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Factor Neural Network and Information Ecology †

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Abstract: In this paper, we use the mathematical theory of factor space to discuss the survival space and ecological problems of the information carrier. It is pointed out that the factor neural network is a suitable mathematical tool to study the information ecology, and it puts forward the preliminary view on the application prospect of the information ecology in the big data and artificial intelligence.

Keywords: biology neuron; factor neuron (FN); factor neuron network (FNN)

1. Introduction

Considering the complication of the classification, Information science needs to define information in different levels [1]. The classification of information ecology is more complex, compared with the Information Science, so the information ecology needs to be defined in different levels obviously. Judging from the level of cognizing Informatics, the carrier of information has been separated from the source of information [2], information is a mirror image of material noumenon, which is not equal to the original image. The information carrier has its own information ecology. The material movement forms the ecology of the ontology, and the information transformation of the material ecology gives another connotations of the information ecology. These two connotations are not only related but also different from each other. If we can't see the differences, we will be confused by them.

In this paper, from the top level of the Informatics, we explore the survival space and its ecology of the information carrier. We are facing the era of big data now, and data is the generalized carrier of information. How to store and develop the big data, and form a good ecology is the actual background that we should consider. This paper is a mathematical paper, which provides the theoretical support for the information theory based on the factor space and factor neural networks. Factor space is a mathematical theory proposed by Wang P.Z. [3] in 1982. On this basis, Liu Z.L. [4] put forward the theory of factor neural network in 1992. The second section describes that the factor neural network is a mathematical tool to study information ecology, and the third section illustrates the application prospect of the information ecology in big data and artificial intelligence.

2. Factor Spaces and Factorial Neural Networks

With the brain as the subject of knowledge and the neuron as the carrier, the information is transformed into the building of knowledge through the information transformation under the interaction of the subjective and objective.

What is the forming process of the ecology? "Knowledge is derived from the information, in the support of the instinctual knowledge, and understanding information can be generated to empirical knowledge. The latter through knowledge verification (if true) will grow into normative knowledge, and a part of empirical knowledge and normative knowledge may be precipitated to common sense knowledge" [5]. This is a process of knowledge ecology, which is from "immature" experiential knowledge to "mature" normative knowledge and then to "over mature" common sense knowledge". Empirical knowledge from sense perception to consciousness forms the concept ignorantly and induces the relationship between the elements of the concepts preliminarily; Normative knowledge has a clear concept, and uses logical reasoning, to form the deductive system of the concept (description of the connotation of the concept, including reasoning knowledge);

From the mathematical description, factor space has the following uses in the forming of knowledge ecology:

(1) Factor analysis and synthesis

If you want to understand the information you need to analyze firstly and then integrate it. For example, if you want to know what is John? It is necessary to analyze his height, weight, age, occupation, personality, and so on. The focus of these analyzes is called the factor. Different goals choose different factors. There is no way to understand things without the factors. The factors are in mathematics defined as a qualitative mapping that maps the object into an attribute value. For example, the height factor is mathematically expressed as mapping f: U → {very high, tall, medium, short, very short}. Here, f is the name of the factor = height, and U represents a specific crowd called definition domain. X(f) = {very high, tall, medium, short, very short}, is called the phase space of f and also known as the dimension of a factor. The phase consisted of the linguistic value which describes the state of the attribute is called the qualitative phase. Relatively speaking, there is also a quantitative phase space: X(f) = (0.1, 2.6) (m). The qualitative word can be transformed into a fuzzy subset in the quantitative phase space, and fuzzy mathematics can be used for this transformation. The quantitative phase space corresponding to a factor dimension is not necessarily one-dimensional but may be multidimensional. Each factor derives a factor variable x in its dimension, which takes a value from X(f).

The nerve cells of the human brain are stratified by factor partition, and the single neuron excites only one attribute value under its factors. When an object excites nerve cells in different partitions simultaneously, the synapses connect to those cells will be stronger and will form a synaptic tumor with respect to a concept after multiple repetition. The memory of the object is indeed the solidification of a knowledge unite. A knowledge element is a solidified connection of a set of neurons.

A factor has a dimension, and the phase space of multiple factors of the Cartesian product space is integrated into a high dimensional space $X = X(f_1) \times ... \times X(f_n)$. A multidimensional variable $x = (x_1,..., x_n)$ is varying in X. The general phase of an object u is x if and only if $f_1(u) = x_1 \wedge ... \wedge f_n(u) = x_n$. The logical symbol means 'and', which can be interpreted as occurring at the same time. Simply speaking, X is called a factor space. (More complex definitions are omitted here). Set the height and weight each 5 phases, then the two factors have 25 configurations. It is not that every point x in X has practical meaning, the configuration of extremely short and heavy is impossible. Set

$$R = \{x = (x_1,..., x_n) \in X \mid \exists u \in U; f_1(u) = x_1,..., f_n(u) = x_n\}$$

R is a collection of real configurations taken from all objects, called the background relationship between those factors. Each point in R is called a real comprehensive point. The background relationship is further developed into the background distribution and fuzzy background distribution in the uncertain environment, which plays the core role in the theory of factor space.

Each of the actual comprehensive points represents a knowledge element. "Basic research contents of information science should include the information space, information structure" [6]. The factor space is the information space that we are looking for. It can be discussed in the information structure.

(2) Concept generation by factor space

Information structure is knowledge structure. The unit of knowledge structure is the concept. The concept has the extension and the connotation. The connotation describes its attribute configuration, which is apparent in the factor space, and the extension is the set of objects, which shows the boundaries in the field of U. Connotation and extension must match to form a concept, which can meet the consistency (that is, mutual certainty) is called the basic concept. A set of factors in the factor space classify the objects in the U: for any real integration point x, set

$$[x] = \{u \in U \mid f_1(u) = x_1, \ldots, f_n(u) = x_n\}$$

which is called the x atom in U. (x, [x]) is a pair that satisfies the connotation and extension of affinity, which is called an atomic concept. The atomic concept can be used by logic operation ∨ (called synthesis) to get all the concepts. The number of such concepts can be exponential explosion, and do not need to remember. The concept that can be in the factor space table for the rectangle (i.e., conjunctive paradigm) called the basic concept, and it need to extract memory. Factor space has a simple algorithm for basic concept extraction. The mathematical representation of the conceptual generation was put forward by Wille [7] in 1982 in the formal concept analysis. Because there is no thought of the factor space, and the algorithm is slow, at the same time there is an N-hard problem. While the algorithm complexity by the factor space is O (m^2n), where m, n stand for the numbers of objects and attributes respectively.

(3) Induce reasoning in factor space.

"Logic is a science that can be used studies the structure of information and the law of information processing, The future of the logic need to at least can describe all kinds of information form and the information structure theory, standardize all kinds of information processing and information conversion process theory, process, and deal with all kinds of uncertain information reasoning theory, etc., we call this universal logics" [8]. According to the idea to discuss reasoning, it should include the whole process of reasoning knowledge ecology. The inference of empirical knowledge is induction, and the inductive knowledge is the judgment sentence: If x is A, y is B. X and y are two factor variables. A and B are the attribute concepts of the two factors. In the stage of standardization, it is necessary to use strict logical reasoning to confirm whether the inference can be proved from the given axioms. The traditional logic does not discuss induction, only to talk about the use of the law and the syllogism, with axioms to cover up the problems. The idea of universal logic makes the factor space to discuss and describe the induction process.

"There is no reasoning between independent factors; reasoning comes from the causality between factors. The characteristic of logic is rationality, and rationality reflects the causality, therefore logic has the factor characteristic" [9]. The joint background distribution of two independent factors is equal to the product of the edge background distribution. It shows that there is a connection between the two if it is not the joint distribution of product distribution, and the background distribution determines all the inference knowledge between the two factors. As shown in the Figure 1. Let x and y be the conditional factor and resulted factor respectively. For subsets A in X and B in Y, $A(x) \rightarrow B(y)$ is a tautology (Identically true proposition) if and only if $(A \times Y) \cap R \subseteq (X \times B) \cap R$. (i.e., the cylinder extending of A is contained by the cylinder extending of B under the background relation R) There is a decisive theorem in the factor space to confirm this assertion. Its essence is that the implication of logical reasoning is the 'included' of the set. For a set of background distribution data given by the factor space, the factor space proposes a retrieval algorithm, In order to get the instances of cylinder extending containing relation from information space, summed up get the rule tree. This is a typical description of the human brain.

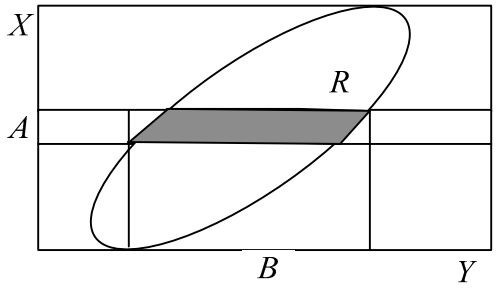

Figure 1. Background distribution determines all the inference knowledge.

(4) Decision making and controlling in factor space

Decision making and controlling is essentially a derivative causal rule extraction: if the decision is taken as a resulted factor, the extract causal rules will be transformed into a decision method. If the control variables are taken as the resulted factor, the extract causal rules will be converted to the control of multiple factors. They do not need to open another chapter in mathematics, but there is a special mathematical description of the object, which is the weight distribution. Weight is the trade-off between factors. One of the most important functions of the factor space is the decision evaluation around the weight. It has developed a set of potential theory of variable weight synthesis [9]. In the future, it is possible to adjust the evaluation system through the parameters of the differential equation to control the critical condition of the forced system.

(5) Information ecology description by factorial neural networks

The beginning of the mankind is like a baby just opened his eyes and no concept, while meaning is empty description and extension is chaos of the universe. The development of human beings from the concepts of zero to today's magnificent knowledge building comes out step by step. Knowledge ecology can be described by factor neural networks.

A factor space describes a knowledge package. Each knowledge package regards the extension of a superordinate concept as the domain of discourse, and according to the goal of solving problem, we select a set of factors to divide the concept, so as to realize the refinement of knowledge granulation. According to the form of the factors, the knowledge package is connected into the factor neural network, and the knowledge is fused to form the ecology of information development. The brain creates itself in the process of transforming information into knowledge, and the knowledge is solidified in the human brain as the knowledge neural network. The factor neural network is topologically isomorphic to the knowledge neural network, which can fully describe the knowledge ecology.

3. Applications in Big Data and Artificial Intelligence

Big data changes the normal state of data from storage to flow, not only to further change the number of data, but also to change the nature of the data, from digital to image, audio and video, and all recorded information. Factor space provides an information processing space for the intelligence of big data. Once the data is put into the factor space, the meaning of the information that it carries is revealed. The background of the data formed in the background space contains all the knowledge of concept extraction and causal reasoning. The data is the isomorphism of the human brain memory Goods. Data survives in the factor space, but information extraction and conversion in neural networks. According to the characteristics of the brain and the topology isomorphism of the neural network, an important direction of artificial intelligence is so called a man-machine cognition body [10], which is a self-organized soft/hardware ecosystem swallowing and spiting data in internet, and transferring data to cognition to knowledge. It is characterized by the extraction, development and application of knowledge, in order to achieve the purpose of intelligence for all walks of life, and promote the sustainable development of the science.

Conflicts of Interest: The authors declare no conflict of interest.

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