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Communication Between Neural Networks, and Beginning of Language

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Abstract: There is a view that the cranial nerve circuit is composed of a combination of the same modules as the basic functions. According to that view, the author has presented the module (Basic Unit) that performs parallel-serial mutual conversion and has shown that the neural network that recognizes and generates arbitrary time-series data can be constructed by combining the module. In Chapter 2, the neural network that has the functions of federated learning and imitation that enable collective behavior of animals is shown, and added an idea of concrete circuit configuration to published papers. In Chapter 3, following a consideration of the fundamental role of language, a neural network with the same basic structure connected to the upper level of the neural network shown in Chapter 2 but with functions closely related to language is presented. The new neural network consists of a pair of neural networks that handle languages and images respectively. Each activated part is expressed using the Category theory concept. Category's entity is a set of Basic Units connected each other and changes of their state. The activated Categories are tied with the corresponding activation part in the pairing neural network, and interconverting is performed. The state of the Basic Unit may be inspired by sensory organs, but behave independently of the actuating behavior of conventional neural networks connected to the low position. Humans can generate an image of events that may occur in past or in future even if that are not directly related to the situation in front of the eye, and share their images by dialogue. The dialogue consists of time series data with a response format such as question or negation. The newly added neural network helps generate shared recognition.

Keywords: Short-Term Memory, Long-Term Memory, Serial Parallel Conversion, Parallel Serial Conversion, Mirror Neuron, Prediction, Category Theory, Federated Learning

1. Introduction

Many of the animals that live in groups exchange information such as the existence of food and the imminent danger by crying and gesturing. Wolves hunt in groups, and small fish swim in groups reminiscent of giant creatures to intimidate foreign enemies. The calls and gestures they make are not recognized as a language because they do not have a grammatical structure. If they evolved to use language, they would have an overwhelming advantage in collective action. There is a theory that the first animal to use language is Homo erectus, which evolved from a chimpanzee and a differentiated human race and appeared about 2millon years ago [1]. In other words, it is claimed that their lives changed and culture was born because they had the ability to introduce grammatical structures into time-series data composed of calls and gestures. Regarding the acquisition of abilities, Chomsky have the view that the radical evolution (catastrophism) that a new area was born in the brain has resulted in the acquisition of the ability [2]. Uniformitarianism has persuasive for the catastrophism. According the theory, the natural phenomena that is currently occurring is a stack that the natural phenomena (evolution) has also occurred in the past, and the evolution of the living things occurs slowly for a long time (gradual theory).

There is no grammatical structure in cry and gesture, but animals that have evolved to some extent use cry and gesture with a syntax structured as a powerful means of communication. There are many species of insects and birds that identify their fellows using cry and gesture. The time series data defined in this paper also has a syntax structure. For example, eating action, which is the most basic operation

of animals, starts with the recognition of the existence of food, extends the arm toward the food, opens the fingers when approaching, and closes when it comes in contact with the food. This operation can be realized by combining logic gate of such as AND, OR and NOT in junior high school level electronic work. The number of nerve cells in animals in the early stages of evolution living with this level of ability may not be so different from the number of elements used in electronic work.

Animals in the next evolutionary stage perform more complex behaviors including judgment in addition to feeding behaviors. For example, it has a function to judge whether to eat all by oneself or to share for the family depending on the amount and type of food obtained. In other words, a function one level higher that selects processing according to the event is required. By combining nerve cells with functions equivalent to the logic gates used in the above-mentioned electronic work, it may be possible to construct an address decoder for reading data in a specific area of the brain and the circuits that selects the operation according the state of the sensory organs. If the nervous system corresponding to these circuits are discovered in the brain, it means that there has been a catastrophic evolution. However, the changes known in neuroscience are gradual evolution, and such as back propagation processing is not beyond that.

The next chapter shows a neural network that recognizes and generates general time series data. The model is all living things, including us. It is thought that they are living by judging the situation in which they are placed on the time series data obtained from the sensory organs and creating a optimal time series of actions to protect themselves. The proposed neural network is a layered connection of modules with basically the same function and structure, and information is exchanged between layers in both directions. The essence of the operation is the ability of imitation and conditional learning in the hierarchical processing of bidirectional time series data according to the segmental structure inherent in the time series data. The explanation of the operation was given in the published paper [3], but this chapter describes it in a simpler and more feasible way. It is composed of elements that are different from conventional electronic circuits, and operates according to Hebb's law. It has the ability to imitate and condition, and shows, for example, the behavior of animals that alert their peers by barking. The ability to imitate and condition is the basis of behavior using symbols, and group behavior using this ability is considered to be the first step toward acquiring language ability.

Wild animals that live alone with prey and food cannot dominate against group of organized animals with vast amounts of information by only strong strength. If they have a language, the usage of the devised tools will be passed on to their friends who live in remote place across generations, and they will not only get advantage to a power struggle but also able to enrich their lives. The essential function of language is not only to explain the situation in front of us, but also to explain the situation to the party who is not in a common place or time. It can be said that gaining this ability is a radical evolution.

Chapter 3 introduces a new structure that can be said to be a radical evolution in order to add language functions to neural networks. The target processed by the neural network presented in Chapter 2 is limited to the neighborhood to which the operation can access, but in the neural network presented in Chapter 3, a neural network that behaves independently of the situation is added. Furthermore, the added neural network exchanges contents with other neural networks using languages.

2. Neural Network Processes Time Series Data by Recognizing Hierarchy

In this chapter, a neural network that recognizes and generates time series data is presented. The model is all living things including us. It can be thought that they are living by judging the situation by the time series data obtained from the sensory organs and creating optimal time series data of actions to protect themselves. Considering the correspondence with the Turing machine, living things can be thought of as automata that move around on the one-dimensional tape while reading and writing the data. However, it is surrounded by a finite wall brought about by the uncertainty of cognition and behavior that is inevitable as it is a living thing. However, animals have evolution through a great deal of trial and error in their history to achieve the functions that we are trying to achieve with machines in a completely different way. Since the neural network that recognizes and generates time-series data presented in this chapter is composed of elements with functions based on Hebb's law, it has contacts near the roots of the evolutionary branches of animals. It is attempted to develop based on computer theory.

$$c_1c_7c_4c_6c_6c_0c_6c_5c_1c_3c_7c_8c_9c_9c_9c_7c_5c_4c_1 \quad (1)$$

$$\downarrow$$

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

Figure 1. *Any string can be split into subsequences.*

As shown in figure 1, if it is composed of a finite type of elements any time series data be divided into a plurality of subsequences in which the same element does not appear multiple times. Since the divided subsequences are considered as elements of new time series data in the upper hierarchy, it can be said that every time series data contains hierarchy context. This division process is a necessary generalization for discussing time series data, but it brings a modular structure and a hierarchical structure to the neural network, and the structure fits well with the knowledge of neuroscience. The division algorithm is published in [4], and knowledge of neuroscience behavior such as glial cell may be possible to reconstruct the algorithm in future.

First, the operation of serial-parallel conversion will be explained. The neural network shown in figure 2 has inputs consisting of a plurality of bits. When the leading data c_0 is

received, the elements of lowest part are activated. For the next data c_1, the elements to be activate is the elements connected to the elements that are already activated by the previous data c_0. But each bit of the input is randomly connected, and not all of the active elements activated by c_0 are activated. In the figure, four parts are activated, and the activity of other parts without a new activation factor (which may accept other time-series data) decreases and returns to the initial state.

Figure 2. *The activated parts expand while receiving the time series data $c_0c_1c_2c_3$.*

Therefore, the activated part narrows as data is received as c_2 and c_3. The output of the element that held the activity when the last c_3 of the time series data is received becomes the recognition result of the time series data $c_0c_1c_2c_3$. It may be similar to the output of the serial connected AND logic gate. The number and position of the elements remaining activated become the pattern of conversion output (parallel data) corresponding to the input (serial data).

Next, the reverse of the above conversion, that is, the conversion from parallel data to serial data will be described. The connection between the elements in the neural network changes while receiving the serial data. The connection between the elements becomes tighter, then causes easy propagation. By adding the connection path shown on the left of the figure 3, the element that outputs the converted parallel data connect to the set of elements at the bottom.

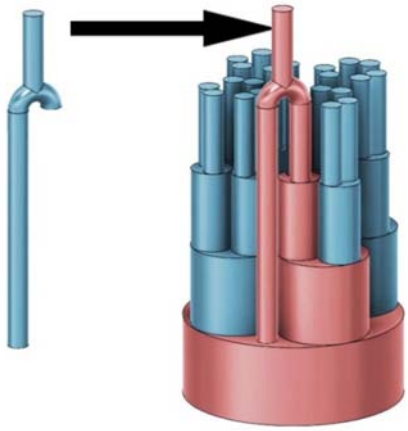

Figure 3. *Add feedback connection to a serial-parallel transform neural network.*

The elements that are ordinary activated by the data at the beginning of the serial data are activated. When the propagation of activation from above and the propagation of activation from the bottom encountered, the state transition at the time of serial parallel conversion takes place again. That is, serial data is triggered by parallel output. It is an operation corresponding to an oscillation circuit using positive feedback in a conventional electronic circuit. Since the elements that make up the neural network are randomly connected, the same connection such as added in figure 3 will probably exist somewhere. If the connection is useful for the operation, it will be strengthened every time it is used. When activated from bottom, serial-parallel conversion is performed as described above. On the other hand, when activated from top, parallel-serial conversion is performed. Serial-parallel conversion and its reverse conversion can be switched while using the same element. A neural network that performs serial-parallel mutual conversion is the basic part of the module configuration and will be called the Basic Unit. The structure of the Basic Unit 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 [5]. Any time series data can be processed by arranging the basic unit of the number of elements displayed at the beginning of the time series data and considering their output as the time series data of the upper layer. The Figure 4 shows that the hierarchically connected Basic Units convey state transitions across hierarchies [6-8].

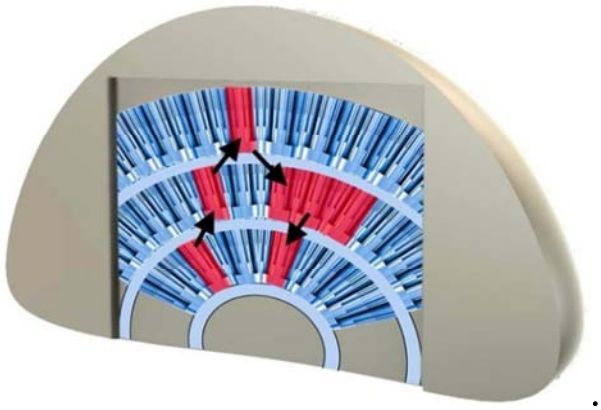

Figure 4. *State changing of Basic Units beyond the hierarchy.*

In the animal brain, even if it is sleeping, the activity of the plurality of parts of the brain are changing. The high activity parts are moved like Domino and contributing to many problems solving. Neurologist Damsio draws like that as follows [9].

In brief, images were advantageous even if an organism were not conscious of the images formed within it. The organism would not yet be capable of subjectivity and would be unable to inspect the images in its own mind, but still the images could automatically guide the execution of a movement; the movement would be more precise in terms of its target and succeed rather than fail.

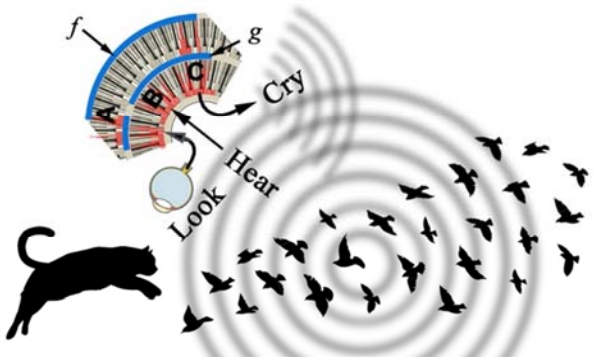

Figure 5. *Flying flock of birds learn to cry when beast is chasing.*

Figure 5 is showing communication and learning in the flying flock of birds being chased from beast and explained the behavior by view of the neural network.

(1) First of all, a bird encounters to beast and cry by fear. The neural network that accelerate cry in the bird is activated.

(2) The bird near hears the cry. That is, neural network B in the bird is activated. Since the neural network C is closely coupled to B, C is also activated and imitates the cry had been heard. The connection g shown in Figure 5 produces this operation.

(3) On the other hand, there is a neural network A activated by looking beast. A is activated simultaneously with a neural network C so the connection F is strengthened. After all, both of A and B can activate C. These behaviors of the neural network described above will be able to express the behavior called “federated learning” in psychology [10-12].

Even insects that live only one summer, may image with the sunrise the changes in the environment that will happen from the memory of the previous day and will make some preparation based on it. Even more animals that live for many years, the seasonal flow may also be imaged. However, it is not possible to express those stories nor tell to fellows.

The purpose of this paper is not to realize a machine that performs the determined one correct and efficiently. Essence of intelligence can only be approached by considering the state transition of intertwined neuronal cells in neural networks. The neural circuit is considered to have the following characteristics as compared to the circuit on a silicon wafer.

(1) Neural networks are composed of a combination of modules (Basic Units) whose essential functions are the same, and acquire the necessary functions by learning.

(2) Even if a part of the circuit is damaged, it does not affect the overall operation if it is a small part.

(3) If the damaged part of the circuit is large enough to affect the overall operation, other parts of the neural circuit learn and substitute the function.

These characteristics are linked to the fact that even if we ourselves have dysfunction due to injury or illness, we are able to recover our function unknowingly or sometimes while receiving rehabilitation treatment by a doctor. Needless to say, organisms without this self-healing function would not have survived the competition for survival.

3. Extended Neural Networks That Interact Together

The neural network shown in the previous chapter logically realized the behavior of animals using elements along the knowledge of neuroscience. The behavior includes federated learning and imitation capabilities and collective action. As an example, group of birds by crying together as message of danger is presented. Since they do not use languages, their communication is limited to fellows in the vicinity sharing the same situation. If they get language ability, can communicate to distant fellows and inherit the knowledge. In this chapter, a new neural network is proposed that processes a language connecting above the neural network shown by the previous chapter.

3.1. A Fundamental Consideration of the Role of Language

First, let consider the essential consideration of the exchange of knowledge by language. We know from information or hearsay that some species of mushrooms and fish has poison, and we do not collect those species. Can we get this information without having a language? Is there any animal except human who can explain to his friends that "the XX just now eaten was bad" while suffering from poison? In the world of wild animals, the individuals who like the food in question die one after another, and only the species that innately dislike the taste survive. More intelligent group of animals can recognize the situation what were happened after eating dying companions and the food chips beside them. It is necessary to tell the story to friends and inherit it for a long time. Any race having language ability can do this.

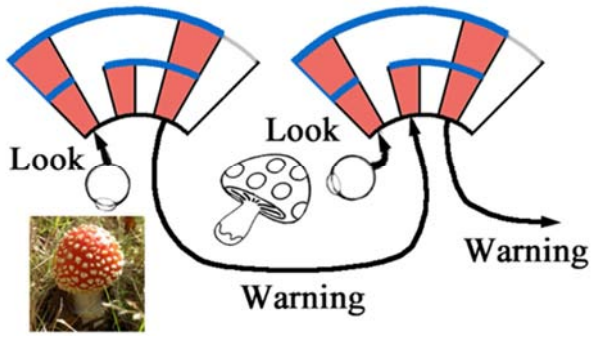

Figure 6. *Can animal propagate information about poisonous mushroom into group by sketch?*

Interactivity is important in this case. The "first discoverer" who witnessed the "incident" related to the poisonous mushroom recalls the "incident" when he sees the poisonous mushroom later and avoids picking it up. The "first discoverer" can avoid the poisonous mushrooms, but in order for the "incident" to become the knowledge of the group, the "first discoverer" must explain the "incident" to his fellow. The explanation is a conversion of an image of an "incident" (that is, a dying companion and a poisonous mushroom near it) into time-series data such as voice. For those who have never seen poisonous mushrooms, it is

necessary to show them to the drawing. The side receiving the time-series data recognize the data and the image of the "incident" is formed. This process is the inverse transformation of the explanation generation process performed by the "first discoverer" based on the "incident". In this way, the fellows who can understand the explanation of the "first discoverer" will avoid poisonous mushrooms and this knowledge will spread. Figure 6 shows how knowledge spreads in a group of animals. The beast depicted in the Figure 5 in the previous chapter has been replaced with a poisonous mushroom in this figure.

In reality, animals except human beings cannot communicate as shown in figure 6. The neural network on the right in the figure cannot handle languages. There are many groups of animals use crying to inform danger or warning, and dexterous bird like a bowerbird might even be able to make a picture of a mushroom or even a model of a mushroom. However, what they recognize is not a picture, but a spot of material on the sand or wall, not a symbol of anything. They cannot imagine events that may occur somewhere or someday.

The following example is a conversation situation where multiple stories are shared.

Girl: This stone is beautiful.

Girl's Father: This is made with handmade grinder by my dead grandfather.

Girl: I'll glad to decorate my neck.

Father: Take it for next festival.

If a polished jade is found from the old cave without letters and murals, it is easy to imagine that there had been lived apes and had been done conversations like above. Because there was language and unique culture, the stone with certain characteristics was treated special and discovered after tens of thousands of years. These are one of the materials to determine that they had been using a language [13, 14].

What is noteworthy in this conversation is that the "dead grandfather," "handmade grinder," and "next festival," which were inspired by the stone in front of them, but are not there, unlike stones. Nonetheless, the two speakers continue the conversation by associating images that seem reasonable to each other to their respective words. In other words, the story in the neural network shown in the previous chapter is consist of changes in the real world captured by the sensory organs and changes involved with exercise organs, but the story described by language is combinations of stories in different time and space even if that was inspired by real world [15].

Therefore, to bring ability of language on neural network, it will be natural to think that neural networks that behave independently of the real situation are needed. The image of the object was created by the sensory organs in the real world. But the image must be corrected if "what you knew in the hearing" appears in front of the eye [16]. On the other hand, psychology, such as love, trust, desire or fear, is not an existing object, but can be shared equally as existing objects in the context. It goes without saying that sharing of these images leads to literary works.

3.2. Addition of Neural Networks That Are Essential for Language Use

The Figure 7 is a diagram in which neural network N_L and N_I operate asynchronously to real time situations of the network shown in the previous chapter. The lower neural network n_L and n_I operate by exercise organs for the surrounding situation recognized by the sensory organ. This is the logic of the basic behavior of the animal, including the feeding behavior. If apply these behaviors to animals, n_L is connecting to exercise organs and sensory organs and govern the means of communicating other members such as crying and gestures. The activation states of n_I and n_L are bi-directionally reflected by federated learning. Activation status of n_I is reflection of danger, fear and desire. And n_I encourages n_L new action. The operation of lower part cannot retain a large amount of data like an upper neural network, but it is quick.

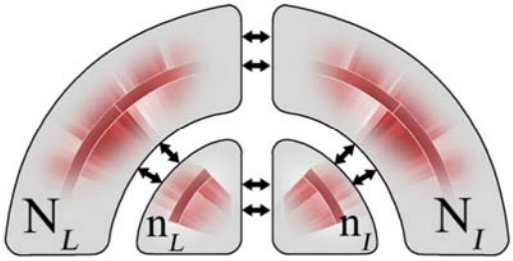

Figure 7. *Neural networks with new functions connected above conventional neural networks.*

Animals with brain that have the left and right roles share as described above are not all of the animals. The significance of thinking about the left and right is the basis of logic development and helps to make a simplified description in order to explore the beginning of language which is the subject of this paper, rather than combining knowledge such as neuroscience. Regardless of whether the neural network is divided into the left and right, if there are two areas activated simultaneously in the neural network, even if each behavior is different, these functions are replicate and widely propagated to other neural networks. As indicated in the previous chapter, the behavior of these neural networks is built in a combination of Basic Unit. Furthermore, since the operation of Basic Unit is built along Hebb Rule, it can be said that the behavior shown following is a deductive construction having consistency with the microscopic knowledge of neuroscience [17]. The state of the neural network is indicated by the behavior of the activated area. That is the state change of Basic Units and the state of connection them in the area. Changing of activated region correspond to the context of the process. Flexible and general formulation can be expected using Category theory [18].

Figure 8 shows a teacher showing a picture of a poisonous mushroom to a neural network to explain the danger and teach how convey the warning to neighbors. Information transmission to neighbors, which was not possible in the figure 6, is made possible by the neural network added at the

top. In the figure, teacher draws a picture of poisonous mushrooms and explains the danger of poisonous mushrooms to the neural network. Since n_L and n_I are activated simultaneously, the coupling between the areas is activated by federated learning, and then the other is activated if one is activated. The same is true between N_L and N_I (a horizontal bar in the figure). The upper N_L and N_I are partially activated by reflecting the state of the lower n_L and n_I. Basically, the lower activated regions are replicated to the upper activated regions. This operation can be expressed by a mapping between Category.

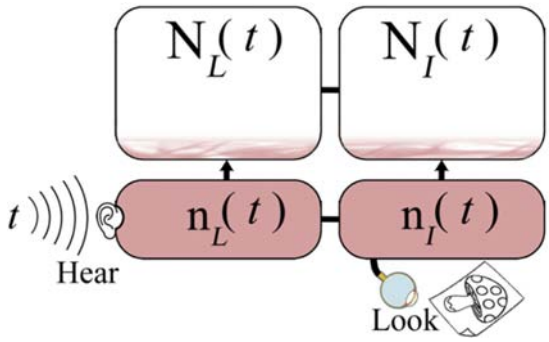

Figure 8. *Teach neural networks how to identify poisonous mushrooms.*

N_I activates the region replicated from the active region of n_I at the time of learning. In addition, this area connects to other activated areas that are the result of N_I past operations, and operate new operations comprehensively. The state of the activated region of N_I activates the corresponding region in N_L. This correspondence is a relationship by federated learning. Specifically, nouns that identify the image, verbs that represent the movement of images and various adjectives.

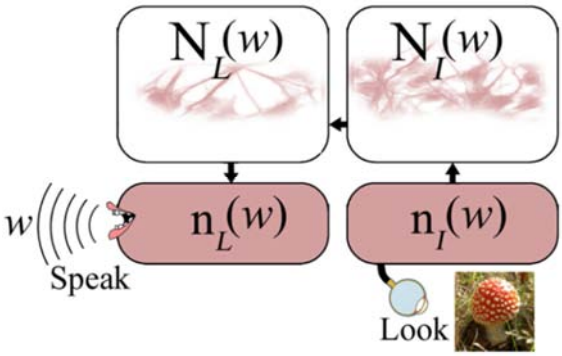

Figure 9. *Neural networks that learned about poisonous mushrooms from the picture can explain about poisonous mushrooms even if encountered that for the first time.*

Figure 9 shows the situation where the neural network is looking at the poisonous mushroom after learning about the poisonous mushroom. Assume the picture of the poisonous mushroom reflects the real thing well. By looking at the poisonous mushroom, n_I is activated, but since it is the first time for a neural network to see it, n_L is not activated. However, as described above, N_I has an activation region developed basing on the replication from n_I during learning, and that region activates the N_L region associated with it during learning. The activation of this N_L area causes the activation of n_L, and become possible to convey what the teacher said during learning to his colleagues.

The time series of changes in the activated region of the NL is the origin of the statement that conveys the situation. If the speaker is a father, the name of the family will appear. If the speaker is a senior in the tribe, it may be accompanied an episode of hunting work. These actions are performed unconsciously. And it is effective in life. For example, if you are given a certain issue, even if you cannot handle with it immediately, you may find a solution with a new understanding after mood change or after sleep.

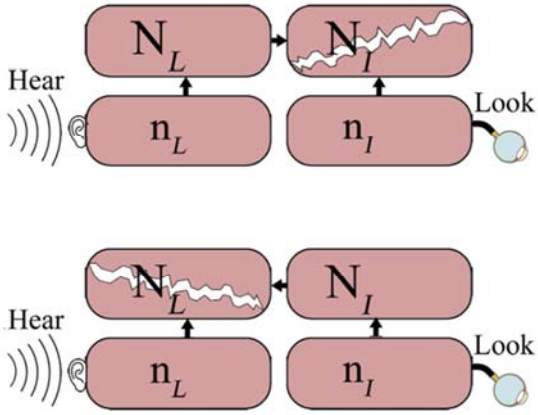

Figure 10. *The cases of discrepancy on conversation.*

Conversations are not always based on mutual understanding. Sometimes it is happened that the thing offered by companion as an orange was something believed to be a lemon, or the lemon offered to companion was actually an orange. Figure 10 is an example of a discrepancy between an image and a word. The corrugated shape shows a discrepancy. The message returned to the other party differs depending on the situation of the mismatch. The language function sorts and responds to the words that caused the disagreement in the form of interrogative sentences or negative sentences using interrogative words such as 5W1H. By repeating this process, both sides will get mutual understanding and develop into a collective culture.

4. Conclusion

Compared to animal information transmission by crying or gestures, language has an epoch-making function that goes beyond the role of information transmission and inherits culture. In this paper with some examples it is explained that the function that characterizes a language is not so much as having grammatical structure, but rather as ability of depiction that transcends time and space. That is, we can talk about things even if that are not existing in front of us. Then, it is shown that the function of the language can be obtained by connecting a new neural network pair on top of the already presented neural network. It is, so to speak, an old and new two-storied neural network.

Daring to compare it with the current computer system, it

can think of the old and new two-story new neural network as a system with a storage medium capable of long-term memory and a simulator that supports the OS in the background. But the images of the events experienced and the stories associated with them how be stored and recalled in new neural networks? While important events seem to be remembered preferentially, trivial things may be recalled even if decades later. There seems to be some mechanism that cannot be guessed from the concept of electronic circuits.

The configuration of the neural network is basically combinations of Basic Units of previous chapter, but some part of the operation explanation would be more clear and simpler if the new function is applied. Regardless the function of the new element is close or not to the hippocampus or amygdala, it can be expected to lead to comprehensive research in various fields.

References

[1] D. C. Dennet, “From Bacteria to Bach and Back: The Evolution of Minds.” In Penguin Books, 2018.

[2] S. Dehaene, “Consciousness and Brain”, Penguin Books, 2014.

[3] S. Yanagawa. 2017, “Learning Machine That Uses Context Structure to Search Policy.” https://jsai.ixsq.nii.ac.jp/. SIG-AGI-007-07.

[4] S. Yanagawa, “New Neural Network Corresponding to the Evolution Process of the Brain”, American Journal of Neural Networks and Applications 2021; 7 (1): 1-6.

[5] Gyorgy Buzsaki, “Rhythms of the Brain”, Oxford University Press, 2006, p43 Networks and Applications, Volume 6, Issue 1, June 2020.

[6] L. Andrew Coward, Ron Sun, “Hierarchical approaches to understanding consciousness”, Neural Networks 20 (2007) 947-954.

[7] Qianli Ma, Wanqing Zhuang, Lifeng Shen, Garrison W. Cottrell, “Time series classification with Echo Memory Networks”, Neural Networks 117 (2019) 225-239.

[8] Paolo Arena, Marco Cali, Luca Patane, Agnese Portera, Roland StraussSC, “Modelling the insect Mushroom Bodies: Application to Sequence learning”, Neural Networks 67 (2015) 37-53.

[9] A. Damasio “The Strange Order of Things”, Pantheon Books, New York, 2018 p. 62.

[10] T M. Iacoboni, “Mirroring People.” Picador 33. 2008, Chapter 4, p106.

[11] Seisuke Yanagawa, “Each Role of Short-term and Long-term Memory in Neural Networks”, American Journal of Neural Networks and Applications, 2020; 6 (1): 10-15.

[12] Hoon Keng Poon, Wun-She Yap, Yee-Kai Tee, Wai-Kong Lee, Bok-Min Goi “Hierarchical gated recurrent neural network with adversarial and virtual adversarial training on text classification”, Neural Networks 119 (2019) 299-312.

[13] D. Everett, “How Language Began”, Profile Books, 2017.

[14] W. J. Freeman “How Brains Make up Their Minds” Weidenfeld & Nicolson Ltd. 1999.

[15] S. Yanagawa “A neural network that processes time series data in which element data is linked to symbols Third International Workshop on Symbolic-Neural Learning (SNL-2019) Poster presentation.

[16] Michael j. Healy, Thomas P. Caudill, “Episodic memory: A hierarchy of spatiotemporal concepts”, Neural Networks 120 (2019) 40-57.

[17] Ann Sizemore, Chad Giusti, Ari Kahn, Richard F. Betzel, Danielle S. Bassett “Cliques and Cavities in the Human Connectome”, Cornell University arxiv.org/abs/1608.03520, 2016.

[18] T. Leinster “Basic Category Theory”, Cambridge University Press 2017.