INFORMATION TECHNOLOGY

Conceptual Fundamentals for Ontological Simulation of Chinese Image Medicine as a Promising Component of Integrative Medicine

S. A. Lupenko, O. R. Orobchuk, A. V. Pavlyshyn

Ternopil Ivan Pului National Technical University; I.Ya. Horbachevsky Ternopil State Medical University

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Abstract. The urgent matter and development of conceptual foundations for ontological simulation of Chinese Image Medicine as a promising component of integrative medicine is substantiated in the article. The comprehensive concept of Chinese Image Medicine as a fundamental for ontological simulation is developed. A unified formal ontological model and language of Chinese Image Medicine, informational environment of its presentation are established. An example of ontological fragment implementation into the Protégé environment is provided.

Keywords: *ontology, ontological simulation, onto-based informational systems, integrative medicine, Chinese Image Medicine.*

Introduction. According to the strategy of the World Health Organization for alternative medicine [1] regulations of the Ministry of Health of Ukraine [2], the development of evidence-based approach to the implementation of alternative and complementary medicine into the formal medicine internationally and nationally is an important strategic challenge. Currently in most countries, as well as the USA, China, Japan, Korea, Russia and many European countries, Brazil, a significant revival of scientific research in unconventional (alternative, complementary) methods of rehabilitation and treatment of humans that have become an important component of integrative medicine is evidenced [3-7]. Integrative medicine is based on the principles of evidence-based medicine; a unique, holistic (universal) approach to the patient and individual standards is applied; it is focused on prevention and health improvement by enhancing the internal capacity of the body; its priority is safety (minimum of side effects), effectiveness and efficiency of medical intervention. Integrative medicine is a trend in medicine when for diagnosis and treatment of human diseases a complementary combination of techniques and methods of contemporary Western medicine and traditional medical practices (e.g. traditional Chinese medicine, Indian Ayurveda, Tibetan medicine) is used. Integrative medicine has been developing around the world since the 90s of the XX century. In the USA, the Academic Consortium for Integral Medicine and Health, National Centre for Complementary and Integrated Health (NCCIH) were established, as well as in 2001 the Institute of Integrative Medicine was opened at Harvard.

In China, integrative medicine has become an integral part of public health successfully combining the achievements of Western medicine and traditional Chinese medicine. Traditional Chinese medicine (TCM) is rooted in the ancient historical reality and includes naturopathy (treatment with products of natural origin, phytotherapy), qigong, meditation, massage, special diets, acupuncture. The methods and means of Chinese Image Medicine (CIM), which is a part of TCM and its historical roots reach the antiquity of Chinese civilization, are of great interest of scientific research. Nowadays CIM gained a new powerful impetus for its distribution and development worldwide, including the USA, Canada, Germany, Switzerland, China, Russia, Ukraine, Belarus, Brazil, Latvia, Estonia, Czech Republic, Slovakia and Hungary. A world famous centre for studying and research in Chinese Image Medicine is Beijing "Kundawell" Medical Research Institute (China).

CIM is holistic (universal) medicine that provides comprehensive diagnosis and treatment of a patient in all its fundamental ontological levels: physical, energy, informational as well as emotional and spiritual (psychic, mental) taking into account their strong relationship to and influence of natural surrounding and social environment on human. CIM is focused on stimulating the energy and informational resources of the human body and mobilization of spiritual and mental dimensions as important factors of curing and healthy lifestyle. When establishing diagnosis and choice of treatment method, an important emphasis is on individual characteristics of human life and diseases course in relationship with surrounding physical, psychological and social environment. CIM features are: significant efficacy (effectiveness), safety (non-invasiveness, no side effects), efficiency (relatively cheap), and ease of learning and use of diagnostic and therapeutic methods. Effectiveness of CIM is confirmed by positive therapeutic effects on a wide range of diseases, including incurable disease in terms of Western medicine. The highest effectiveness of CIM was presented in treatment of: chronic bronchitis, asthma, chronic nephritis, intervertebral hernia in various parts of spine, impotence, chronic prostatitis, uterine fibroids, chronic gastrointestinal disorders, chronic gastritis, Crohn's disease, eye diseases, hypertension, myocardial infarction, atherosclerosis, myocardial ischemia, ICP, arrhythmia.

Taking into account the ancient Chinese origin of CIM, the most of its diagnostic and therapeutic methods are of purely empirical and unstructured nature, and knowledge is semi-structured and of hard access for public. So, the development of a complete CIM scientific paradigm in medicine is difficult, because many theoretical and experimental aspects and patterns of this field of alternative medicine are not defined. In TCM a number of extensive clinical studies, theoretical research were conducted, and appropriate informational and analytical means (ontologies, expert systems, grid systems for TCM [8-14]) were developed, but in Chinese Image Medicine the similar research as well as relevant informational and analytical means are missing. Due to that fact, a program of research in Chinese Image Medicine for 2017-2023 was developed [15]. This program aims to conduct a comprehensive research in Chinese Image Medicine to create theoretical and experimental scientific fundamentals of CIM that promote to definition of underlying causes and schemes of human diseases and establishment of effective methods of prevention and treatment.

Rationale for urgency and aims of CIM ontology development and scope of its application. According to the

program [15], taking into account the necessity for CIM to join the integrative medicine as an evidence-based healthcare area, the development of CIM ontology as fundamental of integrative onto-based informational and analytical environment for CIM research, professional healing and e-learning is one of the current scientific and applied issues. The aim of the development of informational and analytical environment is to ensure the effective work organization and coordination of present CIM practitioners, academic researchers of CIM, those who study CIM and improvement of up-to-date intellectualized informational means and resources for alternative, complementary and integrative medicine at both national and international levels. General structural design of integrative onto-based informational and analytical environment of Chinese Image Medicine research, professional heeling and e-learning is presented in Fig. 1.

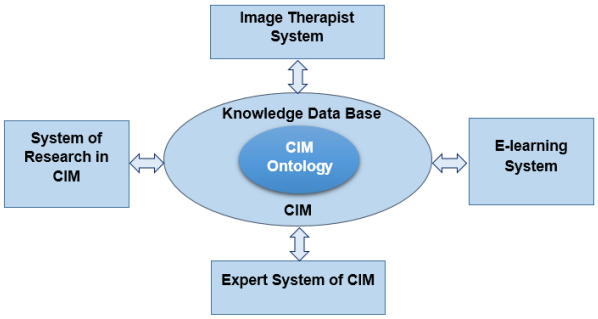

Fig. 1. General structural design of integrative onto-based informational and analytical environment of Chinese Image Medicine research, professional heeling and e-learning

CIM ontology is aimed at necessity of a comprehensive solving of a range of important tasks of theoretical, clinical, experimental as well as informational and analytical areas of Research Program [15], such as:

1. Unification, standardization of information presenting technique (data and knowledge) in CIM, which allows overcoming the problem of semantic heterogeneity of poorly structured and difficult to formalize the knowledge of TCM and CIM, because the use of ontologies eliminate subjective factors, polysemantics, vague concepts and images, which explicitly or implicitly are operated by image-therapists in making diagnostic and therapeutic decisions. CIM ontology enables standardization of CIM concepts and terminology that greatly facilitate CIM therapists to collect and share their knowledge and expertise consistently in the integrative informational environment. Experts can understand each other much better and CIM training system becomes more clear and consistent.

2. The need for high-quality dictionary (glossary) and knowledge data-base (thesaurus) in CIM that would possess such properties: completeness, consistency, interpretability (scientific interpretability as well), commonality, ease of use (because ontology is presented in a computer managed form), integration with other subject areas, including traditional Chinese medicine, unconventional medicine, integrative medicine.

3. The necessity of integrated informational and analytical onto-based environment for CIM research, professional healing and e-learning. The quality and efficacy of this integrated environment depends on the quality of CIM ontology that compiles its structure and functioning.

4. The need to maintain the necessary level of integration, integrity, knowledge and data in CIM for various information technologies and systems that is significantly simplified by using qualitative CIM ontology.

5. The requirement for repeated use of knowledge in CIM intended for different information systems and application. Ontology is a source for such knowledge reuse.

6. The essential for implementation of intelligent search for CIM information on the Internet following semantic search technologies WEB 2.0 that provides highly relevancy of search for necessary information. Semantic search technology WEB 2.0 is based on the use of ontologies of relevant subject areas.

The main areas of CIM ontology application is within the education and training of CIM experts, professional healing by CIM methods, scope of CIM research.

This research is **aimed** at the development of conceptual, formal as well as software and informational fundamentals for ontological simulation of Chinese Image Medicine as an important component of development of integrated onto-based informational and analytical environment for CIM research, professional healing and e-learning.

Objectives. To achieve the goals the following problems should be solved:

1. To develop a concept of CIM ontological simulation considering the scope of its application as the source of integrated onto-based informational and analytical environment of CIM research, professional healing and e-learning.

2. To suggest a comprehensive formal model of CIM ontology.

3. To substantiate the language and informational environment for CIM ontology development.

4. To implement a fragment of CIM ontology into the Protégé environment.

Results

Comprehensive conceptual model of Chinese Image Medicine. CIM domain analysis. In this study, the ontological simulation means the development and analysis of conceptual description of a particular subject domain, i.e. CIM as a formal representation that reproduces a set of concepts (terms) and interactions (logical patterns, connections) of CIM. The result of this simulation is an appropriate CIM model – its ontology. As a model, ontology, besides representation of the objective aspects of the subject domain, should contain purely subjective component that reflects the view of a researcher or a research team (knowledge engineers, domain experts) on the simulated domain.

According to the established informal definition, ontology is a clear specification of conceptualization. Conceptualization is the process of a subject domain conceptual model (concept) establishment and is one of the most complex and labour-intensive stages of ontology development. Conceptual model in a terminology and conceptual form represents domain objects, their properties, dependence and patterns. Conceptual model being a verbal description of a subject domain possesses a three-component signed structure (word-meaning-sense), i.e. formal language (syntactic) level, conceptual (sense, semantic) level and the level of the domain as an object of description. The success of all subsequent stages of the development of CIM ontology and integrated informational and analytical environment depends on accurate, qualitative conceptualization. Subject area of CIM is CIM practice, which is unreachable in its entirety for rational knowledge, but is an ideal, a goal that guides the development of CIM concepts and ontology.

The development of CIM concept, due to which an effective CIM ontology and onto-based informational environ-

ment can be established, is a non-trivial research task; its solution is complicated by a number of objective factors conditioned by CIM domain specifity:

1. CIM theory is based on ancient Chinese philosophic and medical concepts rather than on rigorous scientific concepts of contemporary science, that is why it does not meet the principles of science (consistency, verifiability, sophistication). CIM terms and concepts are characterized by fuzzy, vague, ambiguous interpretations. This significantly complicates ontology development possessing properties of integrity (completeness), absence of logical contradictions, scientific interpretation, preciseness and coherence of its elements and structure.

2. Subject area of CIM is in a state of formation, development, historical, theoretical and applied rethinking. Currently CIM has no evidence-based theories, sometimes its concepts are interpreted in a different way by various CIM experts.

3. Non-conceptual forms of knowledge, such as feelings, images and ideas are very important in CIM. CIM specialist's intentions are often determined by their subjective sensual and image imaginings of disease.

4. Specifity of CIM methods in obtaining diagnostic information as 'internal images of disease' and tactile senses of 'Chi energy' in the tissues and organs of the human body that besides objective component possesses a purely subjective one, which has considerable variations, differences in various CIM-therapists. This leads to fuzziness and ambiguity of conceptual interpretation of patient's condition.

5. Significant dependence of treatment therapies efficacy on skills and individual talent of a CIM practitioner as well as complexity of unification and standardization of logical medical decision-making by a CIM experts because taking into account irrational, intuitive and imaginative components of their mind, consciousness is essential.

6. Conceptual inconsistency between fundamental standards of health care of conventional (Western) medicine and CIM that complicates possibility of CIM ontology development by means of consistency and interpretation in semantic field of Western medicine, science and philosophy.

Obviously, all of the above are complex matters; their solution requires a ground analysis of CIM domain and points to the need of development of a number of complementary conceptual projections (aspects) of CIM concept. These conceptual projections of CIM can be defined: 1. Ancient Chinese traditional conceptual projection – a projection of practical use and comprehension by CIM experts; 2. Western philosophical conceptual projection – describes the most general conceptual structures and regularities that compile CIM and are clear to Western European cultural tradition as the basis and environment of modern science development; 3. Scientific conceptual projection – describes and studies CIM using rigorous scientific methodology (research informal and formal (mathematical) conceptual projections are conditionally defined); 4. Software and semantic (ontological) projection – CIM ontology implemented by the latest software and informational environments.

Each of these CIM conceptual projections are hierarchically organized groups of CIM models that need to be coordinated under a single projection and between different projections that constitute a coherent system of CIM knowledge in the form of CIM ontology. This article focuses our efforts on development of comprehensive CIM conceptual model, which should reflect the general structure of CIM. Following the comprehensive conceptual model, a detailed conceptual model of CIM can be developed.

In general, CIM concept can be represented as a group of its fundamental fragments, i.e.: 1. General theory of CIM; 2. Standards of health and diseases in CIM; 3. Theory and practice of CIM diagnostics; 4. Theory and practice of CIM therapy. Also, a separate part can be devoted to CIM history that represents historical information about the origins and stages of CIM development.

The main CIM concepts and ideas are determined in general theory of CIM that is a practice and philosophical fundamental for the other sections of CIM. The following Eastern philosophical concepts and notions take account of the general theory of CIM: the notion of Tao, Nothingness, the concept of Chi, the concept of Yin and Yang, the concept of Wu Xing, Jing-Qi-Shen life model, the model of life origin Tao-Nothingness-Yin/Yang-Heaven/Human/Earth-Abundant World, the theory of energy channels and bioactive points of human body, the concept of image and visual thinking, etc.

The standards of health and diseases in CIM define the main concepts of health in CIM (the concept of harmony (balance, equilibrium) Yin/Yang as the ontological fundamental of health; the concept of 'empty image' as the standard of health and its rating by methods of image diagnostic; the concept of 'specific kidneys, heart and lungs sensation as well as no sensation of others healthy organs and body parts' as the standard of health and its rating by methods of energy diagnostics by hands; the concept of 'symptomatic sensations absence' as the standard of health and its rating by methods of diagnostics by body), classification and definition of the types of diseases (physical, energy, informational, physical and energy, physical and informational, energy and informational, physical-energy-informational), CIM structure (physical medicine, energy medicine and informational medicine) according to the model of life and types of diseases in CIM.

Theory and practice of CIM diagnostics defines theoretical principles, methods and means of gaining diagnostic medical information by CIM methods and methods of its interpretation.

Theory and practice of CIM therapy determines and formalizes theoretical principles, methods and means of CIM treatment therapies and their association to the diagnostic information.

The main fragments and conceptual projections of CIM and the degree of their development in the literature are presented in Table 1.

Considering the proposed conceptual structure of CIM, CIM ontology should be presented as a group of five sub-ontologies: 1. Ontology of general theory of CIM; 2. Ontology of standard of health and diseases in CIM; 3. Ontology of theory and practice of CIM diagnostics; 4. Ontology of theory and practice of CIM therapy; 5. Historical ontology of CIM. Also, due to the need to present a number of CIM conceptual projections in the developing ontology, precisely: ancient Chinese traditional conceptual projection; Western philosophical conceptual projection; scientific conceptual projection, projected ontology should have the means for their display. Following this data and the fact that CIM ontology is the fundamental of CIM knowledge data-base, it would be reasonable to present the structural components of ontology and onto-based knowledge data-base of CIM as a diagram (Fig. 2).

Table 1. The main fragments and conceptual projections of CIM

	General theory of CIM	Standards of health and diseases in CIM	Theory and practice of CIM diagnostics	Theory and practice of CIM therapy
Ancient Chinese traditional conceptual projection	accomplished	accomplished	accomplished	accomplished
Western philosophical conceptual projection	initial stage	initial stage	initial stage	initial stage
Scientific informal conceptual projection	infant stage	infant stage	infant stage	infant stage
Scientific formal consistent (mathematical) conceptual projection	none	none	none	none
Software and semantic (ontological) projection	none	none	none	none

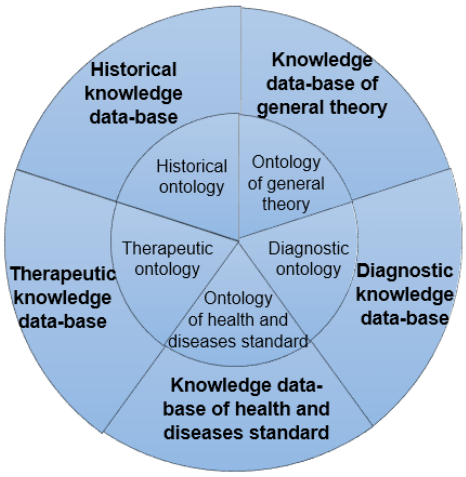

Fig. 2. Conditional image of structural components of ontology and onto-based knowledge data-base of CIM

Comprehensive formal model of CIM ontology. Following the comprehensive conceptual model of CIM and CIM ontology structure discussed above, we provide a comprehensive formal ontology model of CIM as three sets:

$$\mathbf{O} = \{\mathbf{A}, \mathbf{R}, \mathbf{F}\} \quad (1)$$

A – finite set of concepts (notions, terms) of CIM that define ontology vocabulary; **O, R** – finite set of connections between CIM concepts, which represent relationships between concepts (including taxonomic relationship – relationship type 'is a type of' or 'general-specific', composition relationship - the ratio 'is a part of', topographic relationship – relationship that reflect association and spacing of the components of a system, etc.) and properties of concepts (attributes to and limitations on them); **F** – finite set of interpretation functions prescribed in concepts and/or relations of ontology **O**. CIM ontology together with multiple exemplars of all its classes composes CIM knowledge data-base.

Rationale for language and information environment of CIM ontology presentation. An important factor of the ontology design is the choice of the ontologies specification language. For development and specification analysis of conceptual model description of CIM the OWL language was chosen. The CIM conceptual model should be submitted as a formal presentation that reflects the set of all concepts and relationships (logical connections) of CIM, so the OWL language is designed to express concepts, relationships, capacities, annotations and specification of concepts in an integrated, standardized form and eliminates polysemantics and ambiguity of data and knowledge. OWL is based on solvable descriptive logic. Formal semantics of OWL allows getting facts that are not reflected in the CIM ontology clearly but come up from its semantics. Since the CIM ontology is being developed to be used as the fundamental of integrated informational and analytical environment, the OWL language, as a XML-based language, provides integration with other software systems via Web, repeated reuse of CIM knowledge for different informational systems and applications, semantic search for information in CIM and high relevance, interoperability, because it is supported by a great number of editors and solvers of ontologies.

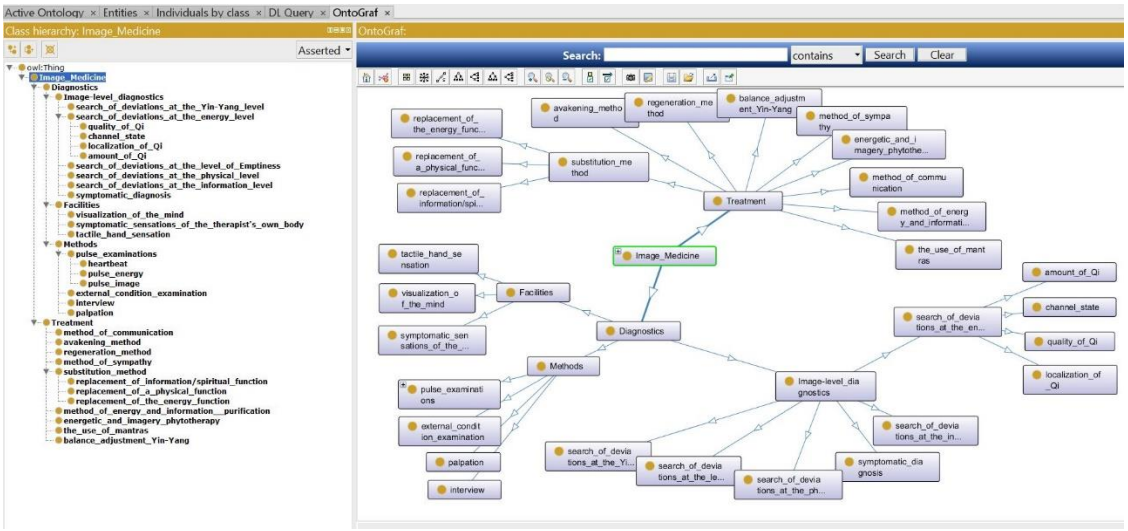

Fig. 3. The example of CIM ontology fragment in the Protégé environment

XML syntax is machine but not human readable. Therefore, usually OWL-ontology is not edited directly; specialized software environment developments are used. Protégé editor is the most convenient and adapted for the development of specialized domain-specific ontologies. Protégé is a local, free to use Java-program based on the frame model of knowledge representation with a clear and easy-to-use abstract window toolkit. Protégé structure contains an ontology editor that allows ontology designing by expanding hierarchy of abstract or concrete classes or slots describing them in a declarative way. The logical model enables use of reasoning scheme (Reasoner), which makes it possible to check whether the assertion and definition in the ontology are mutually consistent and also to recognize definitions compliance to specific concepts that is essential for informational and analytical environment. As an example, the developed fragment of CIM ontology in the Protégé environment is presented in Fig. 3.

Conclusions and further research prospects

1. Topical issue, aims of the development and scope of Chinese Image Medicine ontology and ontology simulation as a promising component of integrative and complementary medicine have been substantiated.

2. The comprehensive concept of Chinese Image Medicine has been developed, emphasizing therein a plurality of fragments and conceptual projections that opens possibilities for CIM ontological simulation.

3. A general formal model of CIM ontology has been suggested.

4. The language and informational environment of CIM ontology development have been established.

The main challenges to be met:

- Development of comprehensive conceptual and formal (mathematical) models of ontology by means of descriptive logic scheme;
- Software implementation of CIM ontology by recent open software environment for development of ontologies and knowledge data-bases;
- Development of criteria for quality and testing, verification and validation of the developed CIM ontology according to international standards and computer assisted testing systems in knowledge engineering and expert evaluation techniques.

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Концептуальные основы онтологического моделирования китайской образной медицины как перспективной составляющей интегральной медицины

С. А. Лупенко; А. Р. Оробчук; А. В. Павлышын

Аннотация. Статья посвящена обоснованию актуальности и созданию концептуальных основ онтологического моделирования китайской образной медицины как перспективной составляющей интегральной медицины. Разработана обобщенная концепция китайской образной медицины как основы ее онтологического моделирования. Предложена обобщенная формальную онтологическую модель китайской образной медицины и обоснованно язык, информационная среда ее представления. Приведен пример реализации фрагмента онтологии в среде Protégé.

Ключевые слова: *онтология, онтологическое моделирование, онтоориентированные информационные системы, интегральная медицина, китайская образная медицина.*