

# Formalization of Chinese Image Medicine Diagnostic Space in Onto-oriented Information Systems

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## Abstract

This article describes the diagnostic space of Chinese image medicine and also creates a mathematical model of this space. This is an important step in the direction of development of an integrated onto-oriented information-analytical environment of research, professional healing and e-learning of Chinese image medicine, which is a representative of unconventional medical areas and a promising component of integrative scientific medicine. A unified model of diagnosis in Chinese image medicine has been developed, which is a function of topological and nosological ontologies, as well as ontologies of methods and ontologies of metrics and scales in Chinese image medicine.

## Keywords 1

mathematical modeling, diagnostic space, ontology, information system, Chinese Image Medicine, Integrative Scientific Medicine

## 1. Introduction

The healthcare industry has undergone significant transformations in recent decades, taking the vector for a more holistic and individualized approach to healing and disease prevention. The presence of negative side effects and aggressive treatment methods of conventional medicine repel patients, prompting them to resort to non-traditional methods of rehabilitation, where treatment is mostly non-invasive with minimal side effects [5, 6, 24]. The integration between official medicine (conventional, Western) and folk (unconventional, alternative, Eastern) medicine comes to the fore, which results in Integrative Medicine [1, 22, 27]. As an example, today many prestigious medical centers offer their patients oriental medicine and other alternative treatments [7, 12]. Especially popular is Traditional Chinese Medicine (TCM), the methods of which are already recognized by many countries [3, 4]. In China itself, due to the Chinese way of life and the tradition of maintaining good health, TCM is part of the official medical system in China [11, 21, 30].

Integrative Medicine is positioned as a project of future scientific medicine, which will be a single metasystem that synthesizes on a dialectical or complementary basis diagnostic, therapeutic, health, preventive and rehabilitation principles, theories, models, methods and means of various existing medical systems. The Integrative Medicine creation is designed to eliminate the disadvantages of conventional and unconventional medicine, through their harmonious complementation and synthesis, which will contribute to the formation of a qualitatively new level of future medicine. WHO (World Health Organization) Strategy contributes to this in the field of folk medicine for 2014-2023 years to support the development, spread and implementation of folk medicine in official medicine [28].

Despite the active development of Integrative Medicine in America, China and Europe, the existence of many international periodical scientific journals, scientific monographs on the formation of

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Integrative Medicine and holding several world and international congresses of Integrative Medicine, it can be argued that today Integrative Scientific Medicine is not a formed theoretical and applied direction, its formation is only at its initial stage. A special difficulty is the process of integration of folk medical systems with official (scientific) medicine, due to the fact that the vast majority of existing unconventional (folk, traditional) medical fields do not have sufficient theoretical and experimental-clinical justification, in particular, in evidence-based medicine, and also for folk medical systems there are almost no modern information-analytical means for collecting, analyzing, systematizing, comparing the results of diagnostic and therapeutic activities of relevant specialists (healers and therapists), there are no information systems to support diagnostic and therapeutic decisions, relevant knowledge bases and e-learning systems, which forms the skeptical attitude of the academic community towards them.

Solving these difficult science-intensive problems requires the development and implementation of a series of comprehensive innovative research programs and technological developments for those folk (unconventional) medical systems that claim to be part of the future of Integrative Scientific Medicine. An example of such a research program is the International Research Program of Chinese Image Medicine (CIM) for 2017-2023, implemented by the Beijing Medical Research Institute Kundawell (China) [9]. The main goal of this research program is to create theoretical, experimental and technological scientific foundations of CIM. As an important component of TCM, Chinese Image Medicine, (origin from Chinese: 意象医学 [Yi Xiang Yi Xue] - Yi Xiang Yi Xue 意 mind, consciousness, 象 picture, image, 医 medicine, 学 science) - an integral system of knowledge and diagnosis methods, therapy, rehabilitation and prevention, aimed at restoring the natural state of human health, is the author's development of Professor Mintang Xu and is based on the systematization (integration) and development of knowledge and traditional TCM methods, in particular, the methods of ancient Chinese medicine Bien Chue schools, psychophysical methods and practices that exist in China within the framework of Taoist, Buddhist and pre-religious traditions, trying to modernize them and supplement them with modern scientific concepts of medicine, biology, psychology, informatics, physics and adapt them to the modern person perception. At the present stage, CIM is in the stage of active transformation of ancient methods and modern scientific research and is an innovative direction in the development of Traditional Chinese Medicine [18]. CIM has received a powerful impetus to its further development and active spread in more than 50 countries.

One of the important tasks of the International Research Program of Chinese Image Medicine is to develop an integrated onto-oriented information-analytical environment of scientific researchers, professional healing activities and e-learning of Chinese Image Medicine. This integrated information-analytical environment will allow to eliminate potential obstacles to the formation of Integrative Scientific Medicine, technologies standardization for providing quality medical care by methods of CIM and is a necessary condition for conducting their comprehensive research at theoretical and applied levels.

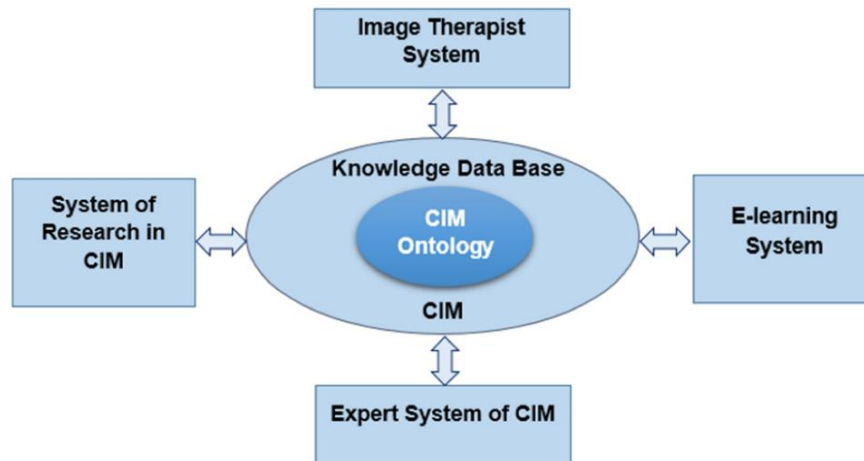
Given the onto-orientation of the integrated information-analytical environment, in order to ensure a high level of semantic quality of representation and integration of knowledge in Integrative Scientific Medicine, as well as in Chinese Image medicine as its promising component, in paper [15] the axiomatic-deductive strategy of their organization is substantiated. Based on the axiomatic-deductive strategy in paper [13], logical-structural models of representation and integration of knowledge from different (conventional and non-conventional) medical systems within the framework of Integrative Scientific Medicine have been developed. In order to clearly specify the knowledge about the methods of diagnosis in CIM, in the environment of Protégé built a diagnostic ontology of CIM.

Building a diagnostic ontology of CIM is an important, but only the first step to develop a full-fledged onto-oriented information system "Image Therapist", which is designed to collect, systematize, comparative analysis and future additions, synthesis of diagnostic and therapeutic data obtained by CIM methods and methods conventional (Western) medicine. In this context, an important next step is the formalization of the diagnosis and diagnostic space of CIM for complete and adequate presentation of diagnostic information obtained by CIM methods in onto-oriented information systems for Integrative Scientific Medicine. This article is actually devoted to solving this problem.

## 2. Materials and methods

### 2.1. Diagnostic information types in the integrated information-analytical environment for CIM

Figure 1 [14] presents the architecture of the information and analytical environment for CIM. The purpose of the development of this environment is to ensure the effective organization and coordination of the work of existing CIM therapists, CIM researchers, people who study CIM, as well as the creation of modern intellectualized information tools and resources in the field of folk [8, 25, 29], complementary and integrative medicine [2, 31, 32].



**Figure 1:** General architecture of integrated onto-oriented information-analytical environment

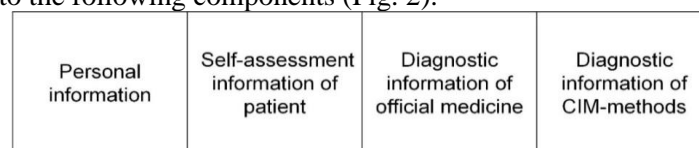
Diagnostic information about the patient in an integrated onto-oriented information-analytical environment of scientific research, professional healing and e-learning of Chinese Image Medicine is proposed to provide according to table 1 [13].

**Table 1**

Diagnostic information types in the integrated information-analytical environment of CIM

Personal information (age, gender, family members, etc.)	Self-assessment information (physical and psychological condition) of the patient before and after therapy, using methods of psychological scaling
Medical information about the patient includes information obtained by methods of conventional (Western) medicine, namely, medical history and results of medical examinations (laboratory tests, results of functional diagnostics, doctor's report, etc.)	Diagnostic information obtained by TCM and CIM methods, namely, the results of diagnosis by TCM (examination, listening, palpation diagnosis results), the results of energy diagnosis by hand and (or) body, the results of internal imaging ("Eye of the Mind", "Second Heart"»)

In particular, in the information system "Image Therapist" the generalized structure of the patient's data can be divided into the following components (Fig. 2).

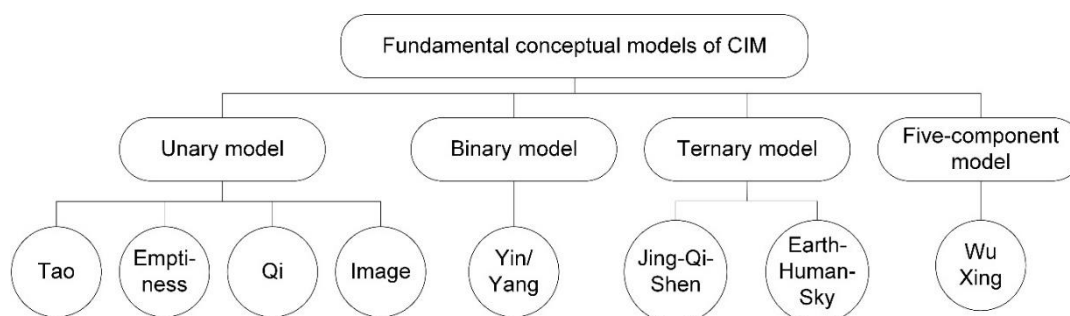


**Figure 2:** Generalized structure of patient data in the information system "Image Therapist"

## 2.2. Conceptual basis of diagnosis formation in CIM

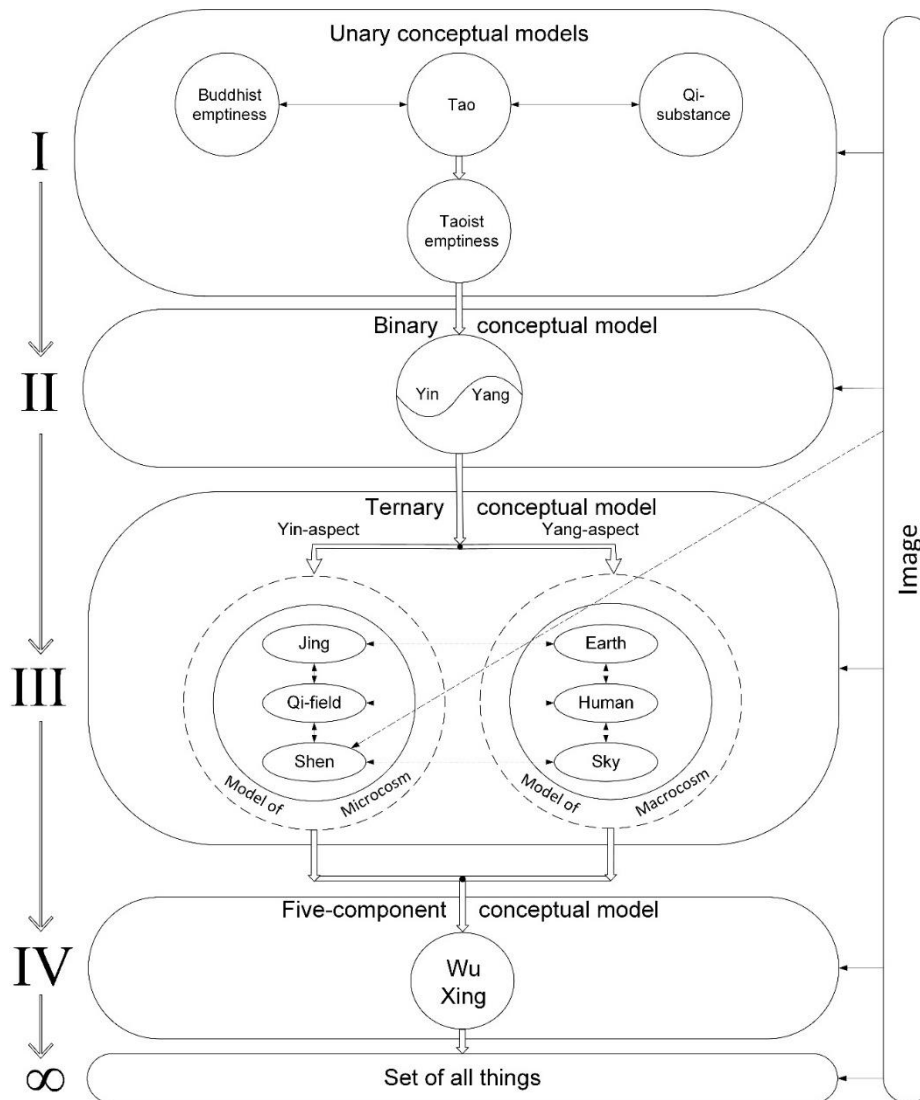
Personal medical data of the patient obtained by conventional Western medicine (laboratory tests, medical history, results of functional diagnostics, etc.) and information about the patient's self-rating are not difficult to form. However, the formation of diagnostic information by CIM methods is difficult scientific problem, the solution of which is possible by developing new mathematical models, methods and means of presenting diagnostic information obtained by CIM methods.

The theory and technology of diagnosis in CIM are based on the traditional for TCM and Chinese culture in general theory of reality and human, the conceptual model of which can be presented as a system of eight interrelated concepts "Tao", "Emptiness", "Qi-substance", "Image", "Yin-Yang", "Jing-Qi-Shen", "Earth-Human-Sky", "Wu Xing". All these traditional concepts of CIM can be combined into a group of unary conceptual models - concepts whose core content is only one concept; binary conceptual models - concepts, the essence of which is revealed through two mutually opposite and complementary concepts; ternary conceptual models - concepts that have three meaningful interconnected centers-concepts; as well as conceptual models of greater than 3 dimensions (n-ary conceptual models ( $n > 3$ )). The group of unary conceptual models of the traditional theory of CIM includes such concepts as "Tao", "Emptiness", "Qi-substance" and "Image". The group of binary conceptual models includes the concept of "Yin-Yang", which is based on two mutually opposite and complementary concepts "Yin" and "Yang". The group of ternary conceptual models includes such concepts as "Jing-Qi-Shen", "Earth-Human-Sky". The group of five-dimensional conceptual models includes the concept of "Wu Xing", the content centers of which are the concepts of "Water", "Tree", "Fire", "Earth" and "Metal" (see Figure 3).



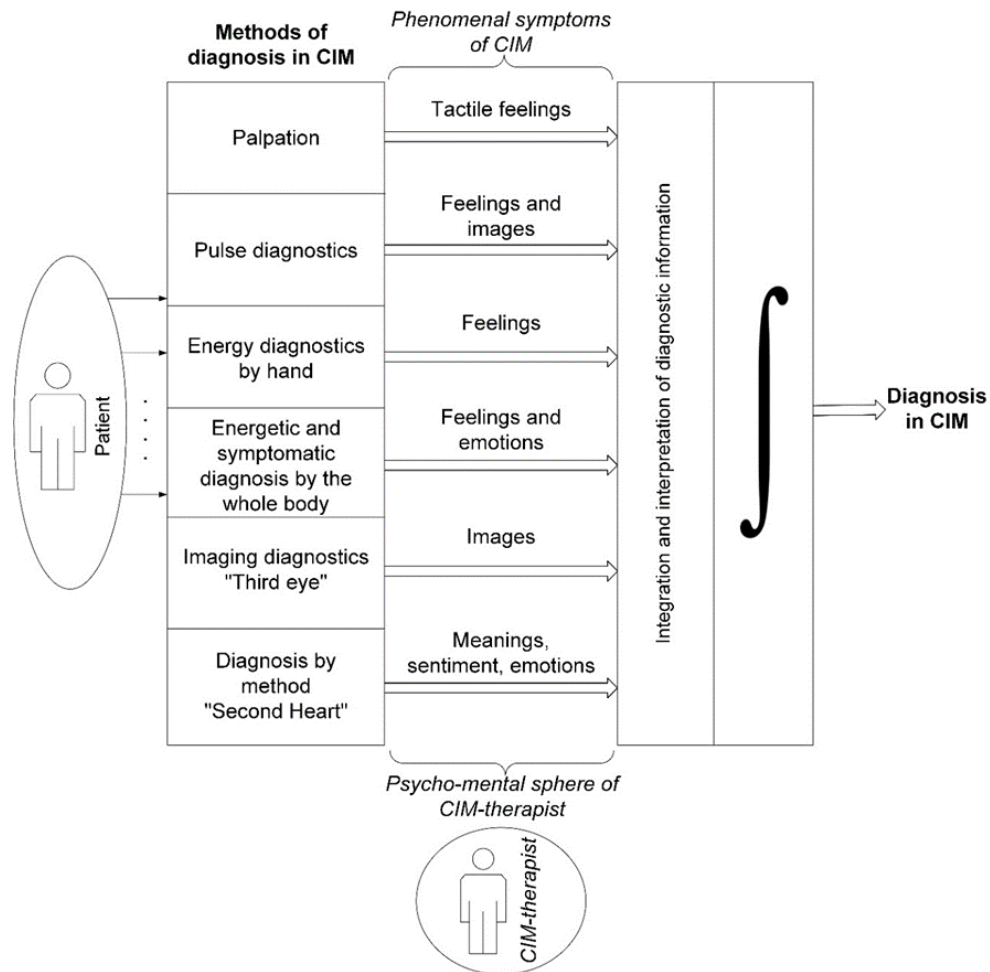
**Figure 3:** Fundamental conceptual models of "Theory of Reality and Human in CIM"

Certain conceptual models of different dimensions correspond to certain ontological levels in the traditional theory of CIM. Thus, in the theory of CIM there are five basic fundamental ontological levels of reality and human, namely, the first most fundamental level is the level of "Emptiness", the second is the level of "Yin-Yang", the third is the level of "Jing-Qi-Shen", which is divided into three ontological sublevels - the level of "Jing", the level of "Qi" and the level of "Shen". It is established that between the fundamental concepts of the theory of reality and man in CIM there is a relation of generation "Tao - Emptiness - Yin / Yang - Earth-Human-Sky (Jing-Qi-Shen) - the set of all things". This relationship reflects the generation of the connotation of a larger dimensional conceptual model from the connotation of a smaller dimensional conceptual model (see Figure 4).



**Figure 4:** Extended cross-conceptual relationship between fundamental concepts in CIM

Evaluation of the patient's condition in CIM is performed at all five ontological levels using the following diagnostic methods: palpation, pulse diagnostics, energy diagnostics (Qi-diagnostics) by hand, energy and symptomatic diagnostics with the whole body, image diagnostics (diagnostics by the method of "Eye of the Mind"), diagnostics by the method of "Second Heart" (see Figure 5). The result of diagnosing in CIM is the formation of a set of sensations, images and conceptual knowledge in the inner space of consciousness of CIM-therapist. In general, in the internal diagnostic space of the CIM-specialist as a whole structure it is possible to distinguish its four aspects (projections), namely, sensory projection (contains information about the patient's Qi state), image projection (contains information about the patient's condition in the form of visual images), psycho-emotional projection (contains information about the psycho-emotional state of the patient in the form of feelings or emotions) and semantic projection (contains semantic interpretation of the received sensations, images, emotions and feelings). The process of diagnosis in CIM is conditionally presented in Figure 5.

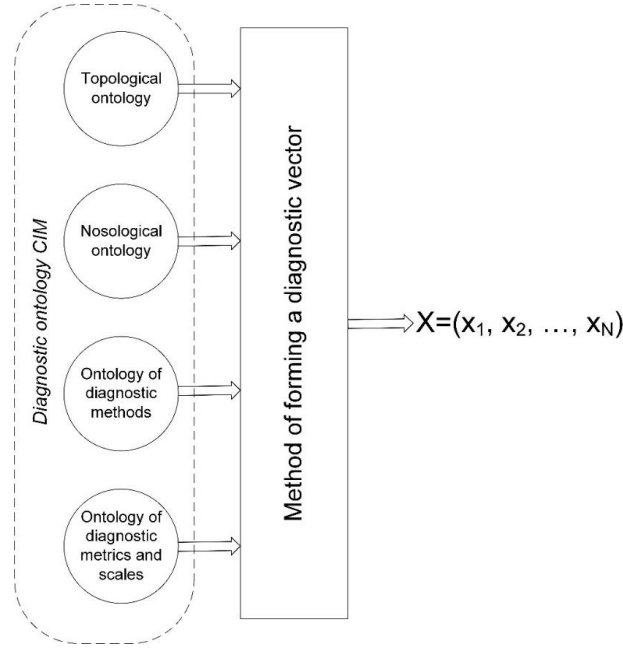


**Figure 5:** Conditional scheme of diagnosis in CIM

By their ontological and epistemological nature, these sensations, images, feelings and meanings (interpretations) have both objective and purely subjective components, which have significant variations, differences in different CIM-therapists. In addition, it is necessary to take into account the irrational, intuitive, heuristic component of the process of making diagnostic decisions by a CIM-specialist. Therefore, one of the main tasks in building a model of the CIM diagnostic space is to separate (select) from the diagnostic information space of the CIM-specialist as a subject-object integrity, its purely objective component, and to develop convenient for the CIM-specialist means of objectification, unified presentation of important diagnostic information.

### 3. Results and discussion

Creation of diagnostic space  $X$  and diagnostic vector  $X \in X$  for CIM should be preceded by the development of a diagnostic ontology  $O_D$  CIM (ontology of the theory and technologies of diagnosing in CIM), which as its sub-ontology should include nosological ontology  $O_N$  CIM, topological ontology  $O_T$  CIM, and ontology  $O_M$  methods of obtaining and specifying sensory-image diagnostic information (ontology of diagnostic methods) in CIM, as well as an ontology  $O_S$  of diagnostic metrics and scales in CIM (see Figure 6).



**Figure 6:** Conditional scheme of diagnostic vector formation in CIM

The diagnostic ontology of CIM can be presented as four of its sub-ontologies:

$$O_D = \{O_T, O_N, O_M, O_S\}, \quad (1)$$

Topological ontology  $O_T$  CIM displays information about the topological localization of diseases.

Given the presence of many ontological existence levels of human diseases in the theory of CIM, the topological diagnostic ontology of CIM can be presented as a set of its topological diagnostic sub-ontologies that correspond to the accepted in the theory of CIM ontological levels (a total of 5 ontological levels), in particular, anatomical (physical) topological ontology  $O_{Tf}$  physical human body, topological ontology  $O_{Te}$  energy-field system ("Qi" system, acupuncture system) of human, ontology  $O_{Ti}$  information (psycho-mental-spiritual) human system. That is, these three topological ontologies  $O_{Tf}, O_{Te}, O_{Ti}$  can be considered as one topological ontology  $\Omega_T$ , which consists of them, namely:

$$O_T = \{O_{Tf}, O_{Te}, O_{Ti}\} \quad (2)$$

The creation of these ontologies is a rather difficult task and it requires additional thorough research. Some issues of ontological modeling are considered in [14].

In addition, it should be noted that in the CIM energy and human information systems have a certain kind of projection on the physical human body, namely, their components are associated with the corresponding anatomical components of the physical body. Therefore, given this connection, it is possible to build a topological ontology (taxonomy) of CIM only on the basis of one anatomical ontology (taxonomy)  $O_{Tf}$  of the human physical body, attributing to each element of the glossary of this ontology the appropriate type of disease at the physical, energy and information levels. It should also be noted that a topological ontology can be represented as a sequence of included topological ontologies  $O_{T_1} \subset O_{T_2} \subset \dots \subset O_{T_k}$  with varying degrees of topological detailing, reflecting the hierarchical organized set of inserted partitions of the human body image into sections (parts of the human body, organ systems, individual organs and organ sections).

Also, the topological ontology should contain information not only about the human body parts, but also information about the relationships between them, which at the formal mathematical level are a set of relationships between elements of topological ontology.

Nosological ontology ontology  $O_N$  CIM reflects knowledge of the diseases types (classes) that are accepted in the diagnostic theory of CIM and built in accordance with generally accepted technologies for developing ontologies [10, 19, 20] using the environment Protégé [16, 17, 26].

Ontology  $O_M$  diagnosing methods in CIM reflects knowledge of obtaining methods and specifying sensory-diagnostic information in CIM. Diagnostic methods are the basis for perception and identification (characterization) of the patient's condition in terms of nosological ontology of CIM.

There are many diagnostic methods associated with each nosological class of CIM, on the basis of which information can be obtained that is sufficient to assign the patient's condition to this nosological class. Therefore, it seems appropriate to indicate which method or set of methods of diagnosing CIM-therapist used to make his chosen diagnosis. It is also necessary to indicate what feelings, images, emotions from the predetermined (created) taxonomy of psycho-mental-spiritual states of the CIM-specialist were present in his mind and were interpreted by him as appropriate nosological signs. Taxonomy nodes of psycho-mental-spiritual states of the CIM-specialist, which represent the possible states of the patient during his diagnosis by CIM-methods, belong to the set consisting of the subset "Feelings", "Images", "Emotions (feelings)", "Desires (wills)", "Meanings (knowledge, interpretation)".

Ontology  $O_S$  of diagnostic metrics and scales in CIM describes the quantitative characteristics (indicators) of the diagnostic space of CIM, which determine the disease manifestation degree and can be set to a certain numerical (for example, from 1 to 5) or non-numerical (for example, very weak, weak, medium, strong, very strong) scale.

Consider in more detail the general structural features of the above ontologies, moreover to simplify the presentation and understanding of the material, we will assume that these ontologies are taxonomies. In this case, we will have a diseases taxonomy (nosological taxonomy) in CIM, which will be presented as a pair:

$$O_N = \langle \Omega_N, \subset \rangle, \quad (3)$$

where  $\Omega_N$  is a set of diseases types in CIM, which is the corresponding glossary of diseases in the CIM theory, and relation " $\subset$ " is a relation of strict inclusion that takes place between the elements (concepts) of the glossary  $\Omega_N$ . As an example, Figure 7 shows a fragment of the CIM nosological taxonomy.

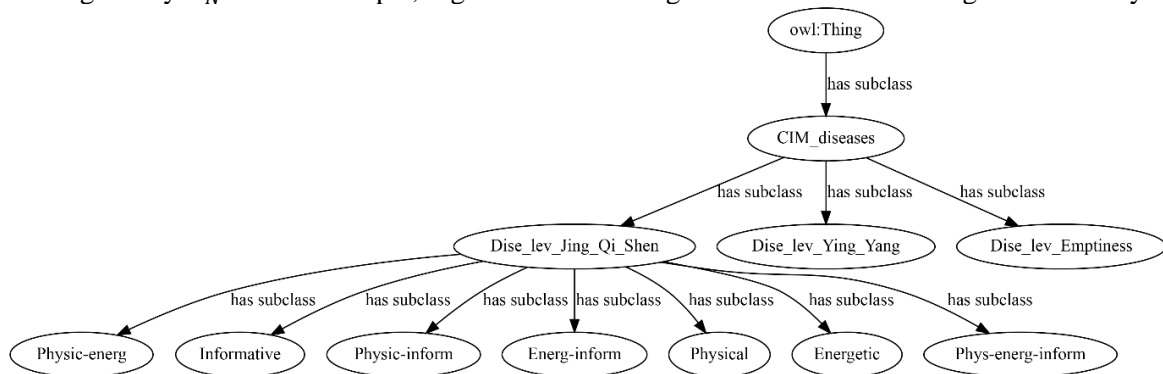


Figure 7: A fragment of the CIM nosological taxonomy

Topological taxonomies will accordingly be presented as such pairs:

$$O_{Tf} = \langle \Omega_{Tf}, \subset \rangle, O_{Te} = \langle \Omega_{Te}, \subset \rangle, O_{Ti} = \langle \Omega_{Ti}, \subset \rangle, \quad (4)$$

where  $\Omega_{Tf}$  is a set of types of anatomical divisions (parts of a body, organs, fabrics) of a human physical body; set  $\Omega_{Te}$  is a set of components (bioactive points, collaterals, energy channels, energy centers) of the human energy system; set  $\Omega_{Ti}$  is a set of components (communication links between organs, psycho-mental elements) of the human information system. In all the above topological taxonomies of the relation " $\subset$ " is a strict inclusion relation that occurs between the corresponding classes of the corresponding sets  $\Omega_{Tf}, \Omega_{Te}, \Omega_{Ti}$ . As an example, Figure 8 shows a fragment of the anatomical taxonomy of the human physical body.

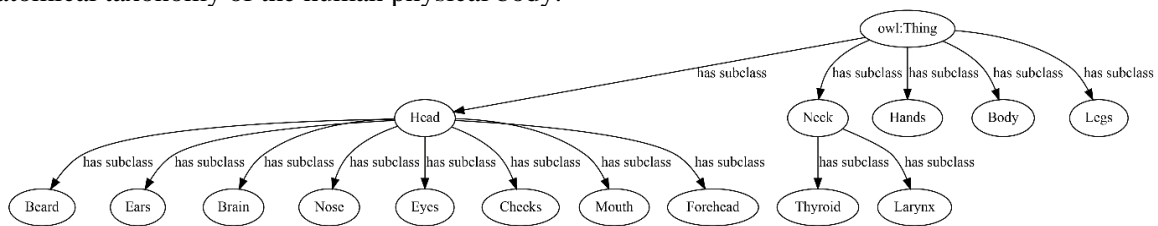


Figure 8: A fragment of the topological anatomical taxonomy of the human physical body in CIM



Diagnostic methods taxonomy will be presented as a pair:

$$O_M = \langle \Omega_M, \subset \rangle, \quad (5)$$

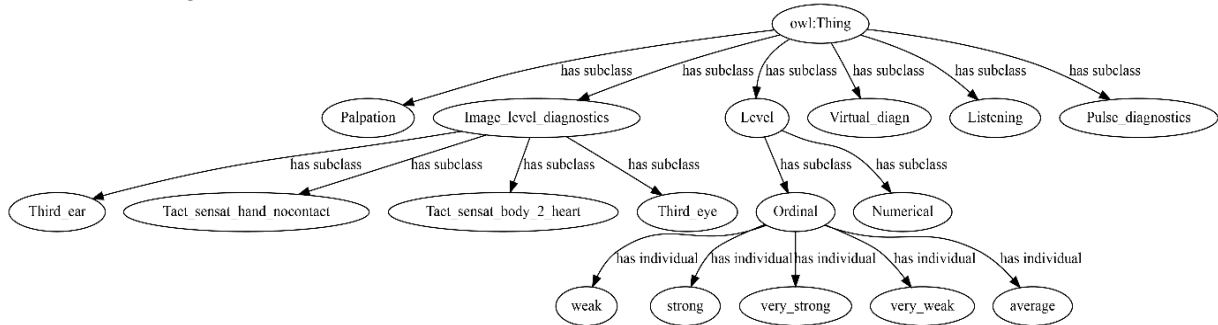
where  $\Omega_M$  is a glossary of diagnostic methods in CIM, and relation “ $\subset$ ” is a relation of strict inclusion that takes place between the elements (concepts) of the glossary  $\Omega_M$ .

A taxonomy of metrics and diagnostic scales will be presented as a pair:

$$O_S = \langle \Omega_S, > \rangle, \quad (6)$$

where  $\Omega_S$  is a glossary of metrics and relevant scales for assessing the manifestation degree of the corresponding nosological unit in diagnosed patients by CIM methods, and attitude “ $>$ ” is a comparison ratio that takes place between the elements (concepts) of the glossary  $\Omega_S$ .

As an example, Figure 9 shows a fragment of CIM diagnostic methods taxonomy and taxonomy of metrics and diagnostic scales.



**Figure 9:** A fragment of the CIM diagnostic methods taxonomy and taxonomy of metrics and diagnostic scales

Information on the components of the diagnostic ontology of CIM is grouped in table 2.

**Table 2**

Components of the CIM diagnostic ontology

Components of the CIM diagnostic ontology	Components description of the diagnostic CIM ontology
TOPOLOGICAL ONTOLOGY CIM	Topological ontology CIM reflects information on the topological localization of diseases involving the physical body, energy system (field system, Qi system) and information systems (psycho-mental-spiritual system, Shen system) of human, in particular, contains information about body parts, organs, physical body tissues, information about bioactive points and energy channels of the human energy system, information about informational, psycho-emotional, mental and spiritual topological aspects of man.
NOSOLOGICAL ONTOLOGY CIM	Nosological ontology of CIM reflects knowledge about types (classes) of diseases which are accepted in the CIM diagnostic theory
ONTOLOGY OF DIAGNOSIS METHODS OF CIM	The ontology of diagnostic methods in CIM reflects knowledge about methods (channels) of receiving and specifications of sensory-image diagnostic information in CIM.
ONTOLOGY OF DIAGNOSTIC METRICS AND SCALES IN CIM	Describes the quantitative characteristics (indicators) of the diagnostic space of CIM, which determine the disease manifestation degree and can be set to a certain numerical or non-numerical scale.

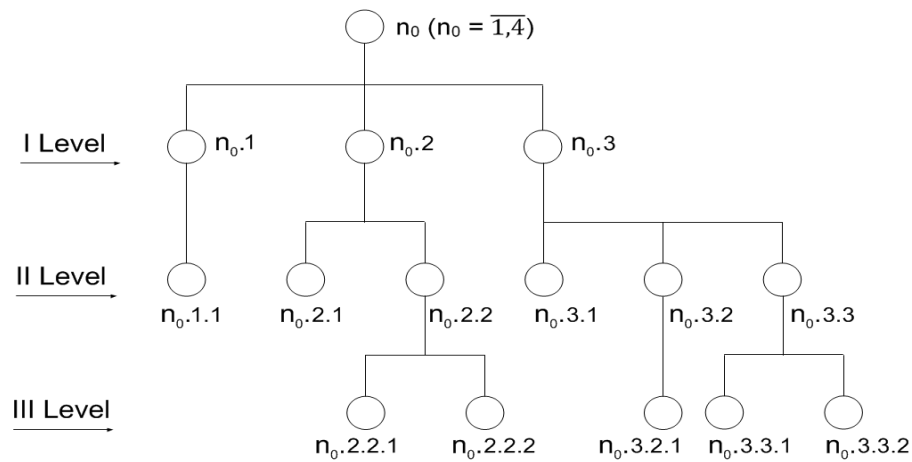
At the most abstract level, the diagnostic space can be represented as a set of all possible diagnoses in the CIM, and each individual diagnosis will be presented as a result of design according to a certain procedure  $F(\cdot)$  from the ontologies described above. In this case, the CIM diagnostic space is a function of the ontologies  $O_T, O_N, O_M, O_S$ , namely:

$$X = F(O_T, O_N, O_M, O_S), \quad (7)$$

where  $F(\cdot)$  - a certain type of method (algorithm, procedure) formation of the diagnosis in CIM from the corresponding ontologies  $O_T, O_N, O_M, O_S$ .

The creation of the above ontologies (taxonomies) is the first step in building a model of the diagnoses and diagnostic space of CIM. The next research stage is to build a procedure for forming a diagnoses and diagnostic space from nosological ontology in CIM, topological ontology, ontology of diagnostic methods and ontology of metrics and scales in CIM.

The taxonomy can be graphically represented as an ordered root tree, the nodes of which are glossary-concept classes, and the edges will reflect the inclusion ratio. This method of graphical taxonomies representation is often used in ontology development environments. For convenience CIM diagnostic space formation from the above taxonomic trees it is necessary to carry out coding of their tops. We will use this principle of coding nodes of taxonomic trees. Each taxonomic tree is assigned a serial number  $n_0$  from 1 to 4. For example, to ontology  $O_T$  is assigned number 1 ( $n_0 = 1$ ), to ontology  $O_N$  is assigned number 2 ( $n_0 = 2$ ), to ontology  $O_M$  is assigned number 3, and to ontology  $O_S$  is assigned number 4. The upper node (root) of the taxonomic tree will be denoted by a number equal to the ordinal number of the corresponding taxonomic tree (corresponding ontology). Each level of a taxonomic tree is encoded by an integer equal to the number of its appearance in the direction from the top (root) of the tree to its branches. In general,  $k$ -th level of a taxonomic tree with a serial number  $n_0$  is presented as a combination of numbers separated by a period  $n_0.k_1, \dots, k_i$ , where the first component displays the ordinal number of the taxonomic tree, and  $i$  displays the ordinal number of the level in this taxonomic tree [23]. For any node, the last digit indicates its sequence number at this level from its ancestor, and all previous digits indicate the ancestor node. Figure 10 shows an example of coding taxonomic tree nodes according to the above approach.



**Figure 10:** Coding example of taxonomic tree nodes for CIM

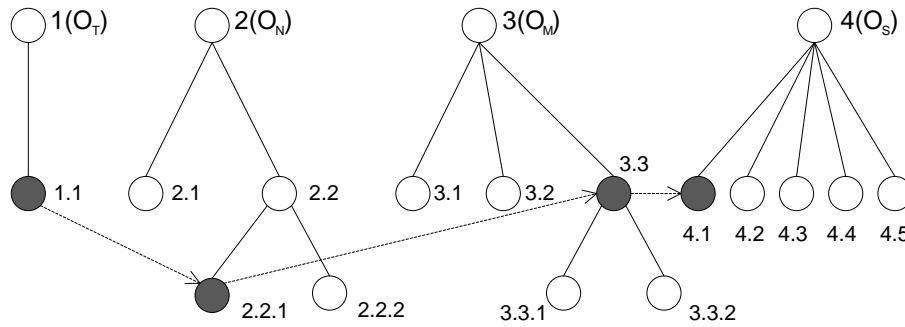
Based on the above, we create a procedure for forming a vector  $X = (x_1, x_2, \dots, x_N)$  information diagnostic space  $X$  Chinese Image Medicine, which is a unified formalized representation of the diagnosis by CIM methods. Each  $i$ -th component  $x_i$  of vector  $X = (x_1, x_2, \dots, x_N)$  reflects the detected by the CIM-therapist deviation from the norm in the physical system, energy system and information system of the diagnosed patient. The total number of  $N$  components of the diagnostic vector  $X = (x_1, x_2, \dots, x_N)$  for each patient, in general, will be different, because it is the number of detected by the CIM-specialist deviations (diseases, pathogenic factors) in a particular patient, which are presented in terms of constructed taxonomies of CIM.

In general,  $i$ -th component  $x_i$  of vector  $X = (x_1, x_2, \dots, x_N)$  is four formal objects:

$$x_i = \left\langle (n_{O_T}.k_1, \dots, k_{j_1})_i, (n_{O_N}.l_1, \dots, l_{j_2})_i, (n_{O_M}.g_1, \dots, g_{j_3})_i, m_i \right\rangle, i = \overline{1, N}, \quad (8)$$

where  $j_1, j_2, j_3$  - ordinal numbers of the levels of the corresponding taxonomic trees from ontologies  $O_T, O_N, O_M$ , which are generally different for different  $i$ -th component  $x_i$ ;  $n_{O_T}.k_1, \dots, k_{j_1}$  - node ordinal number of the topological taxonomic tree of  $O_T$ ;  $n_{O_N}.l_1, \dots, l_{j_2}$  - node ordinal number of the nosological taxonomic tree of  $O_N$ ;  $n_{O_M}.g_1, \dots, g_{j_3}$  - node ordinal number of the taxonomic tree of  $O_M$ ;

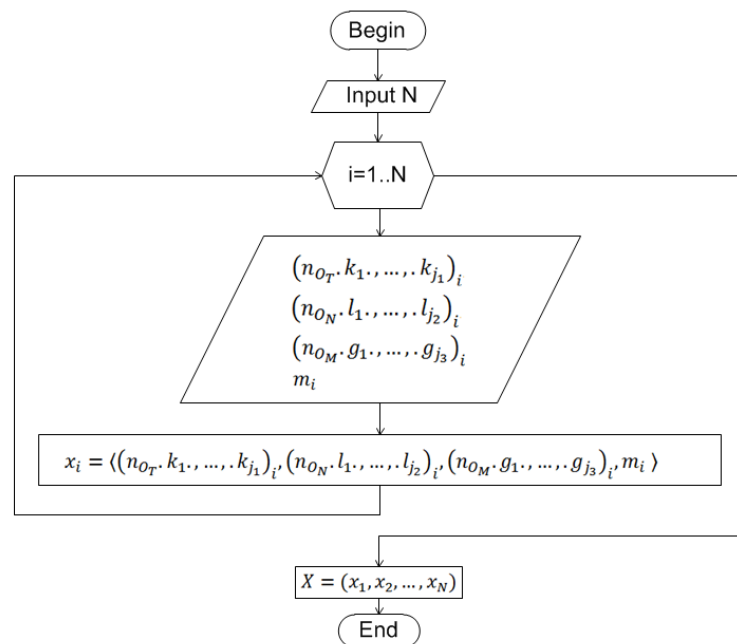
$m_i, \overline{1,5}$  – a natural number that can take values from 1 to 5 and characterizes the manifestation degree of the disease (deviation from the norm, pathogenic factor) (in the absence of deviations from the norm number  $m_i = 0$ , larger value  $m_i$  indicates a greater manifestation degree of the disease). You can provide the following numerical scale interpretation of the disease manifestation degree: 1 – very weak, 2 – weak, 3 – medium (moderate), 4 – strong, 5 – very strong. Figure 11 shows an example of the formation of  $i$ -th component  $x_i$  of a diagnostic vector according to the above approach.



**Figure 11:** Procedure for forming of  $i$ -th component  $x_i$  of a diagnostic vector for CIM

Figure 11, for example, presents simplified fragments of ontologies  $O_T, O_N, O_M, O_S$ , and the dashed line connects the nodes that were selected in the diagnostic process. Thus, the  $i$ -th component  $x_i$  of  $X = (x_1, x_2, \dots, x_N)$  information diagnostic space  $X$  of Chinese Image Medicine for this example will be displayed as  $x_i = \langle 1.1, 2.2.1, 3.3, 4.1 \rangle$ .

Figure 12 shows generalized block diagram of the formation algorithm of the diagnostic vector  $X = (x_1, x_2, \dots, x_N)$  of Chinese Image Medicine.



**Figure 12:** Generalized block diagram of the formation algorithm of the diagnostic vector  $X=(x_1, x_2, \dots, x_N)$  of CIM

Thus, the diagnostic space  $X$  contains both qualitative and quantitative characteristics (indicators), which in their entirety holistically characterize the patient's condition by CIM methods. Qualitative characteristics are contained in CIM ontologies, and quantitative ones determine the manifestation degree of a disease and can be set on a certain numerical (for example, from 1 to 5) or non-numerical (for example, very weak, weak, medium, strong, very strong) scale. Any vector (other than zero) from

space X indicates the presence of a certain type of disease in the patient, which are detected by CIM methods.

The mathematical structure developed above is the basis for the formalization of the diagnosis X and diagnostic space X of Chinese Image Medicine with the aim of its unified presentation in the onto-oriented system of professional healing activities "Image Therapist", which enabled the accumulation of clinical data obtained by the methods of Chinese Image Medicine for the purpose of their objective comprehensive analysis with the involvement of modern intellectualized information technologies.

In figures 13 and 14 show screenshots of the prototype information system "Image Therapist", developed on the basis of the above approaches. The formation of the diagnostic vector occurs by selecting the values of the fields (elements of the diagnostic ontology) on the appropriate screen form. The system implements convenient means of presenting diagnostic information about the patient's condition, which are shown in table 1, the advantage of the environment is the ability to enter both information obtained by conventional medicine and information obtained by Chinese Image Medicine, which allows them to conduct a comparative analysis.

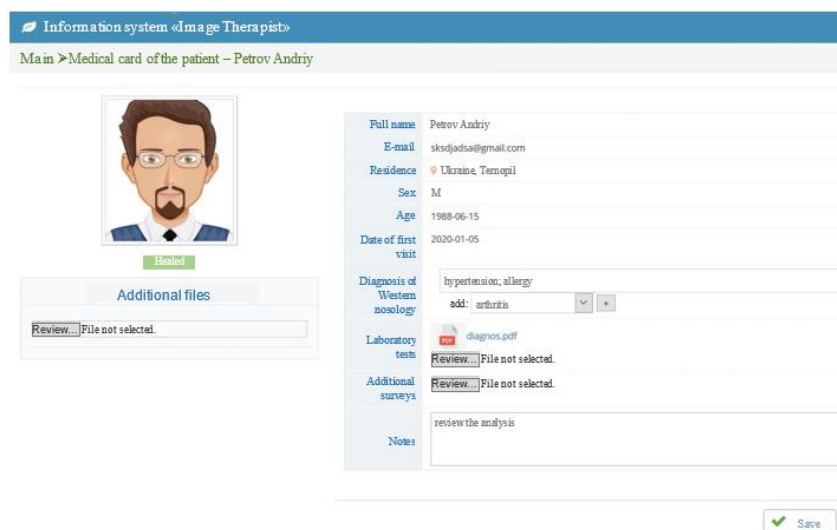


Figure 13: Patient medical card of the System «Image Therapist»

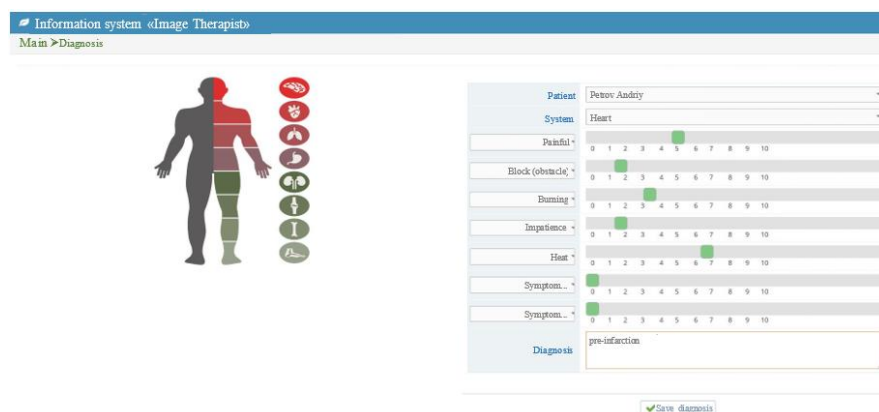


Figure 14: Window with CIM-diagnostic information

## 4. Conclusions

The paper develops a mathematical structure of vector type, which describes and formalizes the diagnosis and CIM diagnostic space for complete and adequate presentation of diagnostic information obtained by CIM methods in onto-oriented information systems "Image Therapist" as an important component of integrated onto-oriented information-analytical environment. Qualitative and quantitative characteristics contained in the mathematical model of the diagnostic space, holistically characterize

the patient's condition by CIM methods including physical, energy, informational aspects. These results are based on previously created nosological ontology, topological ontology, ontology of diagnostic methods in CIM and ontology of diagnostic metrics and scales in CIM, and made it possible to develop a unified method of formalized presentation of diagnostic information obtained by CIM methods in order to accumulate clinical data for their objective analysis with the use of modern intellectualized information technologies.

Such an approach with minor adaptations can be extended to develop a formalized description of diagnoses and diagnostic spaces for other folk medical systems, which will allow the creation of information-oriented systems for Integrative Scientific Medicine, and in the future will allow to develop effective clinically-based synthetic methods of diagnosis and therapy, which harmonically combine (complement) the achievements of conventional and folk medical systems into a single metamedical system. Also, in further research, for the convenience of forming a diagnostic vector of the patient's condition by CIM methods it is appropriate to develop an interactive visual environment based on an image model of the human body and its parts, including physical, energy, informational aspects.

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