Intelligent Health Monitoring Systems

Vladimir Rostovtsev
RSPC of Medical technologies
Ministry of Health of the Republic of Belarus
Minsk, Belarus
Email: vnrost@kmsd.su

***Abstract*—The paper considers the problems of the current state of complex monitoring of human health, as well as relevant diagnostic technologies. An approach to the intellectualization of the process of regular health monitoring based on FSD-diagnostics systems is proposed. The possibility of transition to a new technological level of public health control through the application of the proposed approaches is shown.**

***Keywords*—intelligent health monitoring, OSTIS Technology, ontology, FSD-diagnostics**

I. Introduction

Taking (in a zero approximation and formally) the understanding of health as the absence of a diagnosis of a disease, four gradations of health status should be distinguished:

- harmonious health,
- risk of disease,
- latent (hidden) stage of the disease,
- early stage of the disease (there are already symptoms, but the diagnosis has not yet been made).

Unfortunately, the diagnosis is often made at a late stage of the disease. This means that in order to help the natural intelligence of a doctor, it is necessary to create artificial intelligence systems for medical purposes.

In artificial and natural systems, intelligence is a tool designed to solve problems of recognition and generation of images and problems of recognition and generation of meanings.

Artificial intelligence systems use two approaches, including logical-semantic (based on ontologies) and logical-statistical (based on logical-analytical or neural network algorithms).

In medicine, due to the key importance of the diagnosis of risks and diseases, the most relevant tasks are image recognition, for which both approaches are used - logical-semantic and logical-statistical, including neural network, as well as hybrid versions of the architecture of diagnostic systems.

In addition to the development of intelligent diagnostic systems, the development of two more classes of intelligent medical systems is relevant. Firstly, it is the development of logical and semantic systems for consulting a doctor in the processes of making medical decisions concerning individual health-preventive or treatment-rehabilitation programs, including prescribing medicines. Secondly, it is the development of intelligent user interfaces in order to integrate existing medical information systems into a single distributed interoperable system.

Monitoring systems are diagnostic systems and are highly reliable due to the availability of dynamic data.

Health monitoring is designed to identify the risks of developing diseases and latent (hidden) stages of their development, as well as for timely diagnosis of manifest diseases.

The main task of intelligent health monitoring systems is to provide diagnostics of current risks and latent stages of diseases.

The organization of population monitoring based on laboratory diagnostic methods, even for just a few diseases, is economically unbearable. Existing wearable gadgets do not pretend to diagnose diseases, not to mention the diagnosis of nosological risks.

To solve the designated tasks of health monitoring, the most effective diagnostic technology is the technology of functional spectral dynamic diagnostics (FSD-diagnostics) [1]. This is due to the fact that FSD-diagnostics is effective against all common infectious and non-communicable diseases. Today, only FSDdiagnostics claims to provide economically justified and diagnostically effective health monitoring.

It is technologically important that each recording of the body's FSD-signal allows you to assess nosological risks for hundreds of nosological positions simultaneously in the telediagnostic mode in a few minutes. FSD-monitoring of health will ensure the transition to a new technological level of public health control.

II. FSD-diagnostic

The main areas of the body include genetic, metabolic, functional, mental and wave. Each sphere has its own type of processes.

The wave sphere includes all electromagnetic wave processes in the body and its surroundings. The frequency range of these wave processes is from fractions of Hertz to far ultraviolet radiation.

The state of the wave sphere depends on the state of all other spheres of the body and on the field load. Field cargo consists of technogenic fields (electrosmog), geopathogenic fields and unfavorable space and anthropogenic fields.

The mutual interdependence of the wave sphere with each of the other spheres of the organism makes the wave sphere the main factor, and the material-wave interactions are the main mechanism for integrating the organism into a single whole. Without this mechanism, the integrity of the organism is unattainable as such. The wave sphere "covers" all other spheres, or rather it forms a single organic whole with them.

The division of processes into real and wave processes is conditional. There really are unified and inseparable material-wave processes. Or, in other words, there is a single complex system of material-wave processes in biological organisms. The generalization of these provisions is the fundamental principle of the material-wave dualism of biological processes.

The real-wave interactions are symmetric. Real processes affect field processes, since all real processes generate wave radiation having their own strictly specific spectral-dynamic parameters. In turn, wave processes have an impact on the corresponding spectral-dynamic parameters of real processes. Material-wave interactions are realized mainly through resonance and compensation mechanisms.

In the existing term "biofield", the prefix "bio" has the meaning of a formal indication of the origin of the field, that is, its belonging to a biological object. In terms of content, the biofield is a set of physical electromagnetic fields, which has only one distinctive feature. This feature lies in the high complexity of the organization of the biofield, which corresponds to the complexity of the organization of processes in a biological object. As R. Virchow wrote: ¡¡I do not know anything essentially biological except biological organization.¿¿

Due to the regular display in the wave sphere of all other spheres, or rather the natural unity of the wave sphere and the other spheres of the body, the wave sphere contains information about all processes in the body without exception. This makes the wave sphere a unique source of diagnostic data and a universal intermediary for the correction of any pathological processes. And not only pathological, but also pathogenetic and risk-genetic.

In the development of pathology, there is a sequence of processes of riskogenesis (gradual formation of high risk), pathogenesis (disease formation) and nosogenesis (disease development).

The most important is the diagnostic identification of the processes of risk genesis, and in other words, the diagnosis of disease risks. Diagnosis of nosological risks is an absolutely necessary basis for effective disease prevention. Just as the diagnosis of diseases is a necessary basis for their effective treatment.

Medical technologies for working with the wave sphere of the body are called wave diagnostics and wave correction technologies.

Every process in the body is a functional process. Wave processes are as functional as they are real. The material-wave unity of all functional processes in any biosystems determines the understanding of wave diagnostics as functional diagnostics.

The essence of FSD-diagnostics consists in passive (without any impact) recording of a wave signal from the skin surface for a duration of 35 seconds using a metal electrode in the frequency range from 20 Hz to 11 kHz (EMF audio range), spectral analysis of the recorded signal based on the wavelet transform of Dobsha 3 and subsequent recognition of the presence of spectral correspondences with similar spectra of electronic copies reference diagnostic markers.

Spectral correspondence, that is, the similarity of the marker with the corresponding pattern of the patient's spectrum, expressed in the doctor, who, analyzing the indicators for tens and hundreds of markers, makes diagnostic conclusions. The main classes of markers are markers of physiological organ-tissue processes, inflammatory processes, degenerative processes, etiological agents (viral, bacterial, etc.), environmental factors and medicines.

FSD-diagnostics allows you to diagnose common infectious and non-infectious diseases and their risks across all body systems.

The use of FSD-diagnostics for the construction of intelligent health monitoring systems is favored by the following unique combination of technological factors:

- short time, passivity and ease of recording the FSDsignal,
- one-time access to all markers after recording the signal,
- ease of transmitting the audio signal file to the server
- low cost of the diagnostic cycle in automatic mode, that is, in the presence of an intelligent health monitoring system,
- the ability to use a smartphone to independently record and transmit an audio file of the FSDsignal to a server for automatic diagnostics using an intelligent health monitoring system.

III. Intelligent FSD-health monitoring systems

The logical-semantic approach based on ontologies involves the use of expert knowledge about markers and the nosological object being diagnosed. This approach does not require big data, but places high demands on experts and, in some cases, involves additional scientific research.

The logical-statistical approach is based on the extraction of knowledge from data. The extracted knowledge concerns, first of all, the diagnostic informativeness of specific markers. In addition, the extracted knowledge relates to the diagnostic effectiveness and semantics (expert component) of specific sets of informative diagnostic markers. Highly informative sets of markers are used to statistically assess the risks of the development of the diagnosed processes or to assess the chances of the reverse development of these processes. In the monitoring process, logical procedures for making diagnostic decisions based on preset threshold values of risk values are used as the main logical rules for a variety of current risk assessments. Exceptions to the basic rules are used as additional logical rules for making diagnostic decisions. In health monitoring technology, the basic and additional rules may include parameters of the current dynamics of risk values. The implementation of the logical-statistical approach does not require big data and special expert support.

The neural network approach does not involve the extraction of knowledge explicitly and requires big data, which is often inaccessible in medical diagnostic tasks. In addition, neural network systems are semantically opaque and subject to the influence of digital noise.

Marker data obtained with the help of FSD-diagnostics allow the use of all the mentioned approaches.

The implementation of a complete health monitoring system based on FSD-diagnostics includes the following stages:

1) recording the body's wave signal and calculating the Dobshy-3 wavelets,
2) formation of the patient's wavelet image and logical-statistical recognition of diagnostic markers,
3) identification of informative markers and logicalstatistical recognition of pathogenesis risks,
4) risk profile formation and logical-semantic recognition of system processes,
5) formation of a profile of system processes and logical-semantic generation of an individual scenario of preventive rehabilitation.

Technologically implemented the first three stages of a complete system of health FSD-monitoring. Of these, the third stage requires filling with a variety of nosological monitoring positions.

The technology of designing subsystems of the third stage of the implementation of intelligent health FSDmonitoring systems was developed by us on the example of a system for monitoring the risk of developing mastitis in cows.

The cow mastitis risk monitoring system has the necessary health FSD-monitoring infrastructure (sensors, server, terminals, communication channels) and the actual intelligent FSD mastitis risk monitoring system.

This system belongs to logical-statistical intelligent pattern recognition systems based on a highly informative set of diagnostic FSD-markers of mastitis. A set of 14 wave markers was obtained as a result of multistage selection from a variety of informative markers and includes markers of breast inflammation, drug markers and markers of immune system conditions.

The selection of informative mastitis markers was carried out by us on the basis of an FSD-study and a parallel laboratory study of a sample of cows (90 animals). Laboratory studies included the determination of the number of somatic cells and a microbiological ruler. The sample included healthy cows, individuals with subclinical mastitis and individuals with clinical mastitis (according to the results of laboratory diagnostics).

In the system of FSD-monitoring of the risk of developing mastitis in cows, two main diagnostic criteria were used - the magnitude of the risk of mastitis, that is, the assessment of the probability of developing mastitis, and the direction of the dynamics of changes in the magnitude of risk (its increase) in recent days during daily automatic monitoring, as well as several additional logical rules. The presence of a high risk in combination with the parameters of its growth dynamics makes it possible to identify not only the presence of subclinical mastitis, but also the actual risk of its development. The diagnostic error of the intelligent mastitis risk monitoring system was 5

The implementation of the fourth and fifth stages of the creation of a complete health monitoring system is planned to be carried out on the basis of the Open Semantic Technology for Intelligent Systems (OSTIS) [2]. On this basis, the most transparent prospects for the ontological design, production and operation of semantically compatible hybrid intelligent computer health monitoring systems and other intelligent medical systems open up.

IV. The task of integrating medical systems

The system of individual health FSD-monitoring should be integrated into the general system of intelligent and conventional, non-intelligent computer systems for medical purposes. The task of integrating many existing and projected medical systems is key to reaching a new level of organization of the industry and the healthcare system. The healthcare organization needs to be rethought in the context of the integration of many computer systems for medical purposes based on modern technological means of artificial intelligence. The OSTIS technological system claims maximum compliance with the level of complexity of medical tasks.

Today, the main obstacle to the construction of intelligent medical systems is the difference in the conceptual apparatus of different areas of medicine. Overcoming this is possible only by ensuring semantic compatibility and semantic convergence of subsystems in the design process of medical intelligent systems [3]–[6].

Ensuring semantic compatibility and semantic convergence creates the basis for achieving interoperability