Research on Knowledge Cognitive Network Construction and Operation Mechanism Based on Basic-element Library

Na-na WANG\textsuperscript{1}, Wei LIU\textsuperscript{1,2,*} and Ao WANG\textsuperscript{1}

\textsuperscript{1}School of Maritime Economics and Management, Dalian Maritime University, Dalian 116026, China
\textsuperscript{2}School of Science, Dalian Maritime University, Dalian 116026, China
*Corresponding author

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Abstract. Cognitive Network is an active Network with Cognitive power and intelligence developed in recent decades, and it is a research hotspot in the world. Many new achievements have been made in the research on cognitive process and mode in the world. Great progress has been made in the switching between the two modes of thinking, namely focused mode and diffuse mode. Guided by the theory of Basic-element, this paper studies the knowledge understanding of the network model and its operation mechanism based on the base library and taking the basis as the network node. The introduction of Basic-element into cognitive network is to better describe the heterogeneity, dynamic and multidimensional of network nodes, while the use of Basic-element library can integrate prior knowledge into machine learning system. The knowledge network model for double network, the focused for knowledge network model, the upper divergence for knowledge network model, the lower the knowledge focused on the role network model is formed of block (hypergraph super edge), the block (edge) is mapped to the upper network form knowledge accumulation point, in the lower level of knowledge and strategy in the process of switching. This study is a new model for exploring cognitive network learning. The application background can be optimization problems in transportation network and logistics network as well as intelligent combination problems in other fields.

Introduction

Since the early 21st century, neuroscientists have had in the brain the each other between the two kinds of thinking mode switch made, for the long-term development of the research on the state of concentration and more relaxed state of rest, these two kinds of state of the neural network model based on different, we called it focused mode and diffuse mode, they are very important in learning. In our daily activities, the brain frequently switches between two modes. The focused mode provides you with blocks of knowledge for multiple solutions, while the diffuse mode connects two or more blocks in new ways to help solve different problems.

There are two ways to produce cognition: the first is to reason sequentially, and the second is to follow the intuition of the whole more. Sequential thinking is the opposite of leap-forward thinking. Each small step clearly points to the answer to the question, which is where the focused mode comes into play. Intuition is usually connected by a seemingly different focused mode, which requires a creative diffuse mode.

About cognitive network theory system research, Chinese scholars hui-qiang wang and jun-bo xu's article "cognitive development network architecture", the study of cognitive network architecture this paper summarizes the dynamic, and introduces three kinds of typical cognitive network architecture, on this basis proposes a cognitive network structure based on multi-stage feedback MDE approach based ring - Super (Super - NET) network, and adopts the method of combining PEPA and ODEs formal analysis, has carried on the preliminary has paved the way for the construction of cognitive network theory model \textsuperscript{[1]}. In fu qian's article "preliminary research on cognitive network", the basic concepts of cognitive network are introduced. Then, focused on the system structure and key
technologies of cognitive network, the relevant research work in recent years, such as the architecture of cognitive network and key technologies of cognitive network, are briefly summarized. Chen ning and Wang lei and others article "improved nonlinear Hebbian algorithm based on fuzzy cognitive network" was studied based on fuzzy cognitive network modeling and parameter identification of nonlinear systems, the establishment of a nonlinear system with numerical reasoning and fuzzy information expression of fuzzy cognitive network models, use contain nodes, weights, and feedback the directed graph of said system, puts forward a nonlinear learning algorithm with terminal constraint. Qiu junping and liu ning pointed out in their article "review and evolution analysis of the development of domestic knowledge networks" that the development of knowledge networks has formed a radial network research and development system that takes the collaborative development of knowledge networks and knowledge management as the main line and knowledge evolution, network structure, knowledge sharing and knowledge innovation as the knowledge core. In zhang bin and li yaping's article "review on the research of knowledge network evolution model", they pointed out that the future research of knowledge network model should combine the local structural characteristics of the network and the external attribute information of the nodes to establish the hybrid preferred model. International research scholars, Thomas et al. from Virginia institute of technology proposed the concept of Cognitive Network (CN) and gave its definition: "Cognitive Network is a Network with Cognitive process, which can perceive current Network conditions and make plans, decisions and actions based on these conditions. It has the ability to adapt to the network environment, and has the ability to evaluate the previous decisions and to learn the future decisions. All decisions are to achieve the end-to-end goal, namely the network goal. Shakkottai et al. put forward the concept of cross-layer meter, which solves the problem of poor information flow between the layers of the network and is the representative work in the cognitive network architecture. Balamuralidhar and others will be Context awareness (Context Cognitive) technology is introduced into the Cognitive network node in the design of. Barbara Oakley's book "the way of learning" in the book, she put forward two kinds of thinking mode exist in the human brain: focused mode and diffuse, usually focused on patterns generated after preliminary ideas, inspiration of diffuse patterns to emerge continuously. Knowledge cognition keeps switching between the two modes. Barbara proposed a neural model composed of high-quality blocks for knowledge acquisition.

The study of Basic-element theory is an original subject of Chinese, so International research literature is not much, and it is not the research frontier. Domestic research literature puts forward the concept and theory of Basic-element. Literature studied the role of Basic-element in the construction and evolution of various complex systems. Literature proposed a new concept of the construction of Basic-element base, and proposed a construction model of Basic-element based on the differences and inconsistencies of Basic-element model established by different people in the construction of Basic-element base. The model includes four steps: Affair-element modeling, Matter-element modeling, relation-modeling, and basic-element modeling modification. The operations of adding, deleting and modifying the Basic-element and their characteristics are carried out through the modeling of the Basic-element relationship, so as to achieve the standardization and consistency of the construction of the system Basic-element library.

In the world, research on cognitive processes and patterns has made gratifying progress in switching between the two modes of thinking: the focused mode and the diffuse mode. The generation of Basic-element theory and the introduction of cognitive network can better describe the heterogeneity, dynamics and multidimensionality of network nodes, and the use of Basic-element database can integrate prior knowledge into the machine learning system. On the basis of relevant researches at home and abroad and guided by the theory of Basic-element, this paper studies the knowledge cognition network model and its operation mechanism based on the basis of the Basic-element base and the Basic-element as network nodes. The knowledge network model for double network design, the lower focused for knowledge network model, the upper divergence for knowledge network model, the lower the group focused on the role network model is formed knowledge block (hypergraph super edge), the block (edge) is mapped to the upper network form.
knowledge accumulation point, in the lower level of knowledge and strategy in the process of switching. Because some problems in the transportation network and logistics network belong to the intelligent combination problem, the application of this study takes the logistics network as an example.

**Build the Basic-element Library**

The knowledge base of knowledge cognition is the knowledge base of constructing knowledge cognition network, which is equivalent to the knowledge reserve and prior knowledge of human brain. In the research literature "research on the construction model of Basic-element base and its application" [10], it is pointed out that Basic-element base, as a knowledge system, should have the following four basic characteristics:

(a) integrity. The Basic-element library model must contain the ownership elements within the system boundary. Although different matter-elements have different characteristics, they are a set of functions to be realized in a certain way according to the overall requirements of the system.

(b) correlation. The matter elements of a system are interrelated and mutually restricted, and the relationship of mutual dependence and support has its inherent rules.

(c) purposeful. A system to be studied is a system with a clear purpose, which is reflected by the functions performed by the matter element.

(d) environmental adaptability. In general, the system we are studying belongs to a subsystem of the overall social system. There are also numerous connections between subsystems and systems outside of subsystems. Therefore, a subsystem is not an isolated system, but a system adapted to the external environment.

The Basic-element library consists of three sub-libraries: Affair-element library, matter-element library and relational matter-element library. The overall idea of its construction is shown in figure 1:

![Diagram of Basic-element library and flow chart of its construction](image)

Figure 1. Structure of Basic-element library and flow chart of its construction.

For example, if we consider the problem of logistics network, logistics routes and nodes are two important parts. In a broad sense, logistics routes refer to all the land, water and air routes that can be...
driven and navigated, while in a narrow sense, they only refer to the routes and routes that have been opened up and can be operated in accordance with regulations. Logistics nodes, also known as logistics nodes, are nodules connecting logistics lines in the logistics network, so they are also known as logistics nodules. There are many kinds of logistics nodes and different names of nodes on different lines. Then, each network node is represented by matter-element, the circuit is represented by relational element, and the job on the network is represented by Affair-element, thus constituting the basic element library of logistics network. The construction of the base library can well represent the heterogeneity, multidimensionality and dynamics of the nodes in the logistics network and other complex networks.

Construction of domain knowledge base

A dynamic domain knowledge base is constructed for the research domain. The knowledge base can be built on three levels.

The first level is "fact knowledge", which is expressed in the form of Basic-element, and its source is the Basic-element library we have built before. The subject of fact knowledge is composed of matter elements in the Basic-element library. According to the range and characteristics of the studied problem, the related matter elements are extracted from the base element library. There is a difference between the fact knowledge and the matter-element in the Basic-element base, which is to add one or more "measure marks" for each object according to the criterion of practical problems to identify its status and function. At the same time, the corresponding relationship elements in the Basic-element base are extracted as the relationship characteristics between the metric matter-element and the matter-element. We want to consider, for example, a logistics center, logistics park location selection problem, first of all to related logistics nodes in Basic-element library screening out, every logistics nodes in Basic-element repository is a specific matter element, in the knowledge base is the extension matter-element, both (a measure of the matter-element ), the measurement can be the location of logistics nodes, through put, storage, and other characteristics, thus forming the facts of the logistics center location selection problem.

The second level is "chunking knowledge", which is used to form matter elements in fact knowledge into "chunking" according to relevant rules. Knowledge at this level is mainly expressed in the form of relevant rules. The formation of chunking is driven by input elements, and the fact knowledge is combined according to the purpose characteristics of the elements, and the combination basis is "chunking knowledge". For example, given a number of logistics nodes, according to a number of rules formed by professional knowledge, the rules determine which logistics nodes can form a "block", which logistics nodes plus the proposed logistics center can form a logistics network. These professional knowledge can be traffic accessibility rules, operational ability rules, distance rules, relationship matching rules and so on.

The third level is "strategic knowledge". In the complex knowledge cognitive network to be constructed, it is used to guide the divergence, reorganization and evaluation of knowledge blocks, which is an important driving force to realize knowledge cognition and an important mechanism to generate innovation strategies.

Construction of Complex Knowledge Cognitive Network

The heterogeneity of network nodes, the multidimensional and dynamic nature of node relations are the embodiment of the complexity of knowledge cognitive network. Based on the Basic-element theory and set theory, this study starts from the formalized description of heterogeneous nodes and their relations, and proposes the construction method of complex knowledge cognitive two-layer network based on Basic-element. Fig. 2 is a schematic diagram of a two-layer cognitive network of complex knowledge based on Basic-element.
Figure 2. A two-layer cognitive network of complex knowledge based on Basic-element.

The lower layer of the two-layer knowledge cognition network is called the knowledge concentration network and the upper layer is called the knowledge divergence network.

The nodes of the lower knowledge concentration network are composed of extended matter-elements, and each extended matter-element comes from the matter-element of the Basic-element library and is attached with a "measure mark" to form the so-called "fact knowledge". Several facts are driven by "chunking knowledge" to form knowledge chunking. In other words, the lower knowledge-focused network is equivalent to purposefully chunking the factual knowledge, and each chunking is equivalent to a new cognition.

The nodes of the upper knowledge divergence network are composed of compound Basic-element and some special problems may be composed of extended relation elements. The extended relation element is a kind of relation composed of a core matter element and several other matter elements. The knowledge block in the lower-level network can be regarded as such an extended relation element. The core matter-element is the representative of extended relation element. In the upper diffuse network, the core matter-element is diverged according to its divergence.

The theory of Basic-element proposed in literature\textsuperscript{[11]}, and the basic Basic-element are composed of matter-element, relational element and Affair-element. In the complex knowledge cognitive network constructed by us, the objects involved in knowledge are represented by matter elements, so that they can represent both the homogeneity and heterogeneity of "matter" nodes. Matter-element is the basic element of formal description. The n-dimensional array composed of matter-element $O_{mi}$, matter-feature $C_{m1}, C_{m2}, \cdots, C_{mn}$ and corresponding $C_{wi} \ i=1,2,\cdots,n$ quantity value $V_{wi} \ i=1,2,\cdots,n$ is called n-dimensional matter-element.

$$
M = \begin{bmatrix}
O_{m1} & c_{m1} & v_{m1} \\
& c_{m2} & v_{m2} \\
& & \vdots \\
& & c_{mn} & v_{mn}
\end{bmatrix} = (O_m, C_m, V_m), \text{ Among them}
$$

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For example, when we consider the construction of knowledge cognitive two-layer knowledge concentration network of logistics center location problem, its network node is matter-element, as shown below are two matter-element nodes.

The matter-element representation of logistics nodes $M_i$ and $M_j$

$$
M_j = \begin{bmatrix}
\text{Logistics node} & D_j , & \text{Transport function} c_{m1} , & 45% \\
\text{Storage capabilities} & c_{m2} , & 100 \\
\text{Packaging function} & c_{m3} , & 350 \\
\text{Processing functions} & c_{m4} , & 300 \\
\text{Information function} & c_{m5} , & 75%
\end{bmatrix}
$$

$$
M_j = \begin{bmatrix}
\text{Logistics node} & D_j , & \text{Transport function} c_{m1} , & 85% \\
\text{Storage capabilities} & c_{m2} , & 90 \\
\text{Packaging function} & c_{m3} , & 400 \\
\text{Processing functions} & c_{m4} , & 350 \\
\text{Information function} & c_{m5} , & 80%
\end{bmatrix}
$$

In Network knowledge, Interaction between matters is referred to as affair, described by Affair-element, Affair-element is the basic element to describe events, Affair-element is a driving force of the network, is the external input, also may be emerging (events), action and features as well as about the value of d array as follows:

$$
A = (O, C, V) = \begin{bmatrix}
\text{O}_1 & c_{a1} , & v_{a1} \\
\text{O}_2 & c_{a2} , & v_{a2} \\
\vdots & \vdots & \vdots \\
\text{O}_n & c_{an} , & v_{an}
\end{bmatrix}
$$

Is called n-dimension Affair-element, wherein

$$
C_a = \begin{bmatrix}
c_{a1} \\
c_{a2} \\
\vdots \\
c_{an}
\end{bmatrix}
$$

$$
V_a = \begin{bmatrix}
v_{a1} \\
v_{a2} \\
\vdots \\
v_{an}
\end{bmatrix}
$$

The relation between objects involved in knowledge is represented by relation element, so that it can be reflected in the diversity of network node links, including link direction, weight and variability. A dimensional array of relationship $O_r$, features $C_{r1}, C_{r2}, \ldots, C_{rn}$, and corresponding quantities $V_{ri}, i = 1, 2, \ldots, n$.

$$
R = (O, C, V) = \begin{bmatrix}
\text{O}_r & c_{r1} , & v_{r1} \\
\text{C}_{r2} & c_{r2} , & v_{r2} \\
\vdots & \vdots & \vdots \\
\text{C}_m & c_{rn} , & v_{rm}
\end{bmatrix}
$$
Is called n-dimension relation element, wherein

\[
C_r = \begin{bmatrix}
c_{r1} \\
c_{r2} \\
\vdots \\
c_{rm}
\end{bmatrix}, \quad V_r = \begin{bmatrix}
v_{r1} \\
v_{r2} \\
\vdots \\
v_{rm}
\end{bmatrix}
\]

The relationship between nodes in the network can be more than "have" or "none" through the description of relationship elements, but can be a relationship with many attributes and measure values, which fully reflects the multiplicity and dynamics of the relationship between nodes in a complex network.

**Operation Mechanism of Double-layer Network**

The operation mechanism of the two-layer knowledge cognition network is divided into three levels. The first is the block-generation mechanism of the lower-level knowledge concentration network, the second is the divergence tree generation mechanism of the higher-level knowledge divergence network, and the third is the block-divergence interactive operation mechanism of the lower-level and higher-level network.

The block-generation mechanism in the lower concentration network is mainly based on the rules formed by the correlation, conjugation, implication and extensibility of Basic-element. In section 3 above, the domain knowledge base is constructed according to the problem requirements based on the Basic-element base. The second level of knowledge in the knowledge base, known as "chunking knowledge," is the set of rules by which facts are chunked. Basic-element correlation degree and correlation functions can put knowledge focused on the relationship between the network nodes in the form of quantitative precision, make people from the qualitative description of "relationship" development is closely related to the quantitative description of the degree of difference and can also be expanding things "with nature" qualitative description to quantitative description of a "degree" with nature. According to the relational degree, several elements (mainly matter elements) in the Basic-element library are generated into blocks, which are equivalent to a relatively independent knowledge with a specific topic. In the language of graph theory, each block is equivalent to a super side of the entire network hypergraph. Blocks (super edges) are mapped to the upper knowledge divergence network to form the so-called "knowledge cluster", which can be represented by compound Basic-element, and the upper knowledge divergence network can be formed by using compound Basic-element as nodes.

The divergence tree mechanism in the upper divergence network is mainly constructed on the basis of the divergence of Basic-element. The knowledge clustering generated by the lower concentration network is sparse in the upper network, and it is easy to connect two or more knowledge clustering points by using the divergence tree. The divergence tree can be divided into three types: the same matter divergence tree, the same feature divergence tree and the same value divergence tree. According to the diamond thinking rule, the divergence tree converges to a special knowledge cluster, which is equivalent to a new cognition of solving a problem.

The interactive operation mechanism of knowledge block-diffuse network is the interactive mechanism between the upper and lower networks, and the cognitive process of knowledge is the evolution process of the whole network under the interactive influence of the upper and lower networks. Here, we can use the knowledge of the third level in the knowledge base, that is, the mapping of the new knowledge cluster formed by the upper diffuse network driven by "strategic knowledge" to the lower concentration network, as well as the reorganization of knowledge blocks in the lower concentration network. In this evolution process, the implementation of interactive algorithm depends on the related measure method, the basic measure includes: degree and its distribution characteristics, the correlation of degree, degree of clustering and its distribution.
characteristics, the shortest distance and its distribution characteristics, betweenness and its distribution characteristics, and the size distribution of connected group. The above measurement indexes are all related to the basic eigenvalues of network Basic-element.

The operation process of the two-layer knowledge cognitive network is shown in figure 3, and the convergence of block-divergence interactive operation mechanism means the success of knowledge cognitive learning.

![Figure 3. Schematic diagram of two-level knowledge cognitive network operation.](image)

**Summary**

By introducing the Basic-element theory into the modeling of complex knowledge cognitive network, the extensibility of Basic-element makes it possible to observe and control the possibility of network evolution from the basic components of complex knowledge cognitive network. To solve the problem of formal description of heterogeneous node attributes and dynamic dimensionality of node relations in the cognitive network of complex knowledge and make the description logic operable; The construction of a two-level knowledge cognition block learning network reduces the complexity of network structure evolution control and improves the learning efficiency and applicability, so as to explore new approaches and methods for machine learning algorithms.

**References**


[9] Barbara Oakley, the way of learning, 2016, China machine press

