Development and management of product knowledge base

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ABSTRACT

The design and management of a product knowledge base (PKB) brings forward important aspects in the field of information technology. This article discusses strategies for creating and effectively managing a system based on production rules. The theoretical and practical foundations of PBP design are analyzed, with attention paid to the generation of knowledge from voluminous information data. The paper proposes an algorithm for structuring a subject area through its description using knowledge, which serves as the basis for creating a production knowledge base. The paper highlights the issue of the need to develop algorithms for determining information sets with cause and effect properties, aimed at eliminating subjectivity in the formation of the subject area and information sets. The process of formalizing the concepts of "data" and "information" builds an analytical definition of "knowledge". In this work, based on production knowledge, the concept of "fractality of knowledge" is introduced, and an algorithm for designing a fractal production knowledge base (FPKB) is proposed. The control algorithm of the FPBZ is also presented, and the decision-making procedure is based on the evaluation algorithm (ABO), designed to give the system universality in the sense of its functionality.

Keywords: management of the product knowledge base, practical fundamentals of design, design of a fractal product knowledge base, decision making is based on an algorithm for calculating estimates

1. INTRODUCTION

The difficulties associated with large volumes of data and the high speed of arrival of new information place increasingly stringent requirements on modern information systems (IS). Current information systems mainly present data in the form of text documents or information resources, which is insufficient to effectively support scientific and industrial activities. Instinctively, humans tend to convey information more effectively when it is organized in a network of interconnected knowledge. To address this issue, the proposal advocates for a shift to a qualitatively advanced level of processing and presenting information – the semantic level. This transition enables the consideration of meaning and content within documents, facilitating the extraction of pertinent data crucial for users [1].

The realization of this approach can be achieved through the utilization of an Intelligent Information System (IIS) that leverages general knowledge about the world and the specific subject area it serves, often implemented through specialized software. Currently, the adoption of production knowledge ontologies is on the rise for representing such information. These ontologies not only delineate the semantics of documents and information resources but also contribute to the creation of diverse information systems. The ontology of production knowledge can not only provide a presentation of information that is convenient for human perception, but also support meaningful, including multilingual, access to data, as well as support the process of developing the information information system itself, etc. [2-5].

Especially, intellectualized information systems are widely used in areas where decision-making requires rapid collection, processing, analysis of large volumes of data and information presented in the form of knowledge - Φ^(ue_j) (Δ(x)), where ue_j- an information unit, i.e. fractal of knowledge of the subject area, (Δ(x))- data (set of information) about the properties of the subject area reflected in the properties of the subject area in B3. By its essence, a knowledge base is an information model of a subject area. Based on these considerations, it can be stated that the development of algorithms for designing a knowledge base is in great demand today [6-8].

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Third International Conference on Optics, Computer Applications, and Materials Science (CMSD-III 2023),
edited by Shahriyor Sadullozoda, Ramazona Abdullozoda, Proc. of SPIE Vol. 13065, 130650W

The main objective of this research is to create an algorithm for designing a knowledge base built on the principle of fractality, which is the basis for a production knowledge base. The scientific novelty of this research lies in the development of an algorithmic methodology for creating a knowledge base based on the principle of fractality, as well as in the proposed algorithm for scaling an information unit to generate filtered fractal knowledge from information about the subject area. In addition, the work contributed to the algorithmization of the process of representing fractal knowledge in intelligent systems, which is a significant step in the field of intellectualization of knowledge base design. The work also draws attention to the problem of clarity in the implementation of representations, which is a pressing issue in the light of the ontological properties of knowledge and their "effect-cause" characteristics. This introduction of product knowledge context provides additional depth in understanding and managing knowledge bases for various purposes [9-13] .

The developed algorithm provides an effective tool for creating a knowledge base based on the principle of fractality and can be applied in various fields, such as science, manufacturing, medicine and others, where structuring and organizing large volumes of information is required. The proposed scaling algorithm is an important part of the process of generating fractal knowledge and can be useful in the development of data processing and information systems where fine-tuning levels of detail are required. Using an algorithm to create fractal knowledge in intelligent systems can improve decision-making processes and increase the efficiency of information systems. The emphasis on the "effect-cause" properties of elementary knowledge, expressed in product knowledge, provides insights for clearer and more effective information representation and decision making, which can be useful in a variety of applications, including decision support systems. The results of the study have scientific and practical significance in the field of design and management of knowledge bases, as well as in the development of intelligent information systems [14-16].

2. MATERIALS AND METHODS

When designing a knowledge base for an intelligent information system for a specific purpose, the main emphasis is on developing an algorithmic basis for representing knowledge using the concepts of "data" and "information" [2, 6]. It is clear that a knowledge base management system (KBMS) plays a key role in the design of intelligent information systems. UBZ is software that interacts with user applications and a knowledge base [14-16].

Although the need to determine the form of knowledge representation is undeniable, the question of which form should be chosen remains open. However, the final decision regarding the form of knowledge representation depends on the capabilities of the environment in which this knowledge will be used. Considering that the computing environment serves as a platform for the existence of formalized knowledge, the choice of the form of their presentation is determined by the capabilities of this environment.

We will call a non-empty family of elementary information { J^x(x o) } about x 0 connected by cause- and -effect relationships from S elementary production knowledge about a point x ^{0} from S , for a given information unit (e j) [1 4] and denote $\Phi^{ue_j}(\Delta(x))$, where $\Delta(x) - \{ J^x(\text{x o}) \}$. In this case Φ^{ue_j}, we denote the basis of the fractal as Δ^{ue_i}

For any elementary fractal knowledge $\Phi^{ue_j}(\Delta^*(x_0))$about a point x 0 Є S , $x_0$from the family of subsets $\{ J^x(x_0)\}$ forms a fractal in S , which we will denote by the same symbol Φ^{ue_j}. For any carrier Δ^*(x) of knowledge $\Phi^{ue_j}$from information of the form $J^{ue}(x_0)$, the family of subsets $\{ J^x\}$ forms the basis of the fractal Φ^{ue_j}. The opposite is also true. Every fractal Φ^{ue_j}in X , from subsets $J^x \in X$that contain the point x0 from X , produces knowledge $\Phi^{ue_j}(\Delta^*(x_0))$from information of the form. Moreover, any fractal basis $\Delta^{ue_i}$of this fractal Φ^{ue_j}determines the carrier $\Delta^*(x)$of such knowledge.

Information $\{ J^{K_j}(K_j), J_0^{S_j}(S)\}$ goes into the form of knowledge, or we will call this form the structural form of the object S. Such a description is carried out by algorithm A designing the FPBP.

Stages of specifying algorithm A:

We will give tasks for the stages of the algorithm according to the method described in [17-20].

- At the first step of the algorithm, using the operation $O_1^j, \dots, O_{q(j)}^j$, finds B_1^j ,... B_{uj}^j, those characterizing properties of the subject area (software) S j that constitute the essential aspects of this software. With the help of these sides we can determine that this is the right subject area. Finding B_1^j ,... B_{uj}^jrequires the development of an algorithm that determines the global and local properties of features that characterize S as a subject area. Since B_1^j ,... B_{uj}^jplay a causal role in the formation of S.
- At this step, algorithm A, using the operation $O_1^j, \dots, O_{q(j)}^j$, finds $b_1^{u,j}$,... $b_{q(i)}^{u,j}$I characterize n those properties S (S_j)which are generated by B_1^j ,... $B_{uj}^j$and therefore they express the consequential properties of S. Thus, it becomes possible to describe the structure of S , if they are information carriers, to represent them in the form of implicative relations with properties{ B_1^j ,...B_{uj}^j} .
- After finding B_1^j ,...B_{uj}^j And $b_1^{u,j}$,...$b_{q(i)}^{u,j}$ the algorithm produces a semantic description of S using a set of formulas

$$S= \Phi_{u(k)e_i}^j = B_u^j \to \sum_{i=1}^{q(i)} b_c^{u(k),i} \tag{1}$$

Here the upper index of the formula Φ shows the class number, the lower index indicates the number of knowledge contained in B_1^j ,...B_{uj}^j And $b_1^{u,j}$,... $b_{q(i)}^{u,j}$. Thus, B_u^j expresses information $J^\delta(\Delta(x))$and $b_1^{u,j},\dots,b_{q(i)}^{u,j}$ expresses information $J_1^\delta(\Delta(x)$, where have t consequential properties in the structure of knowledge

$$J^\delta(\Delta(x)) \to J_1^\delta(\Delta(x)) \tag{2}$$

The core of this production will be the knowledge fractal. And the set of formulas $\Phi_{u(k)e_i}^j$is a semantic description of S J in the form of production knowledge.

3. RESULTS AND DISCUSSION

Based on the algorithms described above, the work [21, 22] solved the problem associated with the diagnosis of ischemic stroke in women and men. As a result of solving this problem, we came to the following conclusion. When creating a fractal knowledge base for medical problems, we must first distinguish between clinical data and clinical information. It is very important. Receiving primary data from the medical history of patients in the form of the following tables, in order to construct information units, they must form B_1^j ,... B_{uj}^j. This requires statistical processing of primary data in order to generate information about data that has causal properties of causing ischemic stroke in women. After constructing B_1^j ,... B_{uj}^jwe find $b_1^{u,j}$,... $b_{q(i)}^{u,j}$information about the investigative causes of ischemic stroke in women. Only after these procedures can you begin to design the knowledge base.

Each information unit value is taken from the medical history of the studied images . By studying this table, we determine the frequency of occurrence of an information unit. For example: according to the first line of this table, 16 patients were considered. To calculate the frequency of occurrence of attributes ue j , we will count how many times the considered attribute α 1 (paralysis) was encountered 9 times. This means 9/16 is equal to 0.52 , this coefficient shows us the degree of expression of this information unit.

Thus, the general history of stroke for men and women is as follows

Table 1. Product knowledge base for cerebral ¬stroke.

	α_1	α_2	α_3	α_4	α_5
ZHI	Φ_1^1	Φ_1^2	Φ_1^3	Φ_1^4	Φ_1^5
ZhG	Φ_2^1	Φ_2^2	Φ_2^3	Φ_2^4	Φ_2^5
MI	Φ_3^1	Φ_3^2	Φ_3^3	Φ_3^4	Φ_3^5
MG	Φ_4^1	Φ_4^2	Φ_4^3	Φ_4^4	Φ_4^5

Here ZI – ischemic stroke in women, ZH – hemorrhagic stroke in women, MI – ischemic stroke in men, MH – hemorrhagic stroke in men.

MI:

$$\begin{gathered}
\Phi_1^1 = \beta_1^1 \to (0{,}52\alpha_1^1 \vee 0{,}35\alpha_1^2 \vee 0{,}21\alpha_1^3 \vee 0{,}05\alpha_1^4) \\
\Phi_1^2 = \beta_1^2 \to (0{,}15\alpha_2^1 \vee 0{,}1\alpha_2^2 \vee 0{,}26\alpha_2^3 \vee 0{,}21\alpha_2^4 \vee 0{,}26\alpha_2^5) \\
\Phi_1^3 = \beta_1^3 \to (0{,}42\alpha_3^2 \vee 0{,}15\alpha_3^3 \vee 0{,}42\alpha_3^4) \\
\Phi_1^4 = \beta_1^4 \to (0{,}41\alpha_4^1 \vee 0{,}35\alpha_4^2 \vee 0{,}23\alpha_4^3) \\
\Phi_1^5 = \beta_1^5 \to (0{,}15\alpha_5^1 \vee 0{,}31\alpha_5^2 \vee 0{,}42\alpha_5^3 \vee 0{,}1\alpha_5^4)
\end{gathered} \tag{3}$$

ZHI:

$$\begin{gathered}
\Phi_2^1 = \beta_1^2 \to (0{,}56\alpha_1^1 \vee 0{,}18\alpha_1^2 \vee 0{,}18\alpha_1^3 \vee 0{,}06\alpha_1^4) \\
\Phi_2^2 = \beta_2^2 \to (0{,}05\alpha_2^1 \vee 0{,}11\alpha_2^2 \vee 0{,}38\alpha_2^3 \vee 0{,}22\alpha_2^4 \vee 0{,}22\alpha_2^5) \\
\Phi_2^3 = \beta_3^2 \to (0{,}27\alpha_3^2 \vee 0{,}2\alpha_3^3 \vee 0{,}44\alpha_3^4) \\
\Phi_2^4 = \beta_4^2 \to (0{,}4\alpha_4^1 \vee 0{,}46\alpha_4^2 \vee 0{,}31\alpha_4^3) \\
\Phi_2^5 = \beta_5^2 \to (0{,}22\alpha_5^1 \vee 0{,}33\alpha_5^2 \vee 0{,}22\alpha_5^3 \vee 0{,}4\alpha_5^4 \vee 0{,}4\alpha_5^5)
\end{gathered} \tag{4}$$

MG:

$$\begin{gathered}
\Phi_3^3 = \beta_3^3 3(0{,}21\alpha_3^2 \vee 0{,}26\alpha_3^2 \vee 0{,}528\alpha_3^4) \\
\Phi_3^4 = \beta_4^3 \to (0{,}30\alpha_1^4 \vee 0{,}30\alpha_4^2 \vee 0{,}40\alpha_4^3) \\
\Phi_3^5 = \beta_5^3 \to (0{,}27\alpha_5^1 \vee 0{,}2\alpha_5^2 \vee 0{,}44\alpha_5^3 \vee 0{,}52\alpha_5^4 \vee 0{,}15\alpha_5^5)
\end{gathered} \tag{5}$$

ZhG:

$$\begin{gathered}
\Phi_4^1 = \beta_1^4 \to (0{,}62\alpha_1^1 \vee 0{,}31\alpha_1^2 \vee 0{,}06\alpha_1^4) \\
\Phi_4^2 = \beta_2^4 \to (0{,}06\alpha_2^1 \vee 0{,}56\alpha_2^2 \vee 0{,}18\alpha_2^3 \vee 0{,}12\alpha_2^4 \vee 0{,}06\alpha_2^5) \\
\Phi_4^3 = \beta_3^4 \to (0{,}06\alpha_3^2 \vee 0{,}31\alpha_3^3 \vee 0{,}62\alpha_3^4) \\
\Phi_4^4 = \beta_4^4 \to (0{,}08\alpha_4^1 \vee 0{,}41\alpha_4^2 \vee 0{,}5\alpha_4^3) \\
\Phi_4^5 = \beta_5^4 \to (0{,}12\alpha_5^{1} \vee 0{,}12\alpha_5^{2} \vee 0{,}18\alpha_5^{3} \vee 0{,}37\alpha_5^{4} \vee 0{,}37\alpha_5^{5})
\end{gathered} \tag{6}$$

Thus, table 1 serves us to determine the degree of expression of the attributes of each information unit. (1)-(4) expresses the fractal production knowledge base for stroke

Based on how (1)-(4) are compiled, we can describe the clinical condition of the patient using an information unit as follows. Upon admission of the patient S x to the clinic, its clinical symptoms are expressed as: S x =($\alpha_1^i \wedge \alpha_2^i \wedge \alpha_3^i \wedge \alpha_4^i \wedge \alpha_5^i$). Let's say a patient S x was admitted to the clinic with the following information unit attributes: paralysis (α_1^1), age over 70 years (α_2^5), coma (α_3^4), no pupillary reaction to light (α_4^3), systolic blood pressure below 100 мм. rt. Art. (α_5^1). This patient's state in our concept looks like S x =($\alpha_1^1 \wedge \alpha_2^5 \wedge \alpha_3^4 \wedge \alpha_4^3 \wedge \alpha_5^1$). Here the expression $\wedge$ - is a logical "and". Thus , we will be able to fully formally describe the clinical condition of the patient.

According to the logical development of the process of cerebral stroke, the main cause is vascular vasculitis . And the severity of vasculitis can be characterized using the coefficient β . All this suggests that the patient's clinical condition can be described using cause- and-effect relationships. Such a connection is formally written using the logical implication "→". This expression reads as "if ... then." It follows from this that we can formally express the patient's condition using β as β→ S x or β →($\alpha_1^i \vee \alpha_2^i \vee \alpha_3^i \vee \alpha_4^i \vee \alpha_5^i$), where $\vee$ - is a logical "or". In fact, these expressions reflect elementary knowledgeΦ^{ue_j} about stroke. Thus, this approach allows us to create a production knowledge base of cerebral stroke.

And e j are placed in columns , by line - the form or class of the disease. At the intersection of rows and columns, elementary knowledge Φ^{ue_j}about the type of disease associated with a specific information unit.

4. CONCLUSION

When establishing a knowledge base, the primary objective is to depict the systemic model of the subject area in the realm of knowledge. This undertaking involves not only crafting algorithmic solutions but also refining specific concepts linked to the conversion of information into knowledge. Therefore, the algorithmic delineation of the process to generate fractal knowledge from an information set describing the subject area stands as a pivotal phase in the intellectualization of knowledge base design.

The proposed algorithm for scaling an information unit is an integral part of obtaining filtered fractal knowledge from information about the subject area. This paper presents an algorithmization of the process of generating fractal knowledge in intelligent systems. It is important to note that these representations may not always be implemented with the same clarity. This is explained by the ontological property of knowledge, manifested in the "effect-cause" characteristics of elementary knowledge. Typically, knowledge with such properties is called production knowledge.

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