of this process is equivalent to the classification of the stimulus by Bool operation.

Since the block 3 consist of time series data, connection of the front and rear events is defined. If the first element of B is connected to the last element of A, new time series data AB is defined. This indicates the causal relationship in the case of "If A is B". The spreading of active area causes by not only similarity between elements but also time-series data syntax. An important feature gained through the learning process is imitation. Learning the movement by looking at the behavior of friends and parents is to observe their actions and move motor organs of self to do same. The nervous system, which plays an important role in this process, is called a mirror neuron [9]. Above mentioned time series structures can be constructed using mapping between categories. The development of symbolic logic based on the category theory are various [10, 11].

It may seem like a leap to apply logical symbols in the inference action of a language-less animal. However, their actions, which have lived through rigorous survival competition, are supported by a lot of knowledge and experience. For example, carnivores such as lions that attack herbivores such as zebras estimate values such as the enemy's physique, muscle, and escape location, and wait in a place that matches their endurance of chase before attacking their prey. There is no mathematical strictness, but various logics are built on multiple layers. The results of learning are inherited by parents as skills in life. How many steps does it take to write down these learning processes in a traditional programming language?

In the example of Figure 7, where the birds are being chased by a beast, even the birds that have never seen the beast will sense danger when they hear the cries of their fellow birds and will run away screaming themselves. In other words, both the image of the beast and the cries of their fellow birds are predictive of danger for the birds. That is, the cries of their fellow birds are a form of information transmission. But if a sign with a picture of a beast, like the one shown in the bottom left of Figure 7, were placed in this place, would the birds run away? They would probably just see it as a dirty wooden board. Here, an important theme is hidden about communication between animals. Even animal fMRI: that do not have language often learn the instructions of their pet owners. Some birds, such as parrots, imitate human speech, but no pet follows the parrot's instructions. In addition, pets cannot ask questions like "What is this?" For apes who started walking, it took tens of thousands of years to exchange knowledge with friends. However, the view that they began to use language because their brains had undergone dramatic changes in the meantime may be debatable.

There are groups of monkeys and birds that use wood branches as eating tools. In their society, the inheritance of "technology" occurs by watching and learning from the methods of their parents and friends. To train pet, must give reward or punish immediately after the attempt. Never blame them for past behavior or postpone the reward. On the other hand, humans for necessity of life, need to grind stones or knead clay to make weapons, tableware etc. The group working on the task hopes that the results of the task will eventually help realize a richer and more enjoyable life. In other words, language is the only way to communicate the purpose of everyone’s actions within the group. The model shown in Figure 8 describes interactions involving language between neural networks as an extension of conditioned learning such as imitation. The two sets, upper and lower, are extensions of the neural network shown in Figure 7, with new blocks 3 and 4. Block 1 processes images brought about by visual information, etc., and block 2 processes language. The top layer of the neural network consists of blocks 3 and 4, with block 3 being activated by image-derived time series data from block 1, and block 4 being activated by language-derived time series data from block 2. Blocks 3 and 4 normally operate asynchronously with the lower blocks 1 and 2.

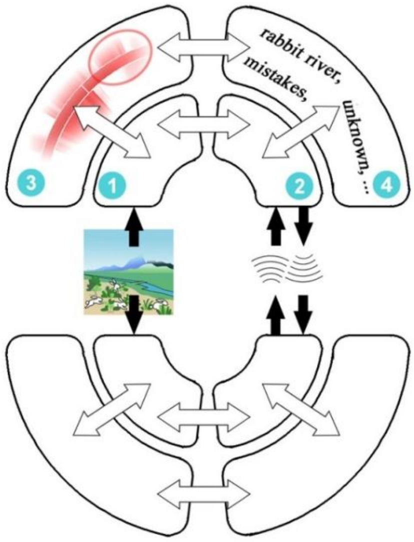

Figure 8. *Dialog between 2 neural networks.*

The timing of synchronization of behavior is when the time series data contained in the activated areas in the blocks are similar above and below. For example, when you are searching for lost thing, if you find that, you recollect the situation when you were last holding it. And also, in a long commentary, inserting "For specifically...." would have the similar effect. On the other hand, while both are not synchronized period, block 3,4 and mappings connecting both blocks remain active. and in the long-term memory, selections and reconstructing of the events those have been experienced are done. This behavior may be able to correspond to the activity of the brain during sleep.

The two neural networks shown in Figure 8 begin with a hierarchical relationship, like that of a teacher and a student, but the exchange of messages is on an equal footing, and knowledge sharing can be achieved by repeated message exchanges. Both neural networks are assumed to live in the environment depicted in the center left of the figure, experiencing various events that occur there. Each event has a name shared by the two neural networks. The exchange of messages, shown by the arrows on the right of the center, is two-way, but the medium is not limited to voice. They communicate using gestures, models, murals, letters, etc. [12]

Examples of the two neural network dialogue shown in Figure 8 are started in a hierarchical relationship like teachers and students, but there are no restrictions on both sides, and the same knowledge can be achieved by repeated questions and answers.

First, the student asks, "Is rabbits swim in that river?" The question is processed by block 4 and activates images, including the river held by the teacher in block 3. Block 3 creates two types of rivers. One is presented by student, and another is the teacher have for a long time. Rabbits do not swim in the river, so the elements that support two active images do not match. The mismatching situation is circled in the block 3. The status of this mismatch is sent to block 4, and words such as mistakes, unknown, lies are activated. The teacher answers to students that rabbits are not in the river and explain the types of fish appending to the other person's knowledge. After hearing the teacher's explanation, students can ask questions about the means and timing of fish capture. Teacher would know that as repeating such questions and answers, students' questions will correct knowledge in the long-term memory. Then, they may be convinced that they have been able to share the basic knowledge of the river and finish the question and answer. Gained knowledge is also spread to third parties.

4. Conclusions

The idea that all functions of neural networks can be realized by combining common structural elements has an affinity with anatomical knowledge of neural circuits. In this paper, the mechanisms of conditional learning and dynamic recognition are explained using category theory. The concept of category theory was also useful in the development of language functions. On the other hand, when considering consistency with symbolic logic, there is a problem that the correspondence with Boolean operations cannot be well defined unless some supplement is made to the Hebb rules in the neural circuit. This is a subject including neuroscience.

The left and right blocks at the top layer of the neural network have a function to tie between the event and the word. This is an indispensable function to establish communication. Since each block handles the time-series data that contains syntax structure, it has a structure suitable for capturing not only languages but also dynamical objects. Therefore, it seems that there is no major barrier to write this part in a programming language and run it on a computer. Although there is no affinity in terms of sensory organs and motor organs, it would obtain meaningful results by incorporating this function into familiar devices. This function can be considered as ChatGPT's extension. And we may enjoy spending time talking to this "nerve pet" like a friend or partner. Regardless of this possibility, I hope that the consideration of the dialogue function described in this paper will be a hint to think about human mental act.

Abbreviations

fMRI Functional Magnetic Resonance Imaging

Author Contributions

Seisuke Yanagawa is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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