

## INFORMATION TECHNOLOGY

# Mathematical modeling of therapeutic information space of Chinese image medicine for its unified representation in information systems for integrative scientific medicine

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Paper received 16.12.20; Accepted for publication 23.12.20.

<https://doi.org/10.31174/SEND-NT2020-244VIII30-15>

**Abstract:** the article is devoted to mathematical modeling of the therapeutic space of Chinese image medicine, which is an important stage in the 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 treatment model for Chinese image medicine has been developed, which is a function of topological ontology, methods ontology and exposure time ontology in Chinese image medicine.

**Keywords:** *mathematical modeling, therapeutic space, ontology, information system, Chinese image medicine, integrative scientific medicine.*

**Introduction.** Existing health care area problems (poly-pragmatism, excessive applying of chemicals and, as a result, allergic reactions, reduced therapeutic effect, "rejuvenation" of many diseases, their transition to chronic forms) require transformation and new approaches to providing quality medical care. Increasingly relevant is the appeal to alternative medicine methods as a valuable ancient medicine experience. In Ukraine [1], as in the world, one of the priority areas of health care development in the coming years is the standardization of technologies for providing quality medical care to a population by methods of unconventional (non-traditional) medicine. This approach is successfully implemented in the framework of integrative medicine, which combines traditional treatments and the best achievements of folk medicine, and has significant potential at all levels of care, especially primary health care and disease prevention. Such integration is consistent with the WHO Strategy for Folk Medicine for 2014-2023 [2], which states that folk medicine is an underestimated part of health care, which in many countries is in demand and used on a par with conventional medicine. Important components of integrative medicine are traditional Chinese medicine (TCM), the methods of which are already widely used in both the East and the West, and the component of TCM is Chinese image medicine (CIM), which is currently under active development and research. A number of theoretical and clinical studies have been conducted for TCM (unlike CIM), and appropriate information and analytical tools have been developed [7-8].

Chinese image medicine is a part of ancient Chinese medicine that studies the influence of images on the physical body of human, both on a complex system and on individual systems, tissues, organs; on the human energy system; on the human information system, which includes such elements as emotions, consciousness, psychology. CIM studies the functions of images, their use in the diagnosis and diseases treatment and in China and Latvia is already officially recognized. CIM therapy is a process of non-drug and non-surgical treatment, the purpose of which is to eliminate the symptoms and manifestations of a

disease, alleviate a pathological condition or other life disturbance, normalize the disturbed processes and recovery, restore health. CIM therapeutic methods mostly have no analogues, are based on vague empirical knowledge of image therapists, and therefore are subjective, with a scientifically unfounded action mechanism. The international recognition of CIM requires a transition from simple accumulation of practical experience to transdisciplinary, multidisciplinary and clinical research using computer technology, which will provide a basic understanding of CIM mechanisms and allow to substantiate them at the scientific level. The first significant steps in the CIM popularization and its introduction into the field of integrated medicine as a scientifically proved medical field were made at the Beijing Medical Research Institute "Kundawell", which is a world center for teaching and research of Chinese image medicine. Here the Program of scientific researches of Chinese image medicine for 2017-2023, which is directed on carrying out of comprehensive scientific researches of Chinese image medicine for the creation purpose of theoretical and experimental scientific bases of CIM, was developed [3].

**Aims.** In this article we will consider the features of building a mathematical model of therapy (treatment) and therapeutic space CIM, as well as their presentation in an integrated onto-oriented information-analytical environment.

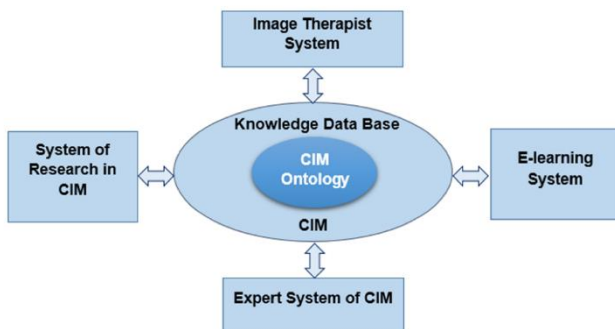
**Main part.** One of the current theoretical and applied tasks of the CIM Research Program is to create an integrated onto-oriented information-analytical environment of research, professional healing and e-learning CIM. The purpose of developing this environment is to ensure effective organization and coordination of existing CIM-therapists, CIM researchers, people studying CIM, as well as the formation of modern intellectualized information tools and resources in the field of folk, complementary and integrative medicine at both national and international levels [4]. The intellectualized core of such an integrated information-analytical environment should be a multilevel onto-oriented knowledge base of CIM. One of the components of

the information-analytical environment is the information system of professional healing activities "Image Therapist", designed for centralized organization, improving the quality (efficiency, safety, controllability, reliability, economy, intensity) of professional activities and sharing experiences of existing CIM therapists.

In paper [5], a separate structure of the general CIM theory was proposed, which was obtained from the conceptual model of CIM. To describe the therapeutic methods, the section "Theory and technologies of therapy in CIM" is defined, which describes and formalizes the theoretical principles, methods and means of therapeutic procedures in CIM, as well as their relationship with the relevant diagnostic information.

CIM therapy is a balancing of health, bringing the wrong condition of the patient into the right one with the images use. For each type of disease in accordance with the three-factor life model in CIM use three main methods (physical, energy, information), as well as combined treatment options (physical-energy, energy-information, physical-information, physical-energy-information). The CIM therapeutic arsenal also includes other methods, including mantras, awakening methods, regeneration and others.

Given the non-standard, unusual for Western medicine nature of therapeutic CIM methods, before creating an information system "Image Therapist" it is necessary to pay considerable attention to the development of new models, methods and tools for processing therapeutic information CIM.



**Fig.1.** Generalized architecture of integrated onto-oriented information-analytical environment for research, professional healing and e-learning of Chinese image medicine.

The information-analytical environment for CIM, the generalized architecture of which is presented in Fig. 1 [4], is developed to ensure effective organization and coordination of existing CIM-therapists, CIM researchers, people studying CIM, as well as the creation of modern intellectualized information tools and resources in the field of folk, complementary and integrative medicine at both national and international levels.

This paper addresses issues related to the treatment (therapy) of the patient by a CIM therapist.

Creation of therapeutic space  $Y$  CIM should be preceded by the development of a therapeutic ontology  $O_{TE}$  CIM (CIM treatment ontology of theory and technology), which as its subontology should include a topological ontology  $O_T$  CIM and ontology  $O_M$  therapeutic methods in CIM, as well as the ontology  $O_t$  exposure time (time of application of therapeutic methods).

From a formal view point, the therapeutic CIM ontology can be presented as such a trio of its subontologies:

$$O_{TE} = \{O_T, O_M, O_t\} \quad (1)$$

Topological therapeutic ontology  $O_T$  CIM displays information about the topological location of the impact (for example, part of the human body, organ system, individual organ or organ area) CIM therapist on the patient. The topological therapeutic ontology practically repeats the topological diagnostic ontology, and at this stage we will assume that they are identical. The topological diagnostic ontology is described more detail in paper [6].

Ontology  $O_M$  therapeutic methods in CIM reflects knowledge of methods of exposing on patient in order to eliminate the disease.

We will assume that the ontologies listed above are common taxonomies. In this case, the topological therapeutic taxonomy can be represented as follows:

$$O_T = \langle \Omega_T, \subset \rangle, \quad (2)$$

where  $\Omega_T$  is a types set of anatomical areas (body parts, organs, tissues) of the physical body, and the ratio " $\subset$ " is a relationship of strict inclusion that takes place between the glossary elements (concepts)  $\Omega_T$ .

The therapeutic methods taxonomy can be presented as a pair:

$$O_M = \langle \Omega_M, \subset \rangle, \quad (3)$$

where  $\Omega_M$  is a glossary of CIM diagnostic methods, and the relation " $\subset$ " is a relation of strict inclusion which takes place between glossary elements (concepts)  $\Omega_M$ . As an example, the figure below shows a ontograph fragment of CIM therapeutic methods.

The duration of therapeutic exposure can range from 5 to 120 minutes, with an interval of 1 minute. Thus, the temporal taxonomy of the impact can be represented as an ordered set of natural numbers in the range [5, 120] with step 1.

The table below summarizes the information about the components of CIM therapeutic ontology.

At a high abstraction level of therapeutic space  $Y$  can be represented as a set of all possible CIM therapeutic effects, and each individual therapeutic effect will be presented as a result of construction according to a certain procedure  $F(\cdot)$  from the ontologies described above. Thus, the CIM therapeutic space is a function from ontologies  $O_T, O_M, O_t$ :

$$Y = F\{O_T, O_M, O_t\}, \quad (4)$$

where  $F(\cdot)$  - formation function of therapeutic exposure in CIM from the corresponding ontologies  $O_T, O_M, O_t$ .

Let's move on to the next stage, namely procedure construction of therapeutic space formation from topological ontology, therapeutic methods ontology and time ontology of CIM therapeutic effect.

To display our taxonomies, we use an ordered root tree, the nodes of which are elements of the glossary, and the edges reflect the inclusion ratio. For formation convenience of CIM therapeutic space from the above taxonomic trees it is necessary to carry out coding of their tops. We use the coding principle applied to the diagnostic space [6]. An example of coding is shown in the figure below.

Based on the above, the procedure for forming a vector  $Y = (y_1, y_2, \dots, y_N)$  information therapeutic space  $Y$  of Chinese image medicine is performed similarly to the procedure of forming a vector of information diagnostic space [6]. Actually vector  $Y$  is a unified formalized presentation of CIM treatment methods. Each  $i$ -th component of  $y_i$  reflects the treatment chosen by the CIM therapist. Number

N components of the therapeutic vector  $Y = (y_1, y_2, \dots, y_N)$  for a particular patient is different, depending on the number of prescribed treatments.

In general,  $i$ -th component of  $y_i$  in vector  $Y = (y_1, y_2, \dots, y_N)$  are three formal objects:  
 $y_i = \langle (n_{O_T}, k_1, \dots, k_j)_i, (n_{O_M}, g_1, \dots, g_j)_i, t_i \rangle, i = \overline{1, N}, \quad (5)$

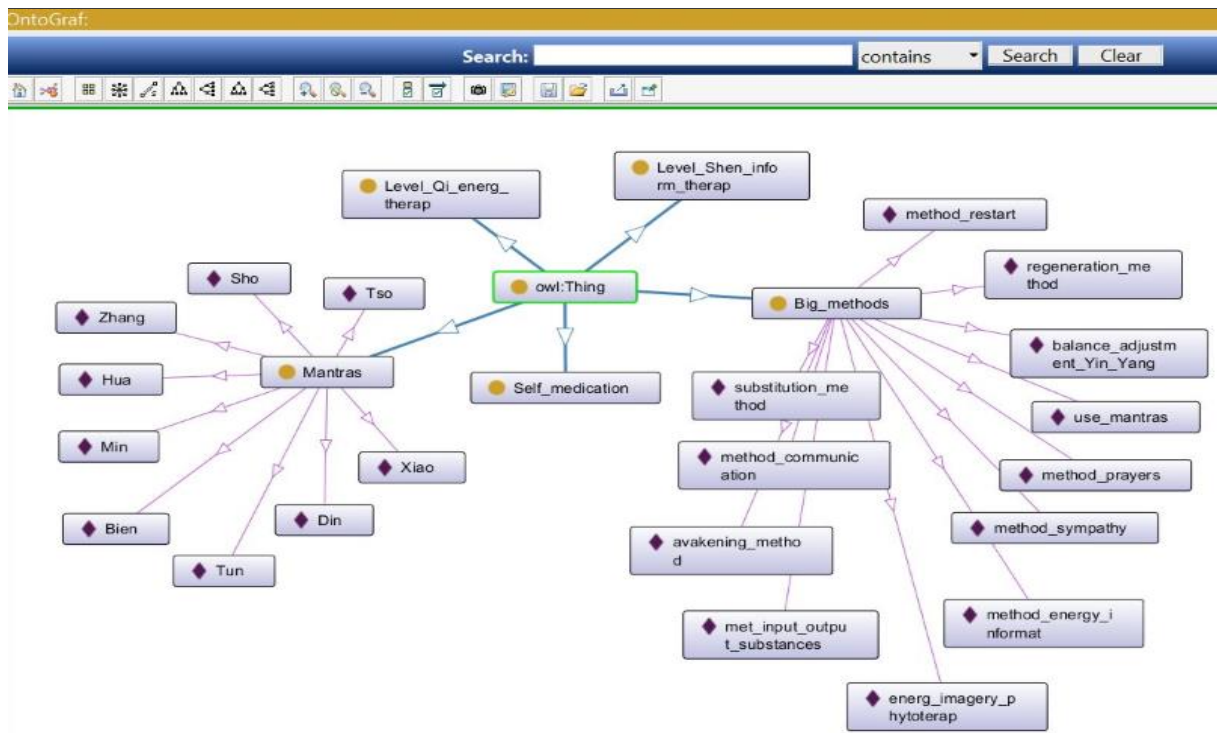


Fig. 2. Ontograph of CIM therapeutic methods

Table 1. Components of CIM therapeutic ontology

Components of CIM therapeutic ontology	Components description of CIM therapeutic ontology
TOPOLOGICAL CIM THERAPEUTIC ONTOLOGY	Topological CIM diagnostic ontology 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 man, in particular, contains information about body parts, organs, tissues of the physical body, information about bioactive points and energy channels of the human energy system, information about informational, psycho-emotional, mental and spiritual topological aspects of human.
CIM THERAPEUTIC METHODS ONTOLOGY	CIM therapeutic methods ontology reflects knowledge of the influence methods on patient in order to eliminate the disease.
TIME ONTOLOGY OF THERAPEUTIC EXPOSURE IN CIM	Describes the exposure time on patient by therapist. Time interval - from 5 to 120 minutes, in 1minute steps.

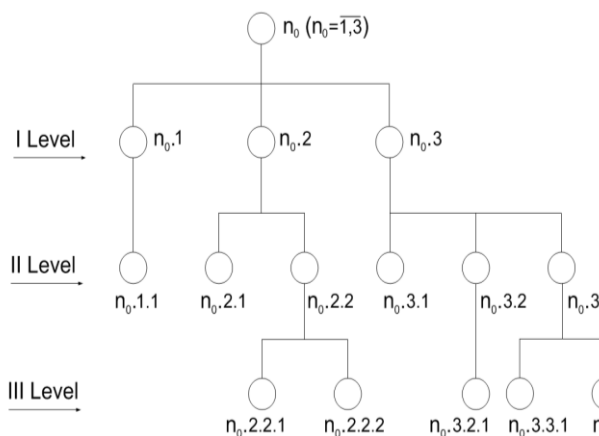


Fig. 3. Coding example of taxonomic tree nodes for CIM

where  $j$  - serial level number of corresponding topological taxonomic tree  $O_T, O_M, O_t$ , and  $n_{O_T}, k_1, \dots, k_j$  - serial node number of the topological taxonomic tree  $O_T$ ;  $n_{O_M}, g_1, \dots, g_j$  - ordinal node number of the taxonomic

tree  $O_M$ ;  $t_i \in \overline{5, 120}$  - a natural number that can take values from 5 to 120 and specifies the time of therapeutic exposure of the CIM therapist, in minutes. Figure 4 shows an example of a therapeutic vector formation according to the above approach. Simplified ontologies fragments are displayed  $\{O_T, O_M, O_t\}$ , the selected nodes (with gray fill) reflect the selected treatment and are connected by a dashed line. Therefore, for this example, the vector  $Y = (y_1, y_2, \dots, y_N)$  information therapeutic space  $Y$  of Chinese image medicine will be presented as  $Y = (1.2.1, 2.3, 3.1)$ .

When developing an appropriate software product, it makes sense to add a text field in which the CIM-specialist could add information that is not displayed by means of formal ontologies.

Thus, the therapeutic space  $Y$  contains both qualitative and quantitative characteristics (indicators), which in their entirety holistically characterize the therapeutic effect on the patient by CIM methods. Qualitative characteristics are contained in CIM ontologies, and quantitative ones determine the exposure time.

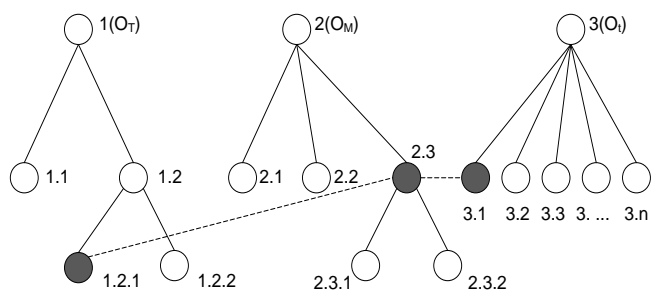


Fig. 4. Forming procedure of therapeutic vector for CIM

A number of modern technologies (Laravel 6, MySQL 5.8, Bootstrap 3) as well as diagnostic and therapeutic CIM ontologies were used in the developed prototype of the system "Image Therapist", the software implementation of which was carried out according to the MVC principle.

Figure 5 shows the window of therapeutic sessions assignments, where the system elements (terms) are used as specific classes samples of diagnostic and therapeutic CIM ontologies, as well as sets of attributes that characterize each element (therapeutic methods), thus part of the onto-oriented CIM knowledge base.

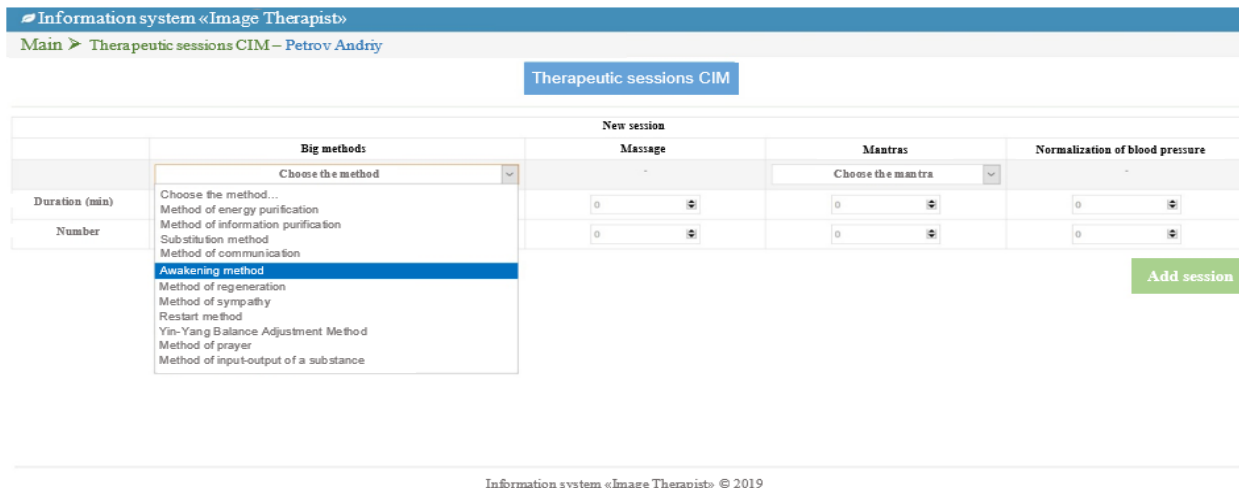


Fig. 5. Window of therapeutic sessions

**Conclusions.** A mathematical model of the CIM therapeutic space has been created and a unified treatment model has been developed for their presentation in an integrated onto-oriented information-analytical environment. This mathematical model of therapeutic space contains both qualitative and quantitative characteristics that holistically characterize the patient treatment by CIM methods. A prototype of the Image Therapist system is described, in which the described approaches to the therapeutic space

and treatment model in CIM are partly implemented.

The developed model allows, together with the introduction into the information system of therapeutic information obtained by Western (official) medicine, to enter therapeutic information obtained by CIM methods, which opens new opportunities for the formation of comprehensive therapeutic information that integrates (complements) various therapeutic effects on the patient in the framework of integrative scientific medicine.

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