Conditions for the Practical Application of Artificial Intelligence in Healthcare

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***Abstract*—The development of artificial intelligence (AI) technologies and their implementation in various industries and spheres of human activity has become one of the key modern trends, and the medical sphere is no exception. The article examines the conditions for the practical application of AI in healthcare, highlights the main stages of technology implementation, and analyzes the main challenges that arise during the implementation of such projects. The authors of the article emphasize the importance of a systematic approach, including analysis of the current state, setting goals and objectives, organizing teams, communication and monitoring, as well as piloting and testing solutions. The article also considers basic aspects related to the legislative framework, economic efficiency and personnel training for the successful implementation of projects in healthcare.**

***Keywords*—healthcare, artificial intelligence, digital development of healthcare, implementation of AI.**

I. Introduction

The development of artificial intelligence (AI) is one of the most relevant trends in the development of modern technologies, influencing most areas of activity, including healthcare. The introduction of AI in this area involves improving the quality of medical care and enabling doctors to focus on more complex tasks that require human participation. However, during the implementation of such projects, a number of problems and contradictions arise that require detailed analysis. This article examines the conditions and stages of the introduction of AI in healthcare, including organizational, legal, technical and personnel aspects. The authors of the article note that the proposed approach is not unique to the healthcare industry, and believe that it can be applied to other national industries and areas of activity.

II. Stages of forming conditions for the practical application of AI

A. Basic conditions for the use of AI.

In order to effectively apply and implement AI technologies, it is necessary to define the main stages of this process, which include:

- Analysis of the current situation.
- Determine what problems AI solves.
- Calculate the economic effect.
- Determine what resources we have available.

Before you begin implementing AI, it is important to analyze the current state of affairs, i. e. to determine the "initial data". At this stage, it is important to understand the following aspects:

It is necessary to carry out an analysis of contradictions. The authors of the article note the works of Genrikh Altshuler with his theory of inventive problem solving (TRIZ), 40 basic techniques for eliminating technical contradictions as a good approach to understanding the process of identifying contradictions. TRIZ has been and is used today to train engineers by such well-known companies as Procter& Gamble, Motorola, Ford, Siemens, Phillips, 3M, LG and others. TRIZ is based on the collection and analysis of arrays of information on inventive solutions, differentiation of these arrays by levels of complexity of resolving contradictions, identification of techniques and methods for resolving contradictions [1]. TRIZ methods and tools are applicable to solving inventive problems not only in engineering, but also for non-technical systems. TRIZ is used in practice to develop a creative personality, solve inventive problems in various fields, including medicine [2].

To determine whether there is readiness to adopt new things, it is important to consider several factors. Depending on the context – whether it is the introduction of new technologies, changing habits, adopting a new idea, or something else – the approach may differ. Here are some key steps to help determine whether there is readiness [5], [6].

Defining the target audience. It is important to understand who exactly will be the main consumer of the innovation. Different groups of people may react to changes differently. Having defined the target audience, it is easier to assess its attitude to the innovation.

For example, young people are often quicker to adopt technological innovations, while older generations may need additional support and training.

Analysis of change perception. Willingness to change depends on how potential customers perceive the possible consequences of introducing something new. If they see advantages, the likelihood of adoption increases. However, if people are afraid of risks or negative conse-

quences, resistance can be significant.

Research of barriers. It is necessary to identify potential barriers that may prevent the adoption of the new. Barriers may be related to lack of knowledge, lack of resources, fear of the unknown or organizational limitations.

The balance of need and simplicity is a concept of the optimal combination of the functionality of the implemented solution with the minimization of the complexity of its use. A successful digital product is one that effectively solves consumer problems while maintaining a user-friendly and simple interface.

Determine what final economic result can be expected, including the cost-benefit balance.

Calculating the economic effect of implementing a new project, technology or process is an important stage of planning and assessing the feasibility of investments. The economic effect shows what expected benefit can be obtained after implementing the new. The key stages of calculating the economic effect are:

determination of costs: investments, operating expenses, etc.;

revenue assessment: direct income, cost savings, cost reduction,

payback period;

social effect (benefit).

Identify the different types of assets that can be managed: finance, people, time.

B. Formation of goals and objectives. Development of a strategy (plan) of actions

The formation of goals and objectives is the basis for further development of an action plan.

Goals and objectives of practical application of AI in healthcare:

- improving the quality and accessibility of medical care. The introduction of digital technologies and standards will improve the accessibility and quality of medical care;
- reducing the workload of the doctor by transforming current processes. Automation of routine tasks will allow doctors to focus on more complex aspects that require human participation;
- development of medical technologies. AI contributes to the creation of new methods of prevention, diagnosis and treatment, and the production of medicines;
- reduction of healthcare costs. Optimization of processes will allow to significantly reduce costs;
- personalization of medical services, which will allow the formation of a full volume of medical information about the patient, taking into account his/her characteristics.

The strategy (plan) of actions defines the path to achieving goals and objectives and includes the following steps:

- publication of a country-specific regulatory legal act that will define the regulator in the field of AI, its powers and the powers of interested participants;
- definition of the concept, namely: consolidation of the principles and approaches to the development of AI in the country;
- defining a strategy by setting goals and objectives, the AI development system in the country, industry roles and tasks;
- formation of industry policy for the implementation and development of AI in healthcare.

These are the primary organizational and legal steps for separating AI into a separate, independent scientific and technological direction.

C. Organizing and preparing the team. Communication and monitoring

Organizing and preparing a team is an important step, since the use of AI requires dedicated and competent specialists in the field. The preparation process consists of the following stages:

- organization and management of the team. The creation of a multi-level management system will allow for effective coordination of actions;
- coverage of activities, public discussion of issues;
- training and preparation. It is necessary to ensure training of medical and technical specialists to work with new technologies;
- allocation of applied areas. Allocation of applied projects into separate areas or groups, which will allow focusing on individual projects and speed up implementation.

Effective communication and control over the execution of tasks will help to avoid possible problems and increase the efficiency of implementation. This stage involves:

- formation of a common understanding of the process among the participants. Ensuring interoperability of processes, participants and systems. The ability of the participating processes, systems and participants to achieve common goals at the business process level;
- professional expertise, that is, discussion of results and problems with experts and search for solutions;
- systemic communication, the presence of connections and the need for communication;
- communication monitoring. Constant monitoring of the project implementation will help to promptly identify and correct errors. (tracking and regulating the communicative behavior of participants).

D. Piloting, testing and evaluation of results

As part of the piloting, testing and evaluation stage of the intermediate results of this stage, the following is carried out:

- conducting a pilot. Organizing and conducting pilot testing, checking the system's performance in real conditions;
- threat model. Identification of potential threats and risks, models for their response and minimization;
- prototype testing. Implementation of the tested prototype, debugging;
- identification and elimination of errors. Conducting trial operation, eliminating errors identified during trial operation;
- evaluation of results. Analysis of the results of piloting, testing and trial operation.

III. Practical application of AI in healthcare

There are many information systems in use in healthcare organizations of the Republic of Belarus, but they do not meet the basic characteristics of AI.

Information systems that are related to AI must be able to work with big data technologies, self-learn, and seamlessly integrate with other information systems.

For reference. Currently, the definition of AI is given within the framework of the Resolution of the Council of Ministers of the Republic of Belarus dated April 21, 2023 No. 280 "On measures to implement the Decree of the President of the Republic of Belarus dated April 7, 2022 No. 136.

Artificial intelligence is a set of technological solutions that allows simulating human cognitive functions (including self-learning and finding solutions without a predetermined algorithm) and obtaining results when performing specific tasks that are comparable to the results of human intellectual activity, and includes information and communication infrastructure, software, processes and services for data processing and finding solutions [10].

A preliminary analysis of the current state of affairs in digital healthcare development points to the need for a systemic rethinking of approaches to the implementation of AI. To do this, it is necessary to:

- identify emerging contradictions and their relevance to digital development in the field of AI;
- develop an intelligent ecosystem for digital development of healthcare;
- eliminate technological and regulatory contradictions in the implementation of AI in practice.

Working with emerging contradictions in digital development in the field of AI involves not only identifying them, but also searching for potential solutions.

The approaches to identifying and resolving contradictions based on TRIZ are mentioned above, the methods of which can also be used to solve problems in the field of medicine. The application of TRIZ principles allows for effective work with emerging contradictions, which is especially relevant when implementing innovative technologies [7], [8].

A. Basic principles of TRIZ

TRIZ is based on several key principles [3], [4]:

The law of contradictions. Any improvement of one parameter of the system often worsens another parameter. The task is to find a compromise or eliminate the contradiction by introducing additional elements or changes in the system.

Resource Utilization: The solution must utilize the available system resources (materials, energy, space, time).

Ideality. An ideal system is one that performs its function, but is itself absent as a material object.

Evolutionary approach. The system develops according to certain laws of evolution, and the task is to predict the direction of this evolution.

For example, with the growth of medical data, it is necessary to maintain the quality of medical care. Minimizing the heterogeneity of medical data formats should not interfere with maintaining the variety of medical information systems. The solution to these contradictions can be the introduction of new methods of information processing that do not depend on data formats [9].

B. Application of TRIZ in medicine

Development of new drugs. TRIZ can be used to find solutions to overcome limitations of existing drugs, such as side effects, toxicity or inefficiency. For example, it is possible to find ways to improve the delivery of active substances to the body or to reduce the dosage of the drug without losing therapeutic effectiveness.

Creation of new medical devices. TRIZ helps in the development of devices that solve specific clinical problems, such as portable diagnostic devices, robotic systems for surgery, or exoskeletons for patient rehabilitation.

Optimization of medical procedures. TRIZ can be used to optimize medical procedures such as surgeries, rehabilitation, or prevention. For example, it is possible to develop methods that reduce the trauma of surgeries or speed up the recovery of patients.

Resolving ethical dilemmas. TRIZ can help find compromise solutions in cases where moral or ethical conflicts arise, for example, when determining priorities in providing medical care or making decisions about stopping treatment.

Improving the efficiency of medical care. TRIZ can help optimize processes in hospitals and clinics, reduce queues, reduce errors and increase patient satisfaction.

Let's consider an example of using TRIZ to develop a new method of treating Parkinson's disease. One of the main problems in treating this disease is the need for constant medication, which causes side effects and inconvenience for the patient. Using TRIZ, we can propose a solution based on the implantation of a miniature device that will deliver the drug directly to the brain through special channels. This will avoid side effects and ensure a

constant supply of the necessary substance to the desired area of the brain.

C. Advantages of using TRIZ in medicine

Innovativeness. TRIZ stimulates creativity and out-of-the-box thinking, which leads to the creation of unique and effective solutions.

Efficiency. The use of TRIZ allows finding optimal solutions to problems, minimizing costs and maximizing results.

Universality. TRIZ methods can be applied in almost any area of medicine, from the development of new drugs to the organization of work of medical institutions.

Scientific approach. TRIZ is based on the analysis of patterns and trends, which ensures the scientific validity of the proposed solutions.

D. Limitations and Challenges

Despite the obvious advantages, the use of TRIZ in medicine faces a number of limitations and challenges:

Requires a deep understanding of the subject area. To successfully apply TRIZ, it is necessary to have a good understanding of a specific medical task, which requires the participation of specialists with a high level of professional training.

Direct analogies are not always obvious. Some medical problems are so specific that direct analogs from other areas may be absent, which complicates the application of standard TRIZ tools.

Ethical and legal aspects. The medical field has strict regulations and standards that must be taken into account when developing any innovations.

TRIZ provides powerful tools for resolving complex contradictions that arise in medical practice. By applying various TRIZ principles and methods, effective and innovative solutions can be found that improve the quality of medical care, reduce risks, and increase patient satisfaction.

Several examples of resolving contradictions that may arise in medical practice using TRIZ.

Contradiction 1: Effectiveness vs. Side Effects

Problem:

Some drugs are highly effective in treating diseases, but cause serious side effects, which reduces their suitability for widespread use.

Solution:

Using TRIZ principles, such as separation in time and space, the following options can be proposed:

Creation of combination drugs, where one component neutralizes the side effects of another.

Development of methods for controlled release of the active substance to minimize the concentration of the drug in the blood outside the affected area.

Introduction of auxiliary components into the drug that block unwanted reactions of the body.

Contradiction 2: Minimally Invasive Treatment vs. Diagnostic Accuracy.

Problem:

Minimally invasive procedures such as endoscopy or laparoscopy allow for less traumatic interventions for the patient, but they may limit diagnostic accuracy and control over the surgical field.

Solution:

The application of the principle of "ideality" in TRIZ can lead to the following solutions:

Development of high-tech imaging tools such as a high-resolution microscopic camera built into an endoscope.

The use of robots to perform operations, which increases the accuracy of manipulations and reduces the risk of error.

Use of ultrasound navigation to accurately determine the location of organs and tissues.

Contradiction 3: Duration of Procedure vs. Speed of Action.

Problem:

Many medical procedures take a long time to complete, which creates discomfort for patients and a workload for medical staff. However, speeding up the process can negatively affect the quality of treatment.

Solution:

You can apply the principle of dynamism from the TRIZ arsenal:

Automation of routine stages of the procedure using specialized equipment.

Performing multiple tasks in parallel during a single procedure, such as simultaneously administering contrast material and collecting diagnostic data.

Optimization of the sequence of actions to reduce the overall procedure time.

Contradiction 4: Individualized Treatment vs. Scalability.

Problem:

Individualized treatments tailored to the individual patient demonstrate better results, but are difficult to scale and expensive. Mass production of drugs and methods, on the other hand, is cheaper but less effective for each individual case.

Solution:

Using the idea of complexity sharing, we can propose:

Personalized test kits to determine the most appropriate treatment option.

Creating machine learning algorithms that provide personalized recommendations based on big data.

Modular treatment systems where the basic components are universal and additional elements are customized for a specific patient.

Contradiction 5: Accuracy of Diagnosis vs. Time of Diagnosis.

Problem:

Highly accurate diagnostic methods, such as MRI or genetic testing, are time-consuming and resource-intensive, which delays treatment. Faster methods, such as rapid tests, are often less accurate.

Solution:

Let's apply the "anti-object" principle:

Combining rapid preliminary screening with subsequent diagnostic clarification using a highly accurate method.

Development of automated systems for interpreting test results, which speeds up the data processing process.

The use of TRIZ in medicine opens up new horizons for finding solutions to complex clinical problems. This method allows going beyond traditional approaches and offers innovative ways to overcome existing problems. However, successful integration of TRIZ into medical practice requires joint efforts of doctors, scientists and engineers, as well as consideration of all regulatory requirements and ethical aspects.

In addition, it is necessary to develop an intelligent ecosystem for digital healthcare development, which is a collection of all digital healthcare systems, as well as an intelligent metasystem - a top-level subsystem for managing the healthcare ecosystem, the purpose of which is to integrate data from medical systems.

E. Intellectual ecosystem of digital development of healthcare of the Republic of Belarus

The intelligent ecosystem of digital development of healthcare in the Republic of Belarus is a system of interconnected digital platforms, services and solutions aimed at improving the quality of medical care, increasing the efficiency of medical institutions and improving the health of the country's population. This ecosystem includes a number of components, each of which contributes to the overall digital transformation of the industry.

Components of the intelligent ecosystem:

an electronic medical record stores the patient's entire medical history, examination results, doctor's orders and other important medical data. It is available to doctors in real time, which facilitates the process of diagnosis and treatment;

telemedicine allows doctors to consult patients remotely using video conferencing and other modern means of communication. This is especially useful for residents of remote regions who find it difficult to get to specialized clinics;

an artificial intelligence is used to analyze large volumes of medical data, helping doctors make more informed decisions. For example, AI can be used for early diagnosis of diseases, predicting treatment outcomes, and selecting individual treatment plans;

modern digital diagnostic technologies, such as computed tomography, magnetic resonance imaging and ultrasound, allow us to obtain high-quality images of internal organs and tissues, which significantly increases the accuracy of diagnostics;

robots are used in surgery to perform complex operations with high precision. They are also used to rehabilitate patients after injuries and operations;

management information systems make it possible to automate many administrative processes in healthcare institutions, such as scheduling appointments, maintaining patient records, and managing medication inventories;

educational platforms provide physicians and other healthcare professionals with access to the latest scientific research and technology, as well as continuing education and retraining programs;

mobile applications for patients allow them to monitor their health, make appointments with doctors, receive notifications about appointments, and monitor compliance with doctor's recommendations;

biometric technologies are used to identify patients and protect sensitive medical information. For example, fingerprint or iris scanning can replace traditional passwords and access cards;

blockchain can be used to securely store and exchange medical data between different institutions and specialists. This ensures the integrity and confidentiality of the information.

F. Benefits of an Intelligent Ecosystem

Improving the quality of health care. With access to a complete medical history and modern diagnostic technologies, doctors can make more accurate diagnoses and prescribe effective treatment.

Increasing the availability of medical services. Remote consultations and telemedicine make medical care accessible to residents of all regions of the country, regardless of their place of residence.

Cost reduction. Automation of administrative processes and the use of modern technologies allow to reduce the costs of maintaining medical institutions and increase their efficiency.

Personalized treatment. Big data analysis and the use of artificial intelligence allow us to select individual treatment regimens, which increases their effectiveness and reduces the risk of side effects.

Security and privacy. The use of biometrics and blockchain ensures the protection of personal medical information and prevents unauthorized access to data.

G. Challenges and Prospects

Despite significant progress in developing the intellectual ecosystem of digital healthcare in Belarus, certain challenges remain:

Technical and infrastructure limitations. Some regions of the country may lack the necessary infrastructure for the full functioning of digital services, such as broadband Internet and modern telecommunications networks.

Staffing shortages: Insufficient numbers of qualified IT professionals and healthcare workers with the necessary digital skills may slow down the pace of innovation.

Regulatory barriers: Difficulties with regulation and standardization of digital health services may hinder the rapid development of the ecosystem.

However, despite these difficulties, the future looks very promising. The Government of the Republic of Belarus is actively investing in the development of digital healthcare, creating conditions for the introduction of new technologies and improving the quality of medical care for the population.

The metasystem will be a domain knowledge base and a multi-agent intelligent system. Multi-agent systems are AI platforms that include several independent and interactive agents capable of solving various problems. The role of agents can be played by AI models, software, robots, and much more. Their joint use will allow solving complex problems, while conventional AI is focused on creating agents for specific use cases.

The metasystem will allow to implement:

- providing an intelligent natural language interface with users;
- automation of the execution of requests from users and, above all, healthcare organizers with logical and semantic verification of correctness;
- intelligent integration of applied medical systems;
- intellectual support for the implementation of scientific research, including in the field of healthcare organization;
- formation of subject knowledge bases for specific sections and subsections of medicine and the use of these bases for training industry specialists, testing knowledge and checking the correctness of texts;
- intellectual support for making management decisions at different levels of management;
- intellectual support for making medical decisions in practical medicine, including telediagnostics and teleconsultation modes;
- functions of a universal natural language reference system for doctors and patients with role differentiation;
- intelligent forecasting of processes based on various logical and mathematical models, including statistical ones.

Conclusion

For the successful implementation of AI in healthcare, it is necessary to take a systematic approach to solving emerging problems. The most important tasks are to eliminate technological and regulatory contradictions in the implementation of AI in practice, for this it is necessary:

- develop high-level regulatory legal acts in the field of digital development, including the use of AI technologies in the country's healthcare;
- develop a conceptual framework in the field of application of artificial intelligence in healthcare;
- prepare draft regulatory legal documents in the field of application of artificial intelligence in healthcare.

The implementation of AI in practice requires not only technical preparation, but also a detailed approach to issues of legality, ethics and readiness for change on the part of all participants in the process.

References

[1] Mageramov, G. "On the General Principles of Building an Algorithm for the Creative Process," 1973. Available at: https://triz-summit.ru/triz/metod/science/203865/.

[2] Altshuller, G. S., Vertkin, I. M. How to Become a Genius: The Life Strategy of a Creative Personality. Minsk: Belarus, 1994. 479 p.

[3] Altshuller, G. S., Shapiro, R. B. On the Psychology of Inventive Creativity. Voprosy psikhologii [Questions of Psychology], No. 6, 1956, pp. 37-49. Available at: https://www.altshuller.ru/triz/triz0.asp.

[4] Altshuller, G. S. Creativity as an Exact Science. The Theory of Inventive Problem Solving. Moscow: Sov. Radio, 1979. 184 p. Cybernetics (pp. 113-127).

[5] Altshuller, G. Finding an Idea. Introduction to the Theory of Inventive Problem Solving. Novosibirsk: Nauka, 1991.

[6] Altshuller, G. S., Zlotin, B. L., Zusman, A. V., Filatov, V. I. Search for New Ideas: From Inspiration to Technology. Kishinev: Kartya Moldovenyaske, 1989.

[7] Salamatov, Yu. P. Laws of Development of Technical Systems (Fundamentals of the Theory of Development of Technical Systems). In Shans na priklyuchenie [Chance for Adventure], Petrozavodsk: Karelia Publishing House, 1991, pp. 5-174.

[8] Lyubomirsky, A. L., Litvin, S. S. Laws of Development of Technical Systems, February 2003. Available at: http://www.metodolog.ru/00767/00767.html.

[9] Likholetov, V. V. The Theory of Inventive Problem Solving: A Textbook. V.V. Likholetov, B.V. Shmakov. Chelyabinsk: Publishing Center of South Ural State University, 2009. 174 p.

[10] Council of Ministers of the Republic of Belarus. Resolution No. 280 of April 21, 2023, "On Measures for the Implementation of Decree No. 136 of the President of the Republic of Belarus of April 7, 2022".

УСЛОВИЯ ПРАКТИЧЕСКОГО ПРИМЕНЕНИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ЗДРАВООХРАНЕНИИ

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Развитие технологий искусственного интеллекта (ИИ) и внедрение их в различных отраслях и сферах жизнедеятельности человека стало одним из ключевых современных трендов, не исключением является и медицинская сфера. В статье рассматриваются условия практического применения ИИ в здравоохранении, выделяются основные этапы внедрения технологий, а также анализируются основные вызовы, возникающие при реализации таких проектов. Авторы статьи подчеркивают важность системного подхода, включающего анализ текущего состояния, постановку целей и задач, организацию команд, коммуникацию и мониторинг, а также пилотирование и апробацию решений. Рассмотрены также базовые аспекты, связанные с законодательной базой, экономической эффективностью и подготовкой персонала для успешной реализации проектов в здравоохранении.

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