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 noninvasive 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: FunctionalSpectral 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 CO2, arterial blood oxygen saturation SpO2); bioimpedance analysis; Zakharyin-Ged zone diagnostics; Nakatani method diagnostics; frequencyresonance 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.

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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 (FSDdiagnostics) 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 (FSDdiagnostics) 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.