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Promising directions of information technologies applications for improving of control and measuring devices in medical industry

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Abstract. The article deals with the problems of functioning and improvement of measuring and control devices in the medical industry. The classification, principles of organization of specialized, multifunctional and single-functional medical instrument and computer systems are considered. A model for solving the problem of scalability and availability through the use of non-relational data management systems that combine methods for achieving atomicity and data consistency is proposed. The promising diagnostic methods in medicine are described. The importance of a prompt assessment of the patient's condition is emphasized. The optimization and modernization of the digital radiography using modern machine learning algorithms are given and justified.

1. Rationale

Medicine deals with a large number of issues related to humans and animals. It is assigned not only with the role of providing of medical, pharmacological and veterinary services, but it is also involved into functionally logistic, optimization, trust-consulting, software activities. Moreover, it is the fundamental diversity (pluralism of the context) that determines the strategy for planning the life of the state (society) by influencing on such parameters as average life expectancy, the level of infant mortality, etc. Of course, its infrastructure plays a decisive role in ensuring the full value of medical support.

In the context of the digitalization of the world, the general approach to the architecture of software-analytical, hardware-technical means, which have both direct and indirect relation to medicine, plays an increasing role [1].

2. A relativistic approach to device design in the medical industry

The relativistic approach to the design of devices in medicine expresses duplex communication through telematic principles: medicine demonstrates the provision and conceptual design according to the "task - methods" scheme. And informatics provides a "means - methods" complex in a unified methodological approach based on the "task - means - tools - techniques" system.

And here comes a measure of uncertainty in the conceptual and functional understanding. In fact, the covariance component is seen and manifested for the considered invariance. Covariance is expressed in the preamble of the definition, based on the laws of formal logic. After all, the medical tools and devices developed and used for centuries and decades. In particular, the considered technical component (applied tools) directly or indirectly relies on non-obvious cross-cultural covariance during solving of certain problems. In a number of states, there is a differentiation between the so-called "traditional" or "conservative" medicine and "non-traditional". In addition, there is bioengineering that does not combine methods and means considered earlier, but used in the same combinatorial junction [2].

Such a mathematical or even econometric component not only determines the usefulness of the application different methods, principles, devices or other analogues, as valid arguments of covariance (see figure 1), but also determines the dispersion of efficiency.

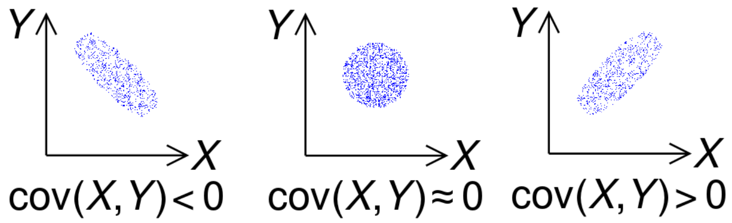

Figure 1. Sign of the covariance of two abstract random variables X and Y.

Let's focus on an example: there are several methods of X-ray therapy (and they are covariant to each other). Methods are useful in academic terms, licenses are valid, but the best effect for a particular recipient or group of recipients is certain. The defining moment is the covariance moment between the characteristics of the areal group and the statistics, and the dynamics of the course of the disease for the control group. Or, using the example of an abstract performer who is identified with a medical device that measures a certain parameter. Covariance is manifested between clarity (the degree of commensuration of measurement logic with perception) and grading [3]. Developed or operated device must present a functional component, i.e.:

- It shall be uniquely identifiable in use.
- It shall have multiple transparent correlations with uniformity of measurements.
- It shall be interchangeable.
- It shall reflect the objective nature of measurements.
- It shall have an internal apparatus, or the properties inherent in the circuit of the measuring device, which level out errors and external interference.

During development of a device, the requirements of ergonomics and reliability must certainly be taken into account. Taking into account the specific heterogeneity of medicine itself, it is undoubtedly necessary to reflect a relativistic approach to design features. Relativism implies a dialogue between technological and social culture, influencing not only the appearance of a medical device, but also the method of work. The desired property of the realized final product shall be a full compliance with universalism in the application and unity of positive subjective perception, which does not repulse various reference groups of patients.

Control devices must have an interactive multilingual mode, a system of protection against harmful actions in case of misuse, and predominantly automatic or automated type of work [4].

3. The principles of classification and the complexity of functioning in a unified medical system

The classification component of informatized medical devices and actuators shall be traced in an explicit form according to the following types: research and clinical information and measuring medical devices and closed systems, as well as multifunctional, single-functional and complex systems.

In one way or another, all means are combined into a medical information system (see figure 2).

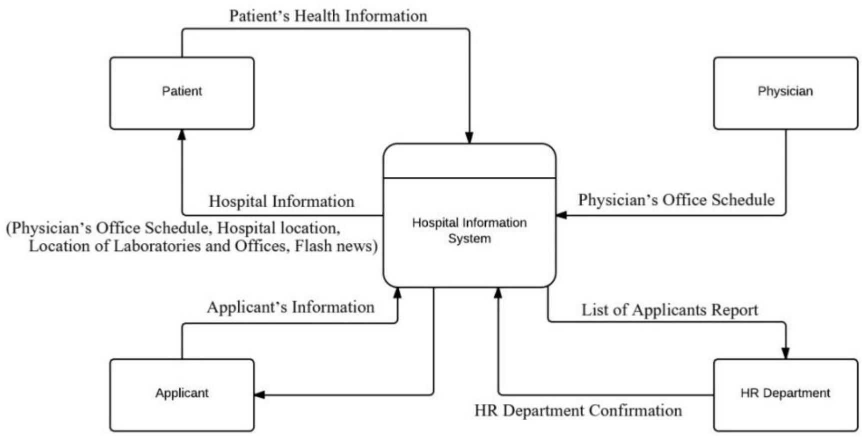

Figure 2. Flowchart of a typical medical information system.

A unified medical system defines an integrative role and a covariance component. The exclusion and minimization of risks and threats to the medical cluster and the patient's health lies precisely with the control component of medical systems. The condition of patients depends on the effectiveness of communication between the human-machine, medical, technical and bureaucratic components, and a streamlined process of coordination in the provision of care. In this connection, complex algorithms and protocols of interpersonal and technical communication are being developed (see figure 3), which control the quality of service, but do not have any effect on the process of improving the efficiency of medical devices, delegating to them the role of performers devoid of an intellectual component [5].

In addition, primary health care physicians are often not satisfied with such complex interactions during the transition from one type of care to another, and communication between physicians, as well as the transfer of data on the patient's condition, is often not carried out in a timely manner due to a number of factors, which exposes patients to all kinds of risks. This problem affects availability of certain technical means for patient (including ambulance squads, specialized medical devices). In large hospitals or in emergency situations (where the scale is larger), this problem acquires a nonlinear progression towards complication [6].

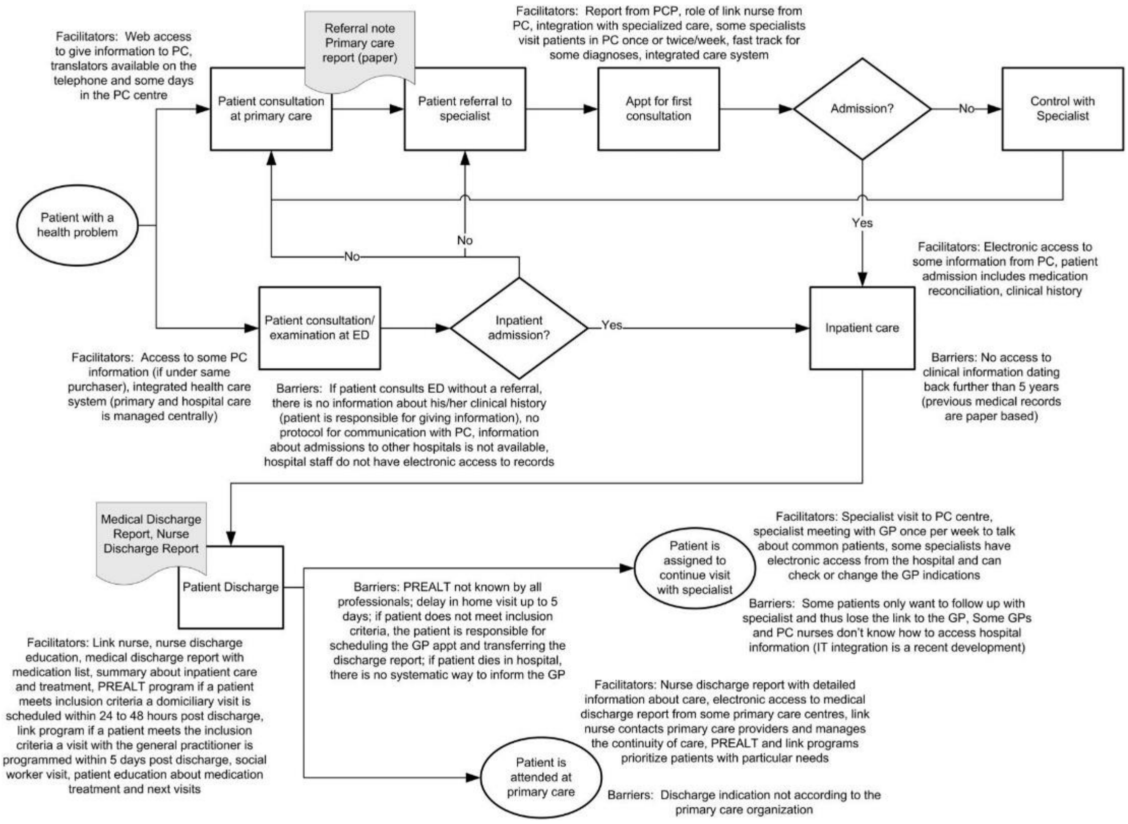

Figure 3. Algorithm for the selection of missing data between hospital and primary care in the dynamics of the process of transition to inpatient care.

The problems of access and scalability in the functioning of medical systems must be solved by reducing to non-redundant communication protocols and improving existing methods and tools. All devices, methods and means of medical monitoring, diagnostics and interventions must imply network interaction. Also, the general specificity of promising technologies and devices already used in clinical practice shall not create the load entropy. This aspect can be eliminated by switch to a non-relational database model (see figure 4).

It is impossible to imagine any information system without data storage. Existing hierarchical and relational systems are rigidly tied to information, declarations, and a discrete space of relations. And non-relational databases (NoSQL) reveal the potential of storing, processing and transmitting data in a telematic sense in heterogeneous and non-reduced (to a certain basis) environments. They can partially solve the problems discussed at the beginning of the article, expressing the principle of non-interference in already well-functioning systems and working according to the principle "as is" with data. In addition, non-relational systems will reveal themselves in analogue devices [7].

This is achieved through graph-orientation and absence of schemes. It means that two documents in a non-relational database data structure do not need to have the same fields and can store data of different types. The adjacent relationship opens the horizon for the implementation of such promising technologies in medicine, in which the information component is complex or does not lend itself to fully coherent declaration. A flexible model for organizing telematic synthesis not only defines a qualitatively new model of medical information systems, but also a resolving (permissible) field of medical research with a pronounced stochasticity and covariance. These include synthesized dynamic slices of the patient's operational map, which has a multi-parameter and incoherent nature (i.e. these factors make the design of programs for the functioning of measuring systems and devices, sensors and medical comparators more complicate). Dynamic diagnostics in the new data model will be easier to organize.

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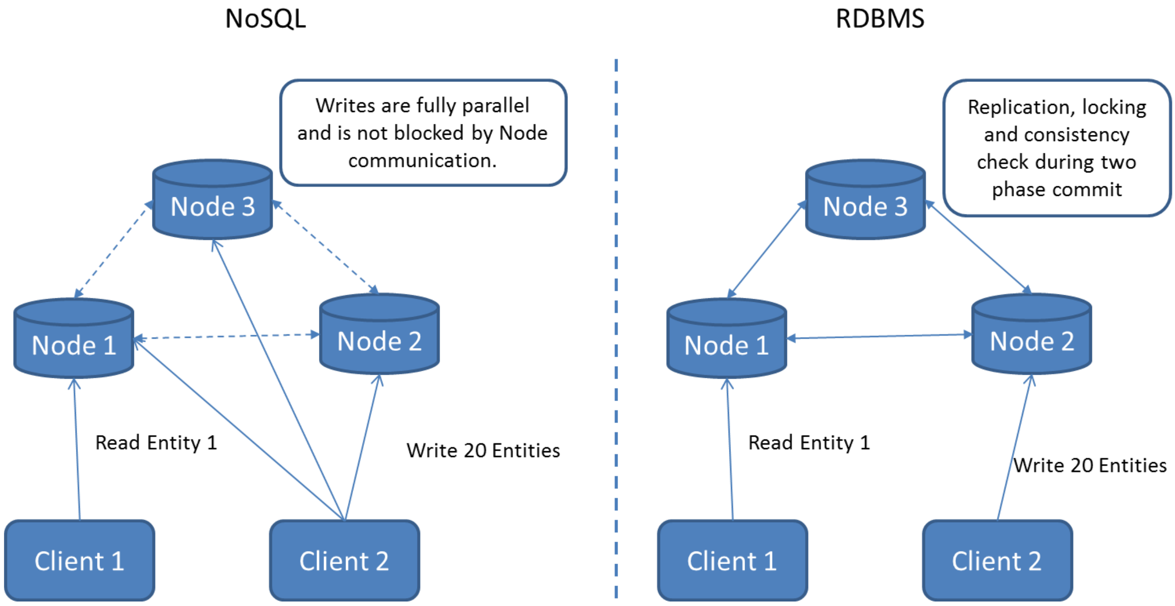

Figure 4. Two distinctive principles of organizing databases (knowledge bases).

And machine learning and artificial intelligence tools will allow to reveal the predictive side of diagnostics in more volume. For example, in digital radiography [8,9,10].

In all digital devices, the image is constructed in the same way. Each digital picture is made up of many separate dots. Each point of the image is assigned a number that corresponds to the intensity of its glow. The degree of brightness of a point is determined in a special device (analog-to-digital converter (ADC)) [11,12,13].

Often, the most common problem in the design of computed radiography, tomography and electrocardiography medical device is the determination of the required bit depth of analog-to-digital converters, and, consequently, the threat of determining a "white spot", implying a minimum tolerance with an insufficient level of bit depth of generated and absorbed data. However, it is associated with a strongly pronounced negative side from the operative diagnosis of the patient and the approximated negative dynamics in the formation of the patient's sheet.

Compilation of covariance-variance matrices together with machine learning algorithms working on use cases with latent vectors can neutralize this component. And the architecture of medical information systems, combining adaptive, that is, NoSQL data will make it easier to use symmetric methods for processing the resulting images. The disordered structure of the variable values of the photosensitive elements of the matrices used in most of these devices makes it possible to use algorithms for working with "collections" (different types of data combined into one structure) and to simplify the existing algorithms for processing of research results based on spatial samples.

4. Findings

Thus, mathematical methods and algorithms used in information technologies are formulated and considered in the article. The importance of the concept of covariance dependences, the role of non-relational databases as a basis for the application of promising technologies in measuring medical devices are indicated. It is due to reduction to the basis, which is necessary for a number of machine learning algorithms, working with stochastic quantities in photosensitive components of equipment.

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