Fundamentals for the Intelligent Non-Invasive Diagnostics

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***Abstract*—The article elaborates the needs of the design and implementation of a intelligent non-invasive diagnostics system. Technological basis for development and different variants of non-invasive diagnostics are proposed as two fundamental components of such system.**

The domestic Open Semantic Technology of Intelligent Systems (OSTIS) is proposed to be used as a core technological foundation while designing the intelligent diagnostic system. The adaptation of diagnostic tasks within logical-semantic approach will allow to carry out differential diagnostics (i. e. formulating several diagnostic hypotheses). Various approaches towards the non-invasive diagnostics have been considered: functional-spectral diagnostics (FSD-diagnostics), bioimpedance analysis, preliminary diagnostics based on the assessment of the basic parameters of functional state, diagnostics by Zakharyin-Ged zones, diagnostics by Nakatani method, frequency-resonance diagnostics.

***Keywords*—non-invasive diagnostics, artificial intelligence, diagnostic decision support system**

I. Introduction

Health is the most valuable resource of the state. One of the task of modern society is to timely detect the disease risk. The implementation of this task requires new diagnostic tools based on the latest technologies. Risk diagnosis will provide significant economics savings towards disease prevention and treatment, as well as improve the quality of primary health care. Risk is the probability of developing a disease [1].

The current problem in the area of risk diagnostic is the creation of non-invasive technology for examination and detection of diseases at early stages in order to carry out individualized prevention. The emerging modern technologies provide ample opportunities for solving this problem [2]. At the same time, let us quote a doctor's critical statements about informatization of medicine: "The global problem is the lack of resources. And we are not talking about the shortage of money, but about the shortage of time. The time of professionals is the main world deficit. Information technology offers great opportunities to save money. Telemedicine, for example, has a huge potential. Support for medical decision-making is of enormous value, but it is not being deployed and practiced" [3].

The importance of the intelligent non-invasive diagnostics problem has several aspects. Firstly, it is **caring** for people's health that leads towards the individual health improvement and preventive care. Secondly, it is an **increase in the quality** of individual preventive care to the population. Thirdly, it is **beneficial** from the economic point of view, as the costs of prevention and treatment are minimized. Taking into account the problem of "time shortage", it is important to minimize time costs, as the procedures are carried out quickly enough. It is important that non-invasive diagnostics procedures are safe and painless.

Therefore, there is a need to continue to investigate and develop the intelligent non-invasive diagnostics, with the primary focus on the development of an intelligent system to support the decision making for non-invasive diagnostic.

The proposed architecture for the intelligent diagnostic ostis-system allows to assess the risk of diseases in patients, and creates the "windows of opportunity" not only for patients and doctors, but also for developers in terms of expanding the functionality of the system.

The main aim of this paper is to create an intelligent non-invasive diagnostic system architecture suitable for screening of systemic and nosological risks and early diagnosis of diseases, i. e. for diagnosing latent and initial stages of pathological process development for the purpose of primary and secondary prevention or timely treatment.

II. Overview of Existing Solutions

The quality of medical care depends on the level of doctors' training and on systems that support decision-making, including in the field of diagnosing the diseases at various stages.

While there are many medical decision support systems in various fields, the deployment of such systems into the everyday practice is relatively slow.

The current state of art of existing medical decision support systems is presented in [4]–[7] and demonstrates that almost every system is focused on a specific disease or group of diseases.

To date, a large number of private, highly specialized decision support systems have been developed. For example, SkyChain is designed for diagnosing lung, liver, breast, and melanoma cancer. The IDDAP system identifies potential infectious diseases and disease states based on the constructed ontology of the subject area. MYCIN is an interactive expert system for diagnosis and treatment of infectious diseases [8]. In [9], an intelligent system for personalized human health monitoring based on biomedical signal processing is designed using the Internet of Things, cloud computing, big data processing and neural network.

The number of localized problem statements and their solutions is so large that it is almost impossible to catalog them and have a common source of information about them. Localized solutions can be found in various information and search engines: PubMed, Scopus, Google Scholar, WoS.

It is difficult for medical staff to use several systems at once in practice, and it is expensive to develop and maintain such systems. Most of the existing systems focus on diagnostics on late stages of disease, while virtually none of the existing system considers the diagnosis in the early stages of the disease.

In terms of diagnostic methods, this article focuses on non-invasive methods of examination for early stages of the disease. Since they are highly informative, do not require long additional preparation of the patient, significant time expenditures, and also during the procedure the integrity of the skin is preserved.

III. Problem Statement

The design and implementation of intelligent non-invasive diagnostic system will require the consideration of identification of technological platform capable to process and support the non-invasive diagnostics. The methodological approach should address the solution of at least three steps:

The first step is to investigate promising methodological directions (variants) of non-invasive signals suitable for implementation of intelligent diagnostics: Functional-Spectral Diagnostics (FSD-diagnostics); preliminary diagnostics based on the assessment of basic parameters of functional state (such as electrocardiogram (ECG), arterial blood pressure, heart rate (pulse, HR), temperature distribution in the local skin area, carbon dioxide volume in exhaled air CO_2, arterial blood oxygen saturation SpO_2); bioimpedance analysis; Zakharyin-Ged zone diagnostics; Nakatani method diagnostics; frequency-resonance diagnostics.

The second step is to formulate general requirements to the diagnostic decision support system.

The Decision Support System for Diagnostics is designed for doctors and patients.

When developing a decision support system for human diagnostics, we believe it is reasonable to shift the focus of attention not only to the development of an intelligent system, but also to the issues of integration and compatibility of different solutions and approaches, and their subsequent joint development.

The third step is to justify the choice of technology for the development of an intelligent system.

Following the formulation of methodological approach, the technological requirements of the system can be summarized as following. The proposed intelligent non-invasive diagnostics system should:

- be oriented to the design and development (improvement) of the system;
- provide the possibility of integration of heterogeneous data pipelines:
- process different types of data
- ensure standardization of data representations (forms of representation, information processing models);
- support modular system architecture that provides the possibility of adding new components and new data types, and their integration into the system;
- ensure integration with modern emerging technologies.
- ensure compatibility of interfacing with different systems, their docking.

The choice of technology to be developed should include the possibility of strengthening technological sovereignty. Since full technological dependence of countries on monopolistic corporations, which we are now witnessing, is a "path dependence" in the current situation. One of the solutions is the development of open-source projects and focusing on efficient exploitation of open-source libraries openly available for research and industrial use free of charge.

IV. Proposed Approach

The purpose of the system is to assist physicians in establishing a diagnosis. For this purpose, it is necessary to establish in the system the principles of diagnosis formation, the structure of the diagnosis, as well as to provide a transparent mechanism of reasoning when making a diagnosis or when proposing several diagnostic hypotheses. Knowledge driven systems solve these problems.

To define a technical solution it is necessary to take into account the three key elements: (1) comprehensibility of the reasoning process, (2) heterogeneous data representation, and data and (3) interface standardisation.

Firstly, when designing decision support systems in medicine, it is necessary to take into account that for practical application these systems require explainability of the reasoning process with provision of reasoning on how the results obtained, as well as the ability to modify the knowledge used in the system in a timely manner. Fulfillment of such requirements is ensured by the ontological approach [10], on the basis of which knowledge bases (KB) in terms and structure familiar to specialists can be created.

Secondly, since different types of data are used as input data, it is necessary to integrate heterogeneous data pipelines, which is ensured by the ontological approach.

Thirdly, when building decision support systems, one of the problems is to provide a uniform description and interpretation of data, regardless of the place and time of their receipt in the overall system. One of the ways to solve this problem can be the introduction of ontological modeling technologies.

A number of other advantages of the ontological approach should be emphasized. Ontologies use logical formalisms, which makes them convenient for use in the development of complex systems. Ontologies are characterized by flexibility, which allows combining information from different sources and building new knowledge on its basis. The main purpose of creating any ontology is to model a certain subject area, in turn, this forms the core of the system, and other modules are easily integrated with this module. Also the knowledge stored in ontological form has a high potential for reuse. Each ontology contains some fragment of conceptual knowledge of the subject area and hence ontology systems are called knowledge-based systems.

A diagnosis ontology includes a structure for describing information, rules for interpreting it and applying it to diagnosis.

In view of the above, it is reasonable to use the ontological approach.

Logical-semantic systems are based on ontologies. Artificial intelligence systems based on logical-semantic knowledge processing work with conceptual apparatus. Logical-semantic systems work with knowledge representations in the form of ontologies, realized, for example, in the form of a knowledge graph, where concepts and other objects correspond to the nodes of the graph and relations between them — to the edges of the graph.

As applied to the tasks of non-invasive diagnostics logical-semantic systems will allow to build parallel hypotheses and form a diagnosis (more or less probable), which is an advantage of their use.

Alternative development tools include ontology editors Protégé, Ontolingua, OntoEdit and others. Recently, the number of publicly available ontology editors has been increased. However, the main problem is that ontology editors are considered in isolation from implementation technology.

The most effective technology for creating ontological systems is the domestic technology of complex life cycle support of semantically compatible intelligent computer systems of new generation (Open Semantic Technology of Intelligent Systems — OSTIS) [11], [12].

OSTIS technology is an open semantic technology for component-based design of hybrid and interoperable intelligent systems.

The OSTIS technology is based on the OSTIS standard, which is a standard of semantic computer systems that provides

- semantic compatibility of systems complying with this standard;
- methods of building such computer systems and their improvement in the process of operation;
- means of building and improving these systems, including language tools, libraries of standard technical solutions, as well as tools (means of synthesis and modification; means of analysis, verification, diagnosis, testing; means of [10].

It should be noted that one of the most important features of systems built on the basis of OSTIS technology is their platform independence. It has an orientation on the semantic representation of knowledge, which is completely abstracted from the peculiarities of the technical realization of intelligent systems.

It is important to consider the possibility to use already developed ontologies on medicine (on various resources), pre-transforming them into OSTIS format with further processing of the expert (adaptation to specific tasks). For example, it is possible to use "Knowledge bases of medical terminology and observations", ontology for representing knowledge about diagnostics of diseases and syndromes realized on the cloud platform IACPaaS [13] and others.

V. Description of the system operation principle

Problem Statement. We aim design the architecture of medical decision support system for patient diagnosis based on non-invasive diagnostics.

Tools for realization — OSTIS technology.

The architecture of the OSTIS system for medical applications consists of the following components:

- OSTIS Knowledge Bases — Can describe any type of knowledge, while being easily augmented with new types of knowledge. Can include such ontologies as disease model, etc.
- OSTIS problem solver is based on multi-agent approach and allows easy integration and combination of any problem-solving models.
- The OSTIS interface is a subsystem with its own knowledge-base and problem solver (separate knowledge base and problem solver).

The intelligent diagnostic decision support system will include the following components:

- Block of input data collection and storage
- Data processing unit

- Block of diagnostic conclusions formation (mechanism of logical conclusion, mechanism of "reasoning" when making a diagnosis, allowing to get an idea of what information was the basis for the diagnosis).
- Block of consulting doctors and patient — issuing a response to the end user of the system about the results of diagnostics, recommendation on further actions.

VI. Non-Invasive Diagnostic Methods

The term "non-invasive" can be translated as "without disturbing the skin".

The following criteria are taken into account when for choosing a non-invasive diagnostic method:

- simplicity of the procedure;
- safety and painlessness for the person;
- examination time;
- the number of features (e. g., markers);
- the number of body systems covered.

Intelligent diagnostics of the human condition is focused on a set of data and considers the human body as a whole.

Non-invasive human diagnostics can be carried out in several directions (variants) of functional diagnostics.

1) Functional spectral-dynamic diagnostics (FSD-diagnostics) for early diagnosis of diseases [14].
2) Bioimpedance analysis [15].
3) Preliminary diagnosis based on the evaluation of basic parameters of the functional state, such as electrocardiogram (ECG), arterial blood pressure, heart rate (pulse, HR), temperature distribution in the local skin area, volume of carbon dioxide in exhaled air CO_2, arterial blood oxygen saturation SpO_2. These measurements can be carried out, for example, using the device "Patient Monitor" [2], [16].
4) Diagnosis by Zakharyin-Ged zones [17].
5) Diagnosis by the Nakatani method [18].
6) Frequency-resonance diagnostics (bioresonance).

The choice of features mentioned above is justified by their prevalence and technological efficiency.

For each identified feature the principle of passivity of the main mode of diagnostics (without influence on the organism) or the principle of activity of the mode of diagnostics (influence on the organism is present) becomes an important indicator.

The passive indicators include: FSD-diagnostics; Zakharyin-Ged zone diagnostics; measurement of electrocardiogram (ECG), arterial blood pressure, heart rate (pulse, HR), temperature distribution in the local area of the skin, volume of carbon dioxide in exhaled air CO_2, arterial blood oxygen saturation SpO_2.

The active indicators include: bioimpedance analysis, Nakatani method diagnostics, frequency-resonance diagnostics.

Let's consider the in great detail non-invasive diagnostic methods mentioned above.

A. *FSD-diagnostics*

The most effective diagnostic technology is the technology of functional spectral-dynamic diagnostics (FSD-diagnostics) applied to solve the tasks of health dynamics monitoring [14]. This is due to the fact that FSD-diagnostics is effective with respect to common infectious and non-infectious diseases, including latent (hidden) stages and actual risks of their development. FSD provides a priori sufficiency (due to markers).

The FSD diagnostic technology is focused on the detection of disease risks (that is often used during early diagnosis). The sensor is a metal electrode that records a wave electromagnetic signal in the sound range.

The core principle of the spectral-dynamic method is to analyze the electrical oscillations of the body field in the frequency range from 20 hertz to 11 kilohertz with an amplitude of 1 millivolt.

FSD diagnosis involves the following operations [19]:

- tool: a sensor (metal electrode) is applied to the patient's skin surface for 35 sec;
- data collection: recording of the body wave signal in the frequency range from 20 Hz to 11 kHz (EMF audio range) is performed;
- signal processing: spectral analysis of the signal based on Dobeshi wavelet transform 3;
- detection problem: recognizing the presence of spectral correspondences with similar spectra of electronic copies of reference diagnostic markers;
- spectral correspondence (similarity of the marker with the corresponding part of the patient's spectrum) expressed in percent is the main indicator for the physician who issues a diagnostic report;
- the diagnostic report contains indications of risks or presence of infectious and non-infectious diseases.

Distinctive features of FSD-diagnostics from existing diagnostic technologies are: the principle of pattern recognition instead of the principle of parameter measurement; the principle of passivity of the main mode of diagnostics (without impact on the body); the possibility of automation of nosological diagnostics (recognition of the disease itself or nosological risk). The examination is performed in less than one minute, and its diagnostic analysis can take up to two hours.

B. *Bioimpedance analysis (bioimpedanceometry)*

Bioimpedance analysis (from "biological" and "impedance" — complex electrical resistance, "bioimpedance" — electrical resistance of biological tissues) — analysis of the amount of fat and fluid in the body, muscle and bone mass and metabolism, a method of rapid diagnosis of human body composition by measuring the electrical resistance between different points on the human skin.

In bioimpedance analysis, the active and reactive resistances of the human body and/or its segments at different frequencies are measured. Based on these measurements, the body composition characteristics such as fat, cellular and skeletal muscle mass, body water volume and distribution are calculated. To conduct bioimpedanceometry, a device called a bioimpedance meter is used, sensor include two pairs of electrodes in the chain "arm–torso–leg" with the use of probing sinusoidal current of constant frequency and low power (no more than 500-800 μA).

The main parameters evaluated by this method are the amount of fluid in the body, body mass index, basic metabolic rate, bone and fat mass, level of physical development and others, as well as their reference values depending on sex and age.

Bioimpedance analysis is used in the medical practice by doctors of different specialties: nutritionists, endocrinologists, doctors of other directions. The technique provides the doctor with a large amount of valuable information, indicates the need for laboratory and functional studies, and helps in determining treatment tactics [13].

There are several ways of measuring bioimpedance, one of them involves performing the following operations:

- the doctor enters data such as age, sex, weight and height, waist circumference, hip circumference, and wrist circumference into a computer program;
- the person is laid down, special sensors — electrodes are connected to his wrists and ankles, through which a weak alternating current of low power is applied;
- results are analyzed by a computer program and given in the form of convenient screen forms with comments.

Measurements are carried out within less than one minute.

C. Preliminary Diagnosis Based on the Assessment of Basic Parameters of the Functional State

The main parameters evaluated by this method are: electrocardiogram (ECG), arterial blood pressure, heart rate (pulse, HR), temperature distribution in the local area of the skin, volume of carbon dioxide in exhaled air CO_2, arterial blood oxygen saturation SpO_2.

Electrocardiography (ECG) is a ubiquitous method of studying heart function based on a graphic representation of the heart's electrical impulses. The intensity of heart muscle contractions is measured and converted into a graphic image (on a tape in the form of teeth). The results determine the absence or presence of abnormalities in heart function. Curve records the heart biocurrents.

Arterial blood pressure is the pressure of blood on the wall of the artery. The value of blood pressure is denoted by two numerical values. The figures 120/80 millimeters of mercury column for the brachial artery are taken as the norm. Systolic (upper) blood pressure — the level of blood pressure on the arterial wall at the moment of maximum heart contraction (the norm is 100-140 mm Hg). Diastolic (lower) blood pressure — the level of blood pressure on the arterial wall at the moment of maximum relaxation of the heart (normal — 60–90 mmHg). Values of normal BP depend on inheritance and age.

Heart rate (pulse rate, HR) is a physical quantity obtained by measuring the number of cardiac systoles per unit of time, the norm is 60-90 beats per minute. Deviations from the normal regular sinus rhythm are considered a heart rhythm disorder. HR depends on age, sex and external factors.

Temperature distribution in the local area of the skin is a comprehensive indicator of the thermal state of the human body. The body temperature of a person during the day varies within small limits, remaining in the range of approximately 35.5°C to 37.2°C. Changes in body temperature may indicate the presence of an inflammatory process in the body. The patterns of change in skin temperature often provide important diagnostic information about a person's condition.

Volume of carbon dioxide in exhaled air CO_2 , is a physiological stimulant of respiration: affects the cerebral cortex and stimulates the respiratory center. The norm is up to 4%.

Arterial blood oxygen saturation SpO_2 is the percentage of oxygenated hemoglobin in the blood (the amount of oxygen in the blood). This is an important indicator of the state of the human respiratory system. The norm is 95-100 percent.

Respiratory rate (RR) is the number of respiratory movements (inhalation-exhalation cycles) per unit of time (usually a minute). The normal respiratory rate (RR) is 16–20 per minute. Respiratory rate depends on the position of the body, physical activity.

These physiological parameters of a person can be measured using various devices, including the "Patient Monitor" (Fig. 1) [2].

Analysis of the measured parameters will allow the doctor to objectively assess the physiological state of the patient [2], [16].

In non-invasive measurements of basic human physiological parameters, the output signals of sensors have different physical nature and, accordingly, the types of data representation are heterogeneous, which, in turn, demonstrates the necessitates the use of ontological approach.

D. Detection of Organ Pathology by Zakhar'ina-Geda Zones

Zakhar'ina-Geda zones are certain skin areas in which reflected pains, as well as pain and temperature hyperesthesia often appear when internal organs are diseased.

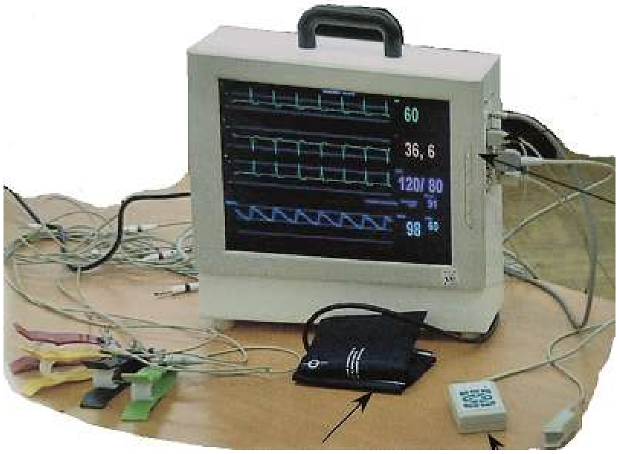

Figure 1. External view of the "Patient Monitor" device

In order to assess the condition of the patient's organs and identify diseased organs, we propose to use Zakharyin-Ged zones.

Initial data is the digitized thermal image of the patient taken in the infrared spectrum (using a thermal camera or heat sensors). It is necessary to compare the obtained image with reference maps of pathologic thermal zones allocation.

The method of detecting diseased organs of a patient involves performing the following operations:

- taking an image of the patient in the infrared radiation range using a thermal camera (obtaining a thermal portrait);
- digitizing the image by comparison and functional transformations;
- comparing the digitized thermal portrait with reference maps of Zakharyin-Ged, which are stored in the computer memory;
- allocation of pathological thermal zones based on comparison of the thermal portrait with reference maps;
- identification of the diseased organ by pathologic zones and output of information on the monitor to the doctor.

Measurements made on Zakhar'ina-Ged zones will allow to give a preliminary assessment of diseases of internal organs [17]. These measurements can be carried out with the help of the device "Patient Monitor".

The use of Zakharyin-Ged zones has been technologically developed in dynamic segmental diagnostics (including Nakatani method diagnostics).

E. Nakatani method diagnostics (riodoraku diagnostics)

Diagnosis using the Nakatani method consists of the studying the segmental cutaneous sympathetic reflex activity and is performed by measuring electrical conductivity values at representative points.

Japanese physician I. Nakatani (Nakatani) developed a method of electropuncture diagnostics of the functional state of meridians based on the measurement of electrocutaneous resistance (ECS) in representative (representative) acupuncture points. By measuring the ECS with an electrical detector in patients with inflammatory kidney disease, Nakatani found points with increased electrical conductivity and called them the electropermeable points.

The lines drawn through the electrically permeable zones are called "riodoraku" (from Japanese: line of good electrical conductivity, where "rio" — good, "de" — (electro) conductivity, "raku" — line). The main purpose of testing cutaneous sympathetic reflexes is to assess the activity of classical Chinese meridians for the subsequent prescription of acupuncture. Nakatani justified the use of galvanic current of 12 V and current strength of 200 μA (with closed electrodes) for diagnostic purposes. In Nakatani's method, current is applied to a point on a 1 cm^2 area of skin.

According to the method, the analysis is focused mainly on the ratio of these indices among themselves rather than using absolute values of current intensity (or ECS). For convenientt use of the method, a "standard riodaraku map" has been developed, where the ratios of the ratio of the current strength indices on skin projections of different "riodaraku", characteristic of healthy people, are graphically laid down. A scale is also used to interpret the indices of cutaneous sympathetic reflex activity in the area of representative zones of each riodoraku [20].

Electropuncture reflexodiagnostics according to Nakatani belongs to the methods of functional research. Through the assessment of the state of acupuncture meridians obtained by measuring the electrical conductivity of a set of representative points, it is possible to determine the functional state of individual internal organs and body systems. According to the Nakatani method, any changes in internal organs are reflected in the electrical characteristics of the skin. Therefore, the parameters of electropuncture measurements can be sensitive indicators, signaling systemic and nosological risks or the development of a pathological process.

The basic principle of this method can be formulated as "treat the person, not the individual disease". Nakatani method testing is widespread in many countries and is even considered mandatory during medical examination in Japan [18].

Electropuncture diagnosis is an integral part of clinical reflexology. The general order of investigations includes several main stages:

- gathering information about the patient;
- examination (measurements) (sensor-electrode);

- analysis and evaluation of measurement results;
- drawing up a conclusion.

The Nakatani method is widely used by reflexologists, mainly to assess the state of the meridian system and subsequent planning of acupuncture [18], [20].

F. Frequency-Resonance Diagnostics (Bioresonance)

The generation of wave diagnostics was created in 1978 by H. Schimmel and was called frequency-resonance diagnostics (bioresonance).

Bioresonance diagnostics is one of the methods of body research, which allows to carry out a complete examination of internal organs and systems in real time, to detect functional disorders at an early preclinical stage, to identify a weak or affected organ, and to determine the pathological process.

The core principle of the method can be formulated as "like cure by like".

Any organism emits electromagnetic vibrations. Cells and organs vibrate with a certain frequency. If we get sick, the vibrations of the affected organ change.

The frequency resonance method of diagnosis is based on the principle of frequency resonance.

This diagnosis involves the following operations:

1) electrodes are "attached" to the patient, which will read the measurements of electrical potentials at the points of skin projection of organs or systems of the body. Diagnostics is carried out on the points: head, hands and feet;
2) measurements of skin resistance by alternating current at various frequencies are started under the action of a very weak electromagnetic current;
3) the doctor, examining biologically active points, sends to each different frequency requests in expectation of resonance. Depending whatever the signal has been , received or not, the doctor finds out if a certain organ or system of the tested patient has a specific set of frequencies characterizing a specifically defined disease;
4) a diagnostic conclusion is formed.

Frequency resonance diagnostics is carried out within 2-2.5 hours.

VII. Non-Invasive Methods of Diagnostics and Periods of Diseases

Several periods (stages) are distinguished in the development of the disease. The most effective, in our opinion, non-invasive methods of diagnostics are proposed for a particular stage of the disease (Table I). It should be noted that diagnosis according to the Nakatani method is not in the periods of the disease, but in the plane of the state of the organism.

Let us emphasize the following periods of the disease:

- prenosologic period (risks) is — the period from the onset of gynesis risk (moment of gestation) to the onset of pathogenesis;
- latent period is the period from the onset of pathogenesis to the appearance of the first clinical signs of the disease.
- prodromal period is — a period of time from the first signs of the disease to the full manifestation of its symptoms (manifestation);
- manifest period (period of pronounced manifestations) has- specific symptoms of the disease are pronounced.

Table I
Disease stages and non-invasive diagnostic methods

Periods of disease	Non-invasive diagnostic methods				
	FSD	Bio-impe-dance	key para-meters	Zakha-ryin-Ged zones	Fre-quency reso-nance
Pre-nosologic period (risks)	+				+
Latent period	+			+	+
Prodromal period	+		+	+	+
Manifest period (period of pronounced manifestations)	+	+	+	+	+

Design and implementation of a diagnostic decision support system is a labor-intensive and time-consuming process. It is expedient to formulate priorities and decompose the tasks.

Analyzing the data shown in the table, FSD-diagnostics allows to identify the risks of diseases and has maximum informativeness and therefore it can form the first stage of the system implementation.

Let us determine the ontologies of the subject level (by diseases) within the framework of this problem.

VIII. Conclusion

Ancient Chinese wisdom says: "If there are no errors in diagnosis, there can be no errors in treatment". The use of intelligent non-invasive diagnostics will improve the quality of preventive medical care for the population.

In the paper, the justification and overall proposed architecture of intellectual non-invasive diagnostics system is discussed in great details.

Several directions (variants) of non-invasive diagnostics are considered: Functional-spectral diagnostics (FSD-diagnostics); preliminary diagnostics based on the assessment of basic parameters of the functional state (such as ECG, arterial blood pressure, HR, temperature distribution in the local area of the skin cover, volume of carbon dioxide in exhaled air CO_2, arterial blood oxygen saturation SpO_2); bioimpedance analysis; Zakharyin-Ged zone diagnostics; Nakatani method diagnostics; frequency-resonance diagnostics.

In non-invasive diagnostics, sensor output signals have different physical nature and correspondingly different types of data representation - and the question arises how to process them. This, in turn, necessitates the use of ontological approach. It is proposed to use the domestic technology of complex life cycle support of semantically compatible intelligent computer systems of new generation (Open Semantic Technology of Intelligent Systems). Logical-semantic approach in diagnostic tasks will allow to carry out differential diagnostics (to put forward several diagnostic hypotheses).

The technological basis for the creation of an intelligent diagnostic system is the technology of OSTIS.

The project of intellectual non-invasive diagnostics is justified by the presence of technological basis of OSTIS, application of logical-semantic approach in diagnostic tasks, as well as different variants of non-invasive diagnostics.

In the future, one of the directions of development of this system is the development of a personal medical assistant for the patient, which is focused not only on early detection of the disease, but also on recommendations to the patient for possible additional examination.

The basis for the functioning of the personal medical assistant is a decision support system. Obtaining knowledge by the patient will contribute to the understanding of his condition and its possible causes.

Important aspects of the system functioning are accumulation of data and knowledge, their systematization and the possibility of system evolution.

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ОСНОВАНИЯ ИНТЕЛЛЕКТУАЛЬНОЙ НЕИНВАЗИВНОЙ ДИАГНОСТИКИ

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В статье предложено обоснование направления работ по созданию системы интеллектуальной неинвазивной диагностики. В качестве ее основополагающих составляющих определены два аспекта: технологический базис для разработки и различные варианты неинвазивной диагностики.

Технологическим базисом для создания интеллектуальной диагностической системы является отечественная Открытая Семантическая Технология Интеллектуальных Систем (ОСТИС). Использование логико-семантического подхода в диагностических задачах позволит осуществлять дифференциальную диагностику (выдвигать несколько диагностических гипотез). Рассмотрено несколько направлений (вариантов) неинвазивной диагностики: функционально-спектральная диагностика (ФСД-диагностика), биоимпедансный анализ, предварительная диагностика на основе оценки основных параметров функционального состояния, диагностика по зонам Захарьина-Геда, диагностика по методу Накатани, частотно-резонансная диагностика.

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