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I/E Selective Activation based Knowledge Reconfiguration mechanism and Reasoning

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** Short Paper*

***Abstract*: As the role of information collection becomes increasingly important in the enormous data environment, there is growing demand for more intelligent information technologies for managing complex data. On the other hand, it is difficult to find a solution because of the data complexity and big scaled amount. Accordingly, there is a need for a special intelligent knowledge base frame that can be operated by itself flexibly. In this paper, by adopting switching function for signal transmission in the synapse of the human brain, I/E selective activation based knowledge reconfiguring mechanism is proposed for building more intelligent information management system. In particular, knowledge network design, a special knowledge node structure, Type definition, I/E gauge definition and I/E matching scheme are provided. Using these concepts, the proposed system makes the functions of activation by I/E Gauge, selection and reconfiguration. In a more efficient manner, the routing and reasoning process was performed based on the knowledge reconfiguration network. In the experiments, the process of selection by I/E matching, knowledge reconfiguration and routing & reasoning results are described.

***Keywords*: Knowledge network, Knowledge reconfiguration, I/E gauge, Selective activation, Reasoning

1. Introduction

As many smart technologies develop, information has grown enormously in both size and complexity. In the era of large volumes of data, there is increasing demand for more intelligent technology to manage large complex data. In particular more advanced methods for acquisition, storage, management, and retrieval are needed to process large amounts of complex data efficiently. A special information processing structure for advanced technology including not only a symbolic linear reasoning process but also machine learning based complex nonlinear process should be designed.

In recent decades, many studies adopting human brain functions have been made as solutions for solving complex problems. As mentioned above, a design of information structure is very important. In particular, for processing complex data, a special knowledge structure with a specially designed network form, which can include both symbolic reasoning chain frame and artificial neural network frame, is needed. Clues to the problem can be obtained from the human brain. The human brain is the final product that has evolved for millions of years and has a very efficient structure and functions for problem solving. The human brain has a well-ordered structure, where neurons make a network of six layers hierarchically in the cerebral cortex. Signal transmission occurred in the synapse between two neurons has attached increasing attention. During signal processing, not all neurons are activated but only related post neurons to the pre neuron are activated selectively and the electric signal can be transferred, i.e., the switching mechanism in the synapse. Because of this switching function, the brain can process large amounts of data of the surrounding circumstances quite efficiently and flexibly.

In this study, a special knowledge network as an information processing basis of formation, management, extraction, routing and reasoning was designed by adopting the neural network structure of human brain. The I/E selective activation based knowledge reconfiguration mechanism is proposed.

Section 2 introduces, the switching mechanism of the signal transmission in the synapse and the structure of the knowledge network designed in a previous study [1, 2]. Section 3 reports, the system overview for I/E selective activation based knowledge reconfiguration and describes their function. The structure of knowledge node is designed and the concept of 'TYPE' and 'I/E Gauge' is defined. Using these concepts, knowledge reconfiguration mechanism and routing & reasoning are provided. The last section reports the `results of experiments on the processing of knowledge reconfiguration and routing & reasoning is shown.

2. Signal processing of neurons in a Synapse and the structure of a Knowledge Network

2.1 Switching of signal transmission in the Synapse of neurons

Signal transmission in the synapse between pre neuron and post neuron is made by an electric signal and chemical events of the neurotransmitter. Neurotransmission depends on the release of chemicals in the synapse. An information marked electric signal, an action potential, travels down the axon terminal of a presynaptic neuron. At the presynaptic terminal, an action potential enables calcium to enter the vesicle cell. Calcium releases neurotrans-mitters from the terminals and into the synapse, which is the space between the presynaptic and postsynaptic neurons. The released neurotransmitters diffuse across the synapse, attach to the receptors of postsynaptic neuron and alter the activity of postsynaptic neuron. Depending on the neurotransmitter, it may be converted into inactive chemicals [5]. The diffused neurotransmitter in the synapse plays the important role of a switching bridge that connects to the postsynaptic neurons. In the switching mechanism in the synapse, the key and lock principle applies to the relationship between the diffused neurotransmitter from the presynaptic neuron and ion channel of the postsynaptic neuron. If matched, the gate of the ion channel is opened and an electric action potential is transferred to the postsynaptic neuron through an opened ion channel. On the other hand, if it is not matched, the gate of the ion channel is not opened and the electric signal transmission stops at this point. Not all neurons are activated. Only the related neurons are activated because of the switching mechanism. As shown in Fig. 1, the electric signal from neuron A is transferred to related neuron B. The pathway to neuron C is inhibited and the signal transmission between neuron A and neuron C is blocked. If the human brain allows every neuron to be activated, it cannot process information appropriately because information becomes entangled. Owing to this switching mechanism, the human brain can select an appropriate knowledge and manage the stored information in a large pool quite efficiently. This selective switching function of the human brain can be applied to solve complex problems in the huge database.

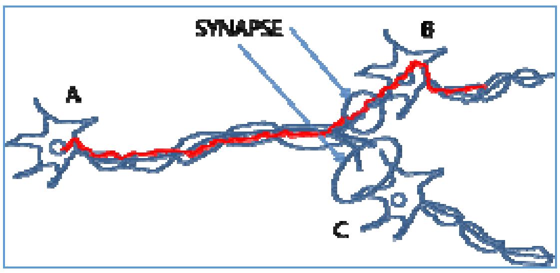


Fig. 1. Switching in the synapse.

2.2 Knowledge Network Design

A knowledge network was designed in a previous study by adopting the real neural network structure [1, 2]. This structure has a strong point in that it can represent not only a logic-oriented semantic network structure, but also the learning network frame of an artificial neural network. This characteristic is appropriate for making the hybrid system of the symbolic reasoning method and machine learning scheme. The knowledge network can be represented hierarchically as a tree structure. The designed knowledge network consists of a node and edge (or arc). A knowledge node that contains various attributes can be specified differently according to the problem solving area.

The following Fig. 2 represents the basic pattern of a knowledge network. The knowledge Ki is connected to Kj by their relationship, R_{ij} . The value of R_{ij} is obtained using Eq. (1).

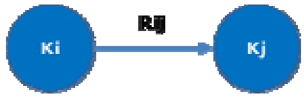


Fig. 2. Basic structure of the knowledge network.

$$R_{ij} = P(K_j \mid K_i) \tag{1}$$

3. I/E Selective Activation based Knowledge Configuration

In this study, the structure of knowledge is designed and an intelligent mechanism that can be processed selectively using the I/E Gauge is proposed.

3.1 System Overview

Fig. 3 shows the system overview for the I/E selective activation based knowledge reconfiguration mechanism. This system consists of MASTER KNOWLEDGE NETWORK, I/O INTERFACE, I/E MATCHING, KNOWLEDGE CONFIGURATION, and ROUTING and KNOWLEDGE EXTRACTION module. The MASTER KNOELEDGE NETWORK plays an important role as a knowledge base and has a network form connected by their relationship. The network consists of knowledge nodes, which have various attributes and are predefined for

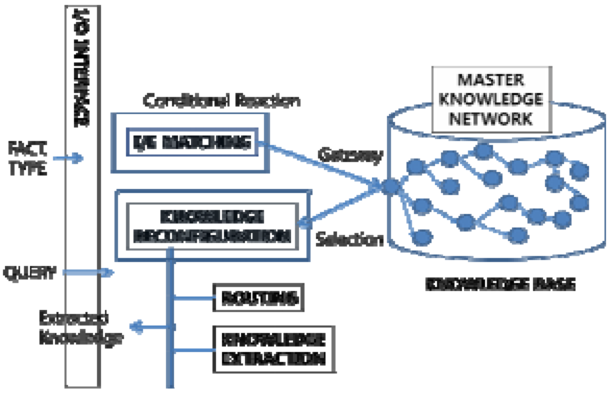


Fig. 3. System structure of I/E Activation based the knowledge reconfiguration mechanism.

intelligent operation. Based on this knowledge network, the system checks the reacting status of the node by calculating the I/E matching value between the incoming data Type and the corresponding knowledge node Type. The activated knowledge nodes are selected by the I/E matching rule, extracted and serve to build a new knowledge reconfigured network temporally. The system responds to the query of the user based on the reconfigured knowledge network. The advantage of the reconfiguring design lies in the point that the system can produce prompt responses to the continuously arriving user's queries from the pre made reconfigured knowledge network in the case of the same user.

3.2 The design of the knowledge node

To operate the knowledge network intelligently, the knowledge node should be predefined. The attributes of the node can have a different aspect according to the application problem. The knowledge node design for this proposed system is as follows:

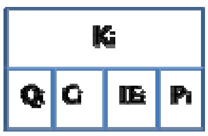


Fig. 4. Knowledge Node Design.

This consists of K_i, Q_i, C_i, IE_i and P_i where

K_i : ID name

Q_i : Type of K_i

C_i : Specification of K_i , Describing factors of K_i

IE_i : I/E Gauge obtained by the I/E matching mechanism. Its value is set to 0.0 in the initial state and changed during the process.

P_i : The probability of occurrence of K_i

3.3 Selective Activation by I/E Gauge

3.3.1 Type definition

Everything has its own characteristics, which is called 'Qualia' [4]. In this study, the characteristics of a thing are defined as 'Type'. The number and characteristics of the Type can be designed variously according to the problem. In this system, five types, of T,F,E,G, and W, are defined and designed for playing an important role in selection and routing in the reconfiguration mechanism.

3.3.2 I/E Gauge

I/E Gauge, which means an inhibitory/ excitatory gauge is prepared for the activation of knowledge nodes in MASTER KNOWLEDGE NETWORK. I/E Gauge is defined as the degree of Type matching between the incoming data and stored knowledge node. A positive I/E matching value represents an excitatory state, and a negative value depicts the inhibitory state. In the case of a negative I/E Gauge, the signal cannot be transferred to the next node for propagation. The value of zero means that the corresponding node stands on the neutral point and plays the role of bridge connecting two nodes.

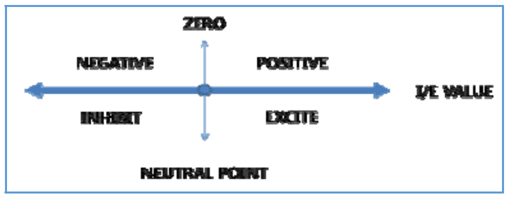


Fig. 5. I/E Gauge.

3.3.3 I/E Matching

I/E Gauge is represented as a term, IE_i , and is obtained using the following I/E Matching table. The I/E Matching table shows the value of I/E Gauge between the two Types.

Table 1. I/E Matching Rule.

I/E Gauge	T	F	E	G	W
T	1.0	0.5	0.0	-1.0	0.5
F	0.5	1.0	0.0	0.5	-1.0
E	0.0	0.0	1.0	0.0	0.0
G	-1.0	0.5	0.0	1.0	0.5
W	0.5	-1.0	0.0	0.5	1.0

3.4 Knowledge Reconfiguration and Routing & Reasoning

3.4.1 Conditional Knowledge Reconfiguration by I/E Matching

The knowledge nodes of MASTER KNOWLEDGE NETWORK are reconfigured by the I/E Gauge value. The key mechanism is that if I/E Gauge has a positive value, the matched node is activated and selected for reconfiguration. On the other hand, if I/E Gauge has a negative value, the corresponding node is inhibited and cannot participate in the reconfiguring process. A zero valued node is concatenated to a new reconfigured network as a bridge.

For an example of the network in Fig. 6, each node is reacted on the incoming Type 'T'.

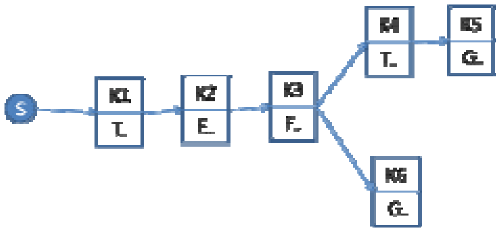


Fig. 6. Initial state of the knowledge network.

In the case of an incoming Type 'T', the values of I/E Gauge for K1,K2,K3,K4,K5, and K6 are listed in Table 2.

Table 2. Reaction to incoming Type 'T'.

ID_i	Q_i	IE_i	Selection
K1	T	1.0	Selected
K2	E	0.0	Selected
K3	F	0.5	Selected
K4	T	1.0	Selected
K5	G	-1.0	Not selected
K6	G	-1.0	Not selected

According to the reaction states, a new reconfigured knowledge network was obtained, as shown in Fig. 7. The nodes, K5 and K6, are inhibited and excluded in the configuration process because they have negative I/E Gauge values.

The configured knowledge network can be made flexibly and have different shapes according to the incoming condition.

3.4.2 Routing and Reasoning Chain extraction

After a new reconfigured network is made, the routing and reasoning chain extraction mechanism can be processed. From the reconfigured network, various routing paths are extracted and the reasoning process flows along the extracted routing paths. The decision making result of the reasoning process can differ according to, which routing path is selected. The selection of extracted routing paths is obtained using Eqs. (2) and (3).

$$H(X_i) = -\sum P_i(X_i) log_2 P_i \ X_i + \sum IE_i \qquad (2)$$

$$\text{SELECT} = {}^{\arg max}_{k} H_i(X_i) \qquad (3)$$

where the entropy values of the extracted paths are calculated and one path with the maximal entropy value is selected for decision making.

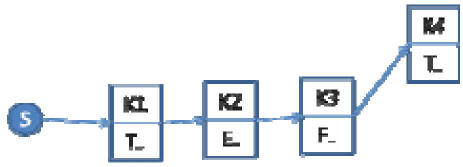


Fig. 7. Changed Knowledge Network by I/E matching.

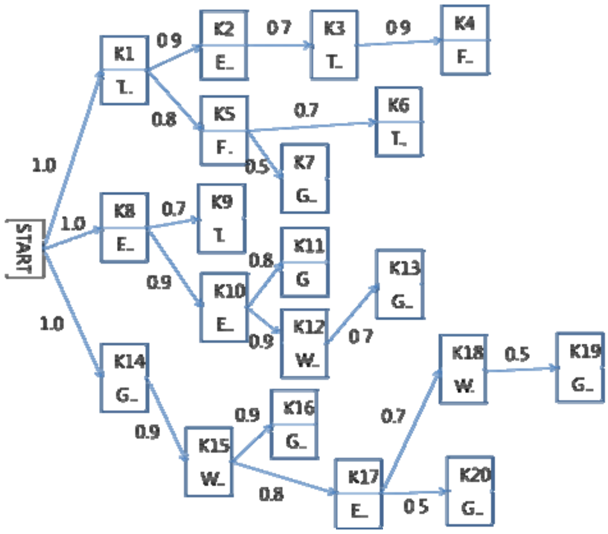


Fig. 8. MSTER KNOWLEDGE NETWORK.

Table 3. Probability of an occurrence of Ki.

K_i	P_i	K_i	P_i
K1	1.0	K11	1.0
K2	0.9	K12	0.8
K3	0.8	K13	0.8
K4	1.0	K14	0.6
K5	0.9	K15	0.5
K6	0.7	K16	0.7
K7	0.6	K17	0.9
K8	0.7	K18	1.0
K9	0.8	K19	0.9
K10	0.9	K20	0.8

4. Experiments

In these experiments, 20 knowledge nodes composing MASTER KNOWLEDGE NETWORK, as shown in Fig. 8, were tested to describe the I/E activation- based reconfiguration mechanism, routing & reasoning and knowledge extracting process. Each node has K_i, Q_i, C_i, IE_i, and P_i factors, respectively, but in this figure, only K_i, Q_i and P_i are marked explicitly. Table 3 lists the probability values of each node, which will be used to

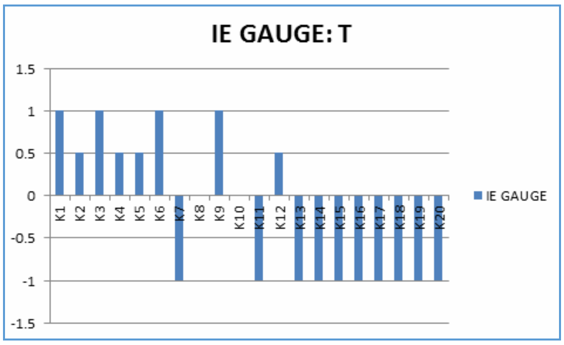


Fig. 9. I/E Gauge by I/E matching Incoming Type: T.

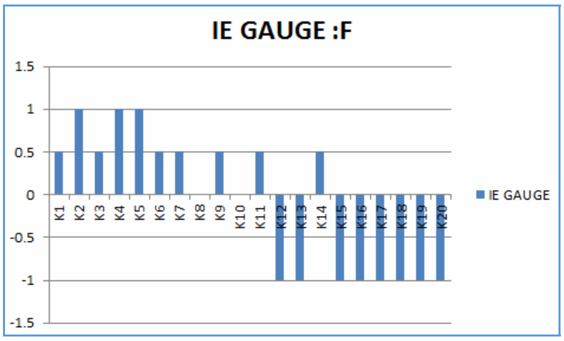


Fig. 10. I/E Gauge by I/E matching Incoming Type : F.

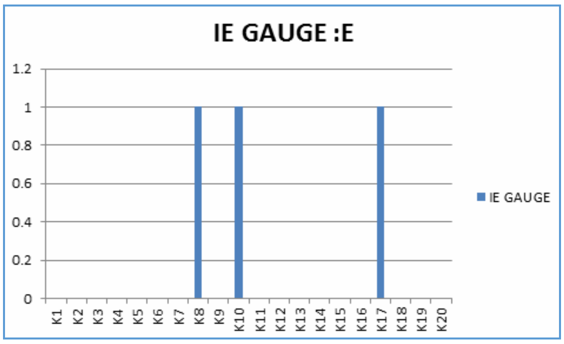


Fig. 11. I/E Gauge by I/E matching Incoming Type : E.

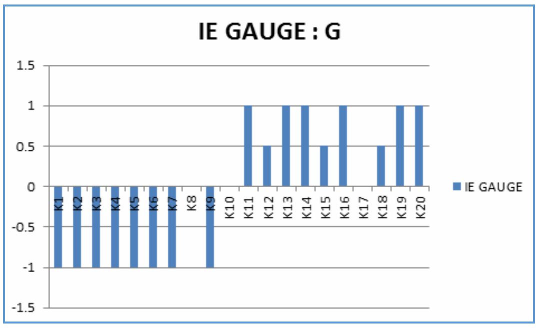


Fig. 12. I/E Gauge by I/E matching Incoming Type : G.

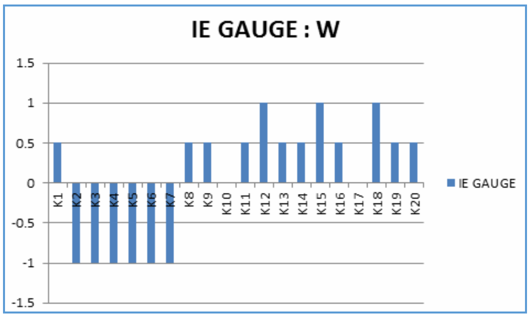


Fig. 13. I/E Gauge by I/E matching Incoming Type : W.

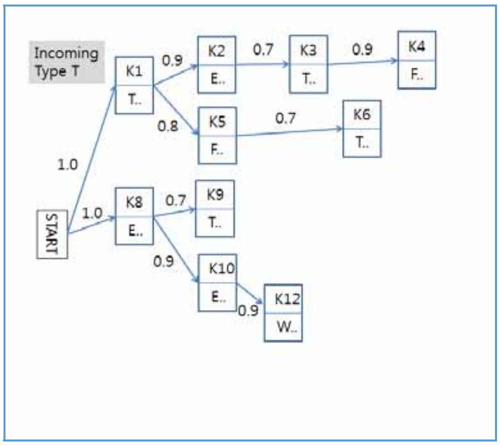


Fig. 14. Knowledge Reconfiguration Network made by incoming data type 'T'.

calculate the entropy. Figs. 8-12 show the changing values of I/E Gauge by I/E matching, which is reacted to the incoming type T,F,E,G, and W, respectively. The I/E Gauge value of -1.0 in the graph represents the inhibited state In this inhibited state, the corresponding knowledge node is not activated. Accordingly, these inhibited nodes do not participate in the knowledge reconfiguration mechanism and the routing & reasoning process. As shown in the Figures, the activation value with related matched type is high and the probability of being selected for reconfiguration is high. Fig. 14 presents a new reconfigured knowledge network made using a knowledge reconfiguration mechanism. In the Figure, only the knowledge nodes matching with the incoming Type 'T' were activated and the other nodes were removed. The system starts the routing and reasoning mechanism based on the new reconfigured knowledge network. Fig. 15 also shows the result of the new reconfiguration knowledge network for the incoming Type 'F'. Different knowledge nodes are activated and a different new knowledge reconfiguration network is created according to the incoming Type. Fig. 16 shows the new knowledge reconfiguration network made by the incoming data type 'E'. In this case, there is no removed data because data type 'E' has no negative I/E value during the reconfiguration process. In this system, the 'E' type was designed to have a neutral characteristic. Figs. 17 and 18 also show the results of the knowledge reconfiguration networks made by the incoming data type 'G' and 'W' respectively. Figs. 19 and 20 describe the final result obtained by the routing paths after the knowledge reconfiguration mechanism. During the process, the entropy of each extracted path was calculated. Among the extracted paths, one path with the highest entropy was

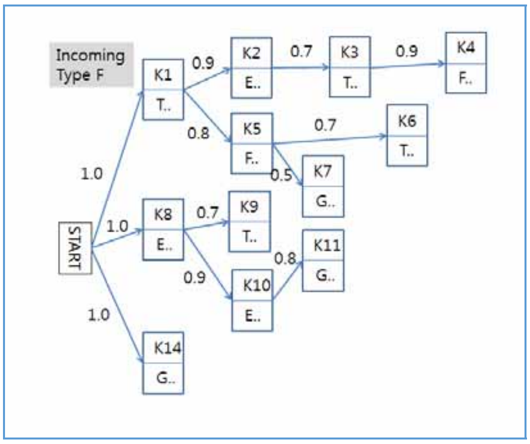


Fig. 15. Knowledge Reconfiguration Network made by incoming data type 'F'.

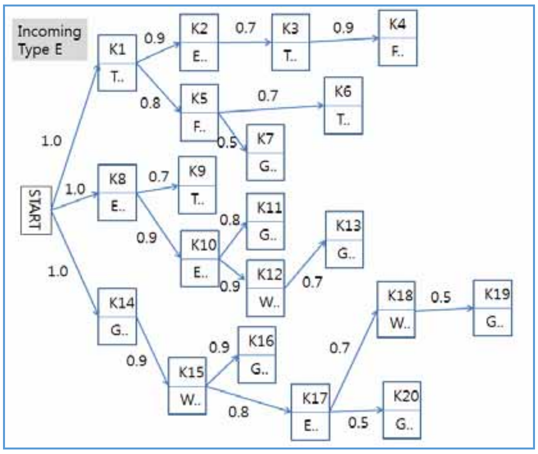


Fig. 16. Knowledge Reconfiguration Network made by incoming data type 'E'.

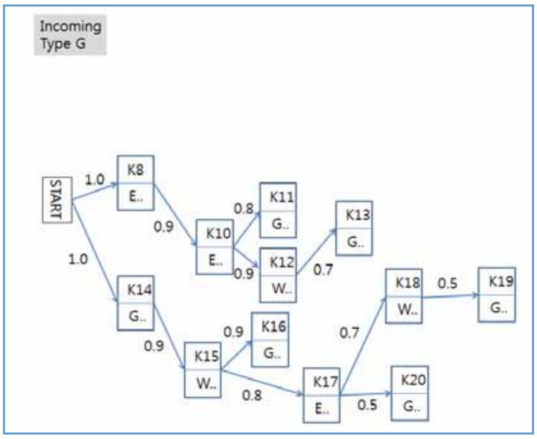


Fig. 17. Knowledge Reconfiguration Network made by incoming data type 'G'.

selected. In the case of the incoming Type T, path P1 was selected and in the case of the incoming Type W. Path6 was selected. The experiment showed that even the same knowledge base reacts with the incoming data Type differently. The difference activation, selection, various different thinking processes, and decision making are

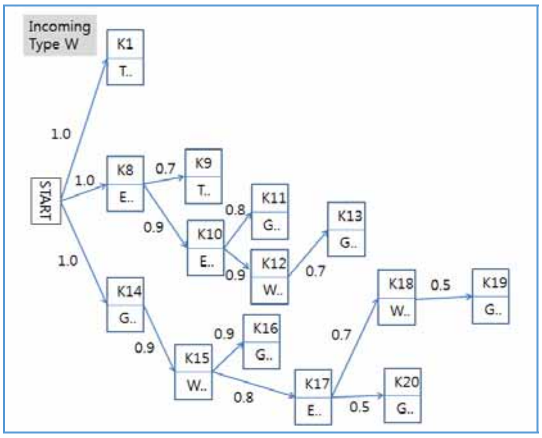


Fig. 18. Knowledge Reconfiguration Network made by incoming data type 'W'.

```
KNOWLEDGE RECONFIGURATION
INPUT TYPE?? T
-----------------
ROUTING...
EXTRACTION...
PATHS

P1 K1 K2 K3 K4
H1 3.118710
P2 K1 K5 K6
H2 2.649613
P3 K8 K9
H3 1.149613
P4 K8 K10 K12
H4 0.727141
NULL

SELECTION P1
```

Fig. 19. Extracted paths by Routing. Incoming Type : T.

```
KNOWLEDGE RECONFIGURATION
INPUT TYPE?? W
-----------------
ROUTING...
EXTRACTION...
PATHS

P1 K1
H1 0.500000
P2 K8 K9
H2 0.685959
P3 K8 K10 K11
H3 1.149613
P4 K8 K10 K12 K13
H4 2.304669
P5 K14 K15 K16
H5 2.892056
P6 K14 K15 K17 K18 K19
H6 3.365988
P7 K14 K15 K17 K20
H7 2.402334
NULL

SELECTION P6
```

Fig. 20. Extracted paths by Routing Incoming Type : W.

induced from the same knowledge network according to the input data Type. The incoming data type can be interpreted as a different person. This can explain why a different person has a different thinking pattern for the same phenomena.

This knowledge reconfiguration scheme can provide a good technology for managing a knowledge base more intelligently and efficiently in the big data era.

5. Conclusion

In this paper, an I/E selective activation based knowledge reconfiguration mechanism was proposed. The knowledge network structure and knowledge node for specifying the problem area were designed specially. To build the selective scheme, the concepts of the Type, I/E Gauge, I/E matching rule was defined. In the experiments, the process of knowledge reconfiguration was tested using the predefined master knowledge network where 20 knowledge nodes are connected to their relationship. As a result, different new reconfigured knowledge networks were made, and based on this knowledge base, this proposed system can produce different reasoning paths and decision making results according to the incoming data type. This knowledge reconfiguration scheme can be applied to various areas and provide a good technology for managing a knowledge base more intelligently and efficiently in the big data era.

References

[1] JeongYon Shim, "Knowledge network Management System with medicine Self Repairing Strategy", PP 119-128, Springer Verlag, Berlin, Heidelberg, 2007.

[2] JeongYon Shim, "Conditional Reconfiguration Mechanism by I/E Gauge", IEEE ISCE2014, The 18th IEEE International Symposium on Consumer Electronics, 22-25 June, Jeju, Korea.

[3] Bruce Goldstein, "Sensation and Perception", Fifth Edition, Brooks/Cole Publishing Company, 1999.

[4] Michael A. Arbib, Jeffrey S. Grethe, "Computing the Brain : A guide to Neuroinformatics", Elsevier Academic Press, 2001.

[5] http://en.wikipedia.org/wiki/Qualia

[6] Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory" Second Edition, Wiley InterScience Press, 2006.

[7] JeongYon Shim, "A Design of Self Internal Entropy Balancing System with Incarnation Process", Vol 4688, LNCS, Springer, 2007.

[8] JeongYon Shim, "Topological Approach of Immunity Based System: Memory Cleaning System", GESTS, 2006.

[9] Olaf Sporns, "Networks of the Brain", The MIT Press, Cambridge, Massachusetts, London, England, Massachusetts Institute of Technology, 2011.

[10] Rita Carter, "Mapping the Memory, - Understanding Your Brain to improve Your memory, The new Neoriscience, Why Mnemonic Tricks Work, A Memory's Synaptic Journey, Keys to Maximizing Memory", Ulysses Press, 2005.

[11] Rex B. Kline, "Principles and Practice of Structural Equation Modeling", Third Edition, The Guilford Press, 2010.

[12] Ning Zhong, Jiming Liu, "Intelligent Technologies for Information Analysis", Springer, 2004. Article (CrossRef Link).

[13] N. Keiding, B.Morgan, T.Speed, P.van der Heijden, "Interdisciplinary Statistics, Generalized Latent Variable Modeling, Multilevel, Longitudinal and Structural Equation Models", Chapman & Hall/CRC, 2004.

[14] Tamraparni Dasu, Theodore Johnson, "Exploratory Data Mining and Data Cleaning, Wiley series in probability and Statistics", Wiley InterScience Press, 2003. Article (CrossRef Link)

[15] Vladimir N. Vapnik, "Statistics for Engineering and Information Science, The Nature of Statistical Learning Theory", Second edition, Springer, 1999.

[16] Rita Carter, "Exploring Consciousness", University of California Press, 2002.

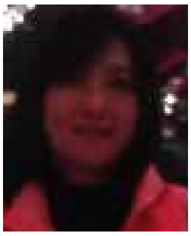
[17] E.Bruce Goldstein, "Sensation and Perception", Fifth Edition, Brooks/Cole Publishing Company, 1999.

[18] Charls T. Meadow, Bert R. Boyce, Donald H. Kraft, Carol Barry, "Text Information Retrieval Systems", Third Edition, Elsevier Academic Press, 2007.

[19] Andrew Ortony, Gerald L. Clore, Allan Collins, "The Cognitive Structure of Emotions", Cambridge University Press, 1994.

[20] Scott L. Miller, Donald G. Childers, "Probability and Random Process, with applications to Signal Processing and Communications", Elsevier Academic Press, 2004.

[21] Carl Edward Rasmussen and Christoper K. I. Williams, "Gaussian Process for Machine Learning", The MIT Press, Massachusetts Institute of Technology, 2006.



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