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НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ “ЛЬВІВСЬКА ПОЛІТЕХНІКА”

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НАЦІОНАЛЬНОГО УНІВЕРСИТЕТУ
“ЛЬВІВСЬКА ПОЛІТЕХНІКА”

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Статті, розміщені у збірнику наукових праць, підготовлено за результатами закінчених науково-дослідних робіт з теоретичних основ інформатики та кібернетики, обчислювальної техніки та автоматизації, систем баз даних та знань, інформаційного моделювання, розподілених інформаційних систем та мереж, управління проектами і програмами, математичного моделювання та обчислювальних методів, математичного та програмного забезпечення обчислювальних машин і систем, інформаційних технологій проектування та створення програмних продуктів, системного аналізу і теорії оптимальних рішень, структурної, прикладної, комп'ютерної і математичної лінгвістики. Для науковців, інженерно-технічних працівників, аспірантів, студентів вищих навчальних закладів.

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За можливі технічні збіги з іншими науковими працями
автори несуть персональну відповідальність*

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INTEGRATED ONTO-BASED INFORMATION ANALYTICAL ENVIRONMENT OF SCIENTIFIC RESEARCH, PROFESSIONAL HEALING AND E-LEARNING OF CHINESE IMAGE MEDICINE

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Обґрунтовано актуальність розроблення, а також сформульовано загальні вимоги та побудовано архітектуру інтегрованого онтоорієнтованого інформаційно-аналітичного середовища наукових досліджень, професійної цілительської діяльності та електронного навчання китайської образної медицини як перспективної складової інтегральної медицини. Сформульовано вимоги та розроблено узагальнені архітектури складових інтегрованого онтоорієнтованого інформаційно-аналітичного середовища наукових досліджень, професійної цілительської діяльності та електронного навчання китайської образної медицини, а саме: для інформаційної системи професійної цілительської діяльності «Імідж-терапевт», бази знань китайської образної медицини, експертної системи підтримки прийняття діагностичних та терапевтичних рішень, інформаційної системи електронного навчання китайської образної медицини, інформаційної системи наукових досліджень китайської образної медицини.

Ключові слова: онтологія, інтегроване інформаційно-аналітичне середовище, китайська образна медицина.

The timeliness of development and formulation of general requirements and architecture of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine as a promising component of integrative medicine is substantiated in the article. Scientific evidence-based integrative medicine is typical for conventional medicine; but unlike the conventional, the integrative medicine synthesizes experience and engages all the best achievements of ancient medicine and contemporary Western one. The integrative medicine is not a new field of medicine; it is its new paradigm that facilitates the new quality of healthcare services.

Traditional Chinese medicine experienced a number of comprehensive clinical researches, theoretical scientific studies and relevant information analysis means were developed (ontologies, expert systems, grid systems), there is no such research and significant information analysis means for Chinese image medicine. The development of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine is aimed to ensure the effective organization and coordination of existing professionals of Chinese image medicine, its scientific researchers, people who study Chinese image medicine and the establishing of modern intellectualized information means and resources in traditional, complementary and integrative medicine on a national and worldwide basis. The developing information environment will enable on a high scientific, technological and infrastructure levels data collection and automated statistical and intellectualized analysis of treatment results by means of Chinese image medicine; will facilitate the creation of a unified database of theoretical, experimental and clinical research in integrative medicine.

Onto-basis of the developed integrated information environment will help to unify, standardize the technologies of information submission (data and knowledge) in traditional Chinese medicine and Chinese image medicine that will make it possible to solve the problem

of semantic heterogeneity of poorly structured and hard formalized knowledge of Chinese image medicine because the use of ontologies eliminates subjective factors, polysemantics, fuzziness of images and concepts that are explicitly or implicitly operated by complementary medicine specialists in diagnostic and therapeutic decision-making. In addition, the developed onto-based environment allows maintaining the necessary level of integration and sustainability of knowledge and data in Chinese medicine for different information technology and systems, and also the possibility of multiple reuse of knowledge for various information systems and applications.

Also the requirements and general architectural components of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine were developed in the study, in particular for the information system of professional healing Image Therapist, a knowledge-base of Chinese image medicine, expert system for diagnostic and therapeutic decision-making support, information system of e-learning of Chinese image medicine, information system of research in Chinese image medicine.

Key words: ontology, integrated information analytical environment, Chinese image medicine.

Introduction

The development and constant improvement of medicine, infrastructure of healthcare delivery is a topical matter, which healthcare practitioners as well as specialists of other spheres of human activities are facing these days. Currently, healthcare industry is also involved in intense globalization of economy, politics, science, technology, social and cultural life, globalization and integration. Specially, this include the problems of integration, synthesis, mutual coordination and complement of conventional (Western) and unconventional (alternative, complementary) medicine that was manifested in the formation of the contemporary development of medicine as an integral (integrative) medicine [1–5].

Scientific evidence-based integrative medicine is typical for conventional medicine; but unlike the conventional, the integrative medicine synthesizes experience and engages all the best achievements of ancient (traditional Chinese medicine, ancient Indian Ayurveda medicine, Tibetan medicine and other traditional medicine) medicine and contemporary Western one. Integrative medicine presents holistical comprehensive view of an individual and human diseases including their physical, psychological, environmental, economic and social aspects for creation of latest effective and safe methods of diagnosis, treatment, prevention and human health protection. The integrative medicine is not a new field of medicine; it is its new paradigm that facilitates the new quality of healthcare services for population.

Integrative medicine has been emerging all over the world since the 90s of the twentieth century. Integrative medicine was developing the most in the US, China, Japan, Korea and many European countries and Brazil. Above all, in the US the Academic Consortium of Integrative Medicine and Healthcare, the National Centre of Complementary and Integrative Health (NCCIH) were created, and in 2001 the Institute of Integrative Medicine was opened at Harvard. In China the integrative medicine is an integral part of public healthcare successfully combining achievements of Western medicine and traditional Chinese one.

Traditional Chinese Medicine (TCM) run deep into past and is a vast system of diagnosis and treatment, which includes naturopathy (treatment with natural products, phytotherapy), Qigong, meditation, massage, special diets, acupuncture. Chinese image medicine (CIM) (Image therapy, Image medicine, and “Yi Xiang Yi Xue”) is one of the oldest areas of TCM, it historically originates in the studies and medical practice of a famous ancient Chinese physician Bien Chue (407-310 BC), who is the founder of the basic techniques in TCM diagnosis and the first medical school of TCM (Bien Chue School). CIM engaged the best achievements of TCM as well as diagnostic and therapeutic methods of Qigong; besides the usual TCM approach it uses diagnostic and therapeutic techniques based on personal special abilities to perceive and modify internal images of a disease, which were firstly mentioned in the ancient Chinese medical manuscripts “The technique of internal reflection” and “The mirror principle of Bien Chue”.

Traditional Chinese medicine experienced a number of comprehensive clinical researches, theoretical scientific studies and relevant information analysis means were developed (TCM ontologies, TCM expert systems, TCM grid systems [6-12]), there is no such research and significant information analytical means for Chinese image medicine. Due to these facts the Program of research in Chinese image medicine was developed in 2017–2023 [13]. This program aims to conduct comprehensive research in Chinese image medicine for creation of theoretical and experimental scientific backgrounds of CIM to investigate fundamental causes and courses of human diseases and effective methods of their prevention and treatment.

The urgent matter of the development of onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine

According to the WHO traditional medicine strategy [14], the regulations of the Ministry of Health of Ukraine [15] the Program of Chinese image medicine research for 2017–2023 [13], and along with the need for CIM admittance into the integrative medicine as an evidence-based healthcare branch, the creation of an integrated onto-based information analytical environment of scientific research, professional healing and e-learning is topical scientific and applied issue. This development of information analytical environment is aimed to ensure the effective organization and coordination of existing practitioners of Chinese image medicine, scientific researchers of CIM and people who study CIM, as well as the establishing of contemporary intellectualized information means and resources in traditional, complementary and integrative medicine on a national and worldwide basis. The main users of the information environment are CIM therapists, students attending a course (online as well) in CIM, CIM scientists and researchers.

The development of such information environment will enable on a high scientific, technological and infrastructure levels data collection and automated statistical and intellectualized analysis of treatment results by means of CIM; will facilitate the creation of a unified database and knowledge-base of theoretical, experimental and clinical research in CIM for effective implementation of the Program of Chinese image medicine research [13].

Onto-basis of the integrated information environment will help to unify, standardize the technologies of information submission (data and knowledge) in TCM and CIM that will make it possible to solve the problem of semantic heterogeneity of poorly structured and hard formalized knowledge of TCM and CIM because the use of ontologies eliminates subjective factors, polysemantics, fuzziness of images and concepts that are explicitly or implicitly operated by CIM therapists in diagnostic and therapeutic decision-making. CIM ontology will enable the standardization of concepts and terminology in CIM that will significantly facilitate CIM therapists to consistently collect and share their knowledge and experience in the integrated information environment. Experts will understand each other much better, and the CIM education system will be more clear and consistent. In addition, the developed onto-based environment allows maintaining the necessary level of integration and sustainability of knowledge and data in CIM for different information technology and systems, and also offers the possibility of multiple reuse of CIM knowledge for various information systems and applications.

Requirements and general architecture for integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine

General requirements for integrated onto-based information analytical environment are:

1. Integrated onto-based information analytical environment should include the following systems as its components: information system for professional healing Image Therapist (ISPH Image Therapist), CIM knowledge-base (CIM KB) expert system for diagnostic and therapeutic decision-making support in CIM (ES CIM), CIM e-learning information system (CIM EIS), information system for CIM research (ISR CIM) (Fig. 2).
2. The information environment should be based on ontological approach and ontological models of CIM and be consistent with previously developed ontologies for traditional Chinese medicine and conventional (Western) medicine.

3. Information environment should be consistent, compatible with existing onto-based information environments, systems and resources in traditional Chinese medicine and conventional medicine (Fig. 1).
4. The information background should be developed using control technologies and quality assurance according to international standards.
5. Information environment must be available (simple and not expensive), so it should be designed using free open source software.

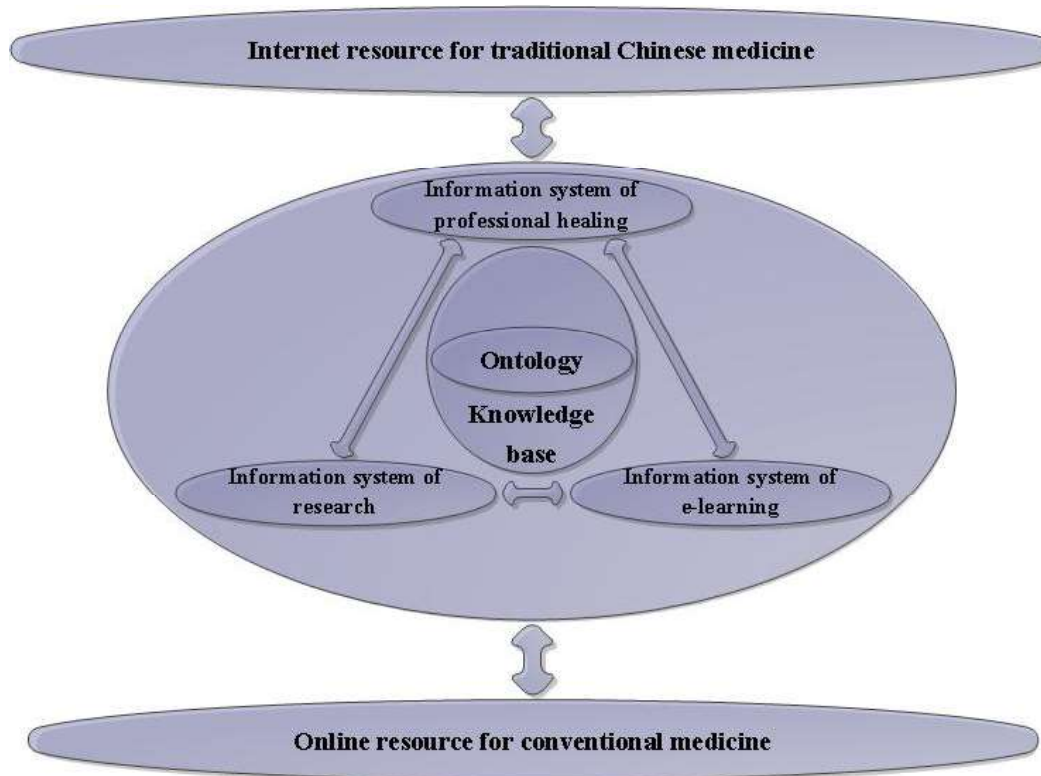


Fig. 1. General scheme of interaction of integrated onto-based information analytical environment of CIM information systems for TCM and conventional medicine

General architecture of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine is presented in Fig. 2.

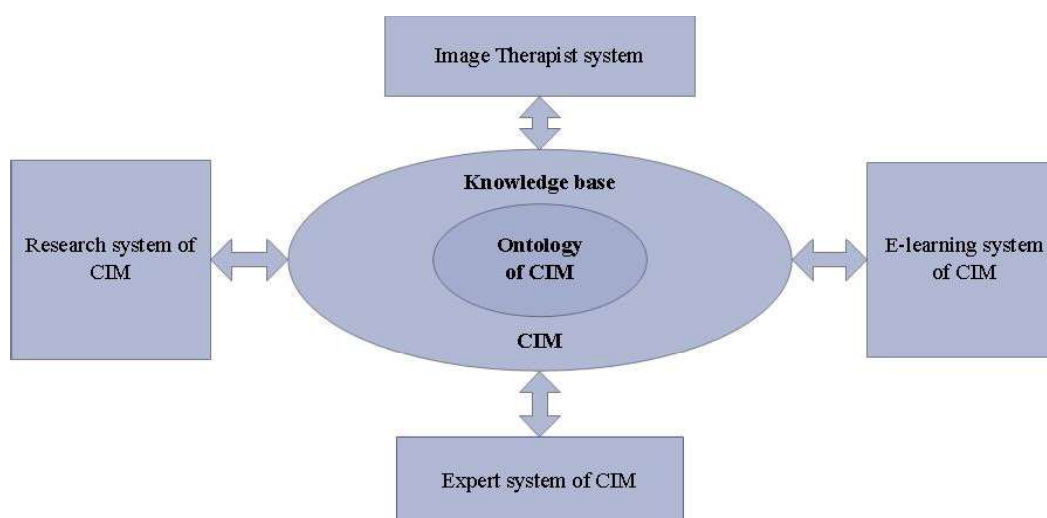


Fig. 2. General architecture of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine

Requirements and general architecture for components of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine

Detailed consideration of the components of information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine and their general architecture.

Information system of professional healing Image Therapist

Information system of professional healing Image Therapist is designed for centralized organization, upgrading (efficacy, safety, controllability, reliability, efficiency, intensity) of professional activities and experience exchange of the existing CIM therapists. Main requirements for this information system are:

1. The structure of the information system should include: 1) CIM therapist's electronic personal office with GUI (graphical user interface); 2) module of diagnostics results generation by means of CIM; 3) module of therapeutic decisions generation (therapeutic records); 4) medical data-base; 5) module of data exchange between CIM therapists (Fig. 4).

2. Image Therapist information system should have access to information systems CIM KB, ES CIM, CIM EIS, and ISR CIM.

3. Module of diagnostics results generation by means of CIM should provide input of personal and medical information about patients including data obtained by means of conventional medicine, such as case history and medical examinations (tests, functional diagnostics results, doctor's conclusion, etc.), and include diagnostic information obtained by TCM and CIM methods, such as palpation diagnostics, energy diagnostics with hand and (or) body, internal image diagnostics ('eye of mind', 'second heart'), and self-assessment information (physical and psychological state) of a patient before and after treatment (Table).

4. Medical data-base in addition to the traditional personal information about patients and their health data obtained by conventional medicine methods (case history, tests, functional diagnostics results, etc.) contains visual data (image) diagnostic information of a CIM therapist, and therapeutic schemes used by an image therapist when healing a patient. The elements of medical data-base should be used as specific examples of CIM ontology classes as a compound of the CIM onto-based knowledge-base.

Types of diagnostic information in the Image-therapist system

Personal information (age, sex, family members, etc.)	Medical information about a patient includes data obtained by means of conventional (Western) medicine, such as case history and medical examinations (tests, functional diagnostics results, doctor's conclusion, etc.)
Self-assessment information (physical and psychological state) about a patient before and after therapy by means of psychologic testing	Diagnostic information obtained by TCM and CIM, such as results of TCM diagnostics methods (examination, auscultation, palpation diagnostics), energy diagnostics with hand and (or) body, internal image diagnostics ('eye of mind', 'second heart')

General architecture of information system of professional healing Image Therapist is presented in Fig. 3.

Taking into account the unusual and rare for Western medicine nature of diagnostic methods and information of CIM, much attention should be paid to development of new models, methods and means of diagnostic information presentation, such as image information in CIM before creation of the information system Image Therapist. First of all, the interactive information subsystem of image diagnostic information display should be developed. The main approach to development of the interactive system of CIM image diagnostic information display is based on image model of the human body and its sites, including its physical energy and informational aspects. Exactly, this model must include hierarchically organized set **A** of nested partitions of human body images (parts of the body, organ systems, single organs and organ areas), the set **R** relations between elements of this partitions, which reflect pathological relationships identified by CIM therapists, as well as the set of attributes that characterize every partition element and every ratio element (physical, energy, informational level, manifestation rate of a disease in a particular scale (10 point scale), additional data).

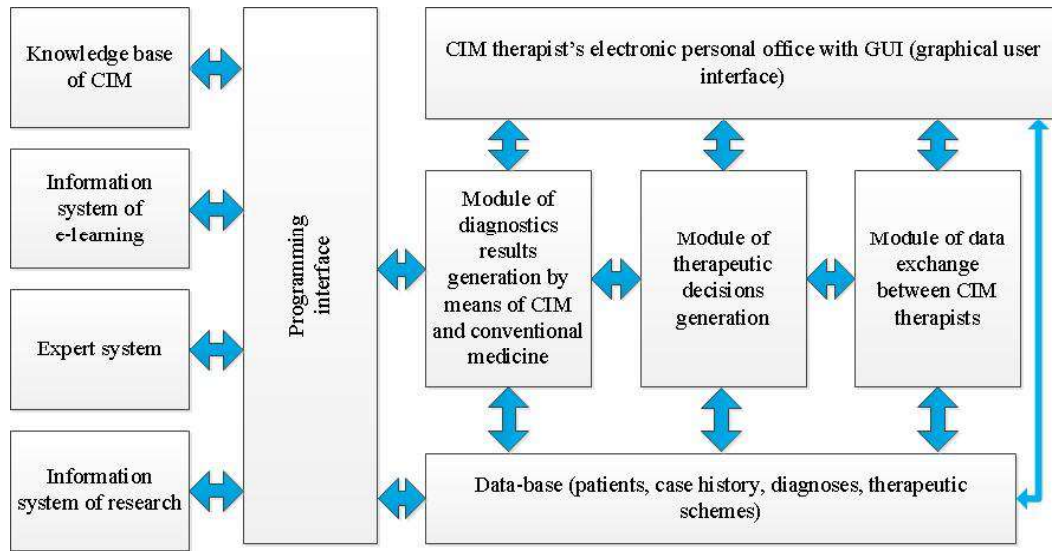


Fig. 3. General architecture of information system of professional healing Image Therapist

Onto-based knowledge-base of Chinese image medicine

Data-base is an important fundamental component of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine. The main requirements for this knowledge-base are:

1. CIM knowledge-base should contain five main components: 1) historical knowledge-base of CIM; 2) knowledge-base of general theory of CIM; 3) knowledge-base of health and diseases standards in CIM; 4) diagnostic knowledge-base of CIM; 5) therapeutic knowledge-base of CIM.
2. The structure of diagnostic knowledge-base should include CIM verbal conceptual knowledge of CIM and specialized knowledge-base “Atlas of images” of visual (image) information of CIM.
3. CIM knowledge-base should be based on ontology of CIM domain.
4. CIM knowledge-base should be consistent with TCM and conventional medicine knowledge-bases that makes possible comprehensive comparative analysis of different conceptual models of disease and treatment methods in CIM, TCM and conventional medicine.

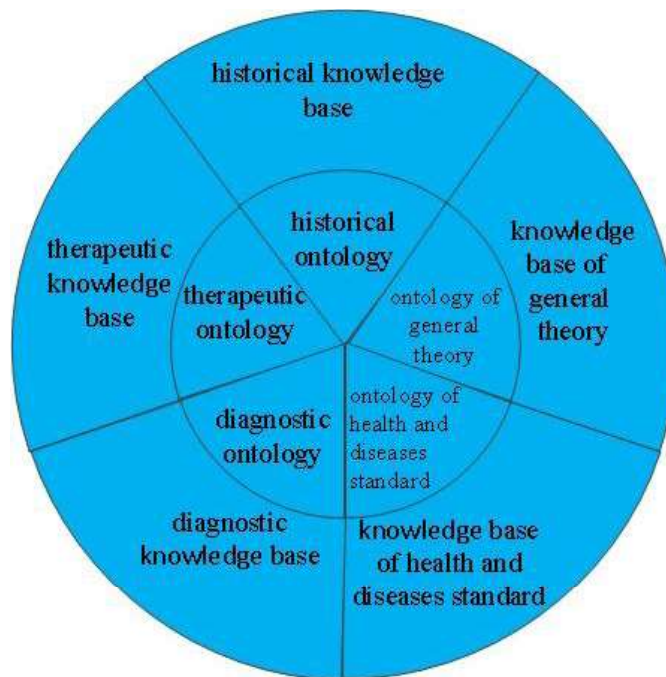


Fig. 4. General image of structural components of ontology and onto-based data-base of CIM

CIM ontology and knowledge-base can be represented as a five-grade structure: 1) historical ontology (knowledge-base) of CIM; 2) ontology (knowledge-base) of CIM general theory; 3) ontology (knowledge-base) of health and disease standard in CIM; 4) ontology (knowledge-base) of theory and practice of diagnostics in CIM; 5) ontology (knowledge-base) of theory and practice of therapy in CIM. Also, the ontology of CIM and its sub-ontology have a number of its projections (aspects), such as ancient Chinese traditional conceptual projection, projection of practical use and comprehension by CIM experts, Western philosophical and scientific conceptual projection.

General image of structural components of ontology and onto-based data-base of CIM is presented in Fig. 4.

Expert system for diagnostic and therapeutic decision-making support in CIM

An important part of the developed information analytical environment is the expert system for diagnostic and therapeutic decision-making support in CIM, which will help to improve the skills of CIM therapists. Expert system will issue diagnostic recommendations and personalized patient care scheme by means of CIM, based on data (personal and clinical) about a patient and CIM knowledge-base content.

The main requirements for the developed expert system include:

1. The expert system should include: 1) graphical user (CIM therapist) interface and administrator (knowledge engineer); 2) inferencing (diagnostic and therapeutic) module; 3) comment and justification module; 4) learning module.

2. Expert system should have access to information systems ISPH Image Therapist, CIM KB, ES CIM, CIM EIS, and ISR CIM.

Taking into account the specificity of CIM, mathematical software of the expert system is based on the use of probability theory, fuzzy mathematics, mathematical logic and theory of ontological modeling.

General architecture of the expert system for diagnostic and therapeutic decision-making support in CIM is presented in Figure 5.

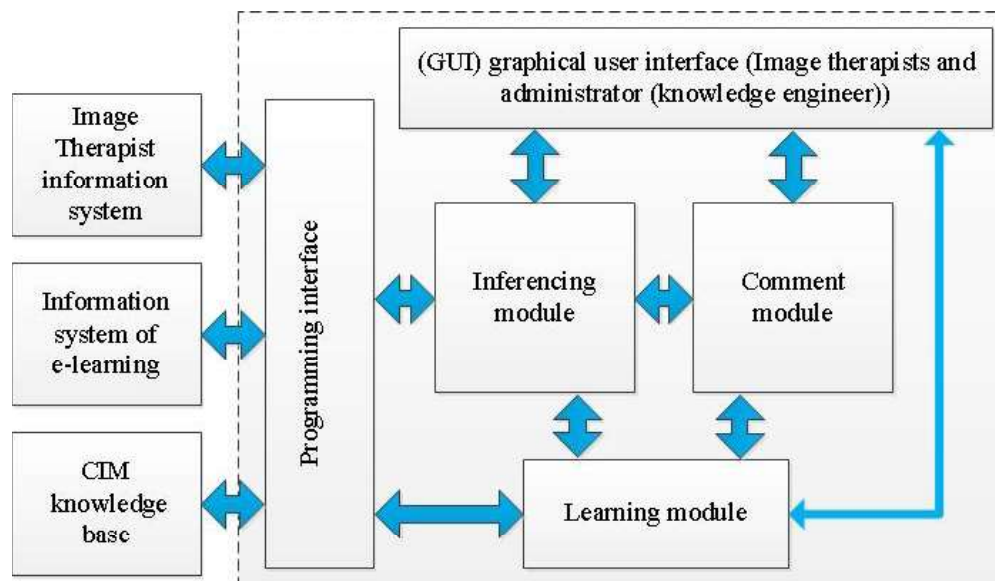


Fig. 5. General architecture of the expert system for diagnostic and therapeutic decision-making support in CIM

Information system of CIM e-learning

An important part of the integrated information analytical environment is CIM information system of e-learning. Development of such e-learning system will considerably simplify, intensify and improve quality and availability of educational process in CIM. The main requirements for CIM e-learning system are:

1) The CIM e-learning system should include: 1) graphical user interface; 2) module of learning control; 3) online help; 4) module of theoretical instructions; 5) practice module; 6) module of knowledge and skills control (tests).

- 2) CIM e-learning system should have access to information systems ISPH Image Therapist, CIM KB, ES CIM, CIM EIS, and ISR CIM.
- 3) CIM e-learning system should harmoniously combine text and image resources and multimedia technology.
- 4) CIM e-learning system should be adaptable to the needs and individualities of a specific user (student).
- 5) CIM e-learning system should be implemented in the form of interconnected multimedia electronic textbooks and units for awareness testing.

For implementation of e-learning information system evidence-based standards of CIM learning should be developed firstly; they include educational and professional program for a CIM therapist, educational qualification of a CIM therapist, curricula and steering documents in disciplines, lecture and practice-oriented learning materials, methods of testing and self-assessment testing of CIM specialists.

General architecture of the e-learning information system for CIM therapists is presented in Fig. 6.

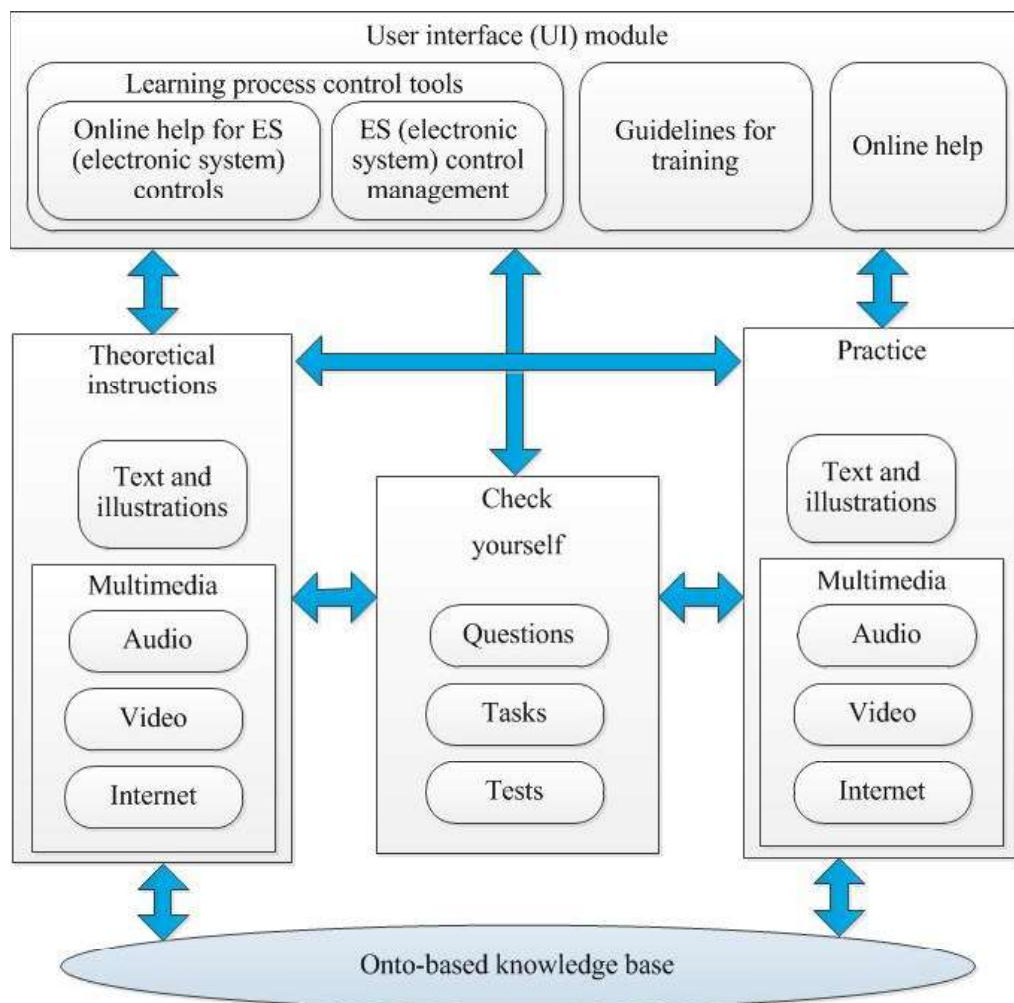


Fig. 6. General architecture of the e-learning information system for CIM therapists

Information system of CIM research

Information system of CIM research (ISR CIM) is designed for analysis, verification, prediction, evaluation of efficiency, optimization of diagnosis and treatment results for CIM therapists. Information system of CIM research benefits to comprehensive analysis and estimation of diagnosis and treatment results for CIM therapists, to evaluation of their efficacy and safety that is essential and important for CIM inclusion into the field of integrative medicine. This system will enable verification (testing) of new concepts, theories, models, methods, which explain the mechanisms of getting CIM diagnostic information and therapeutic effects on the grounds of research results.

The main requirements for ISR CIM are:

1. The structure of the information system of CIM research should include: 1) graphical user interface (researcher, scientist) 2) module of results analysis of diagnosis and treatment by methods of CIM; 3) module of assessment of result grade and optimization of diagnosis and therapy by methods of CIM; 4) module of verification of theories, models, methods and hypotheses in the scientific direction of CIM.

2. Information system of CIM research should have access to information systems ISPH Image Therapist, CIM KB, and ES CIM.

General architecture of the information system of research is presented in Fig. 7.

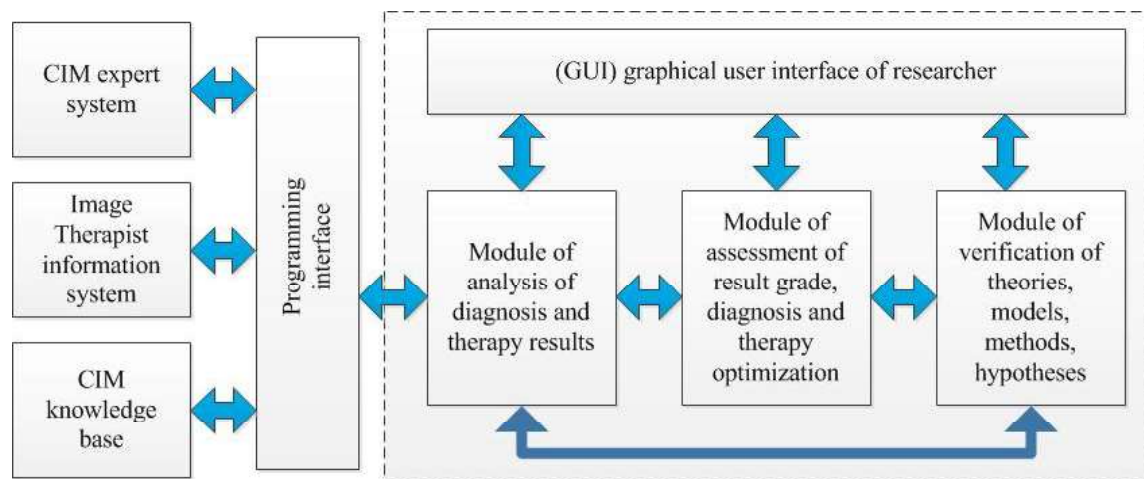


Fig. 7. General architecture of the information system of CIM research.

Conclusions and future research prospects

1. The timeliness of the development of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine is substantiated that would enable organisation and coordination of researchers and practicing CIM therapists activities on a high scientific, technological and infrastructure levels; data collection and automated statistical and intellectualized analysis of treatment results by means of CIM; creation of a unified database of theoretical, experimental and clinical research in CIM that will facilitate the implementation of the program [13] of research on a high scientific level.

2. The basic tasks of the development are substantiated and general architecture of the integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine is developed.

3. The requirements are defined and the general architecture of components of integrated onto-based information analytical environment of scientific research, professional healing and e-learning of Chinese image medicine is developed.

The main tasks that need further solution are:

1. To create software of the developed integrated information analytical environment such as required models (analytical, simulation), methods and algorithms for operation of this integrated environment and its component information systems.

2. Due to the reasonable software specificity to perform simulation, analysis and optimization of structural (architectural) and functional features of the developed integrated onto-based information analytical environment, and to create a detailed (verified) project of integrated onto-based information analytical environment and its components.

3. To substantiate the choice of information technology and software environment for implementation (coding, programming) of the project of integrated onto-based information analytical environment and its components.

4. To implement the project of integrated onto-based information analytical environment in the form of software.
5. To conduct testing, verification and validation of integrated onto-based information analytical environment.
6. To install and train users to work with the developed integrated onto-based information analytical environment.
7. To test and evaluate the operational quality of the developed onto-based information analytical environment of scientific research, professional healing and e-learning of CIM.

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