ARTIFICIAL INTELLIGENCE IN MEDICAL DIAGNOSTICS

ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ В МЕДИЦИНСКОЙ ДИАГНОСТИКЕ

TIBBIY DIAGNOSTIKADA SUN'IY INTELTEKT

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Abstract: *The paper discusses the prospects for the use of artificial intelligence technologies in healthcare, medical diagnostics and treatment to improve the quality and reliability of patient treatment. Artificial intelligence as a separate science of information technology is also developing in the field of grain storage and is used in various fields of medicine. The use of artificial intelligence in medical information systems is provided with a specially compiled database of problematic situations and their signs for each specific area of medicine, as well as a knowledge base on the corresponding medical action. The paper considers a class of intelligent systems that solve the information problem of recognition and monitoring, presents a system focused on solving the problem of recognizing an emergency condition upon presentation of signs of diseases, which should be understood as anamnestic, clinical and laboratory manifestations. The use of artificial intelligence in the diagnostic process will increase the reliability of diagnostic support and increase the reliability of clinical diagnostics in diagnostic decision support systems.*

Key words: *healthcare, medicine, artificial intelligence, medical information systems, database, knowledge base.*

Аннотация: *В статье рассматриваются перспективы использования технологий искусственного интеллекта в здравоохранении, медицинской диагностике и лечении для повышения качества и надежности лечения пациентов. Искусственный интеллект как отдельная наука информационных технологий также развивается в сфере хранения зерна и применяется в различных областях медицины. Использование искусственного интеллекта в медицинских информационных системах обеспечивается специально составленной базой данных проблемных ситуаций и их признаков по каждой конкретной области медицины, а также базой знаний по соответствующему медицинскому действию. В работе рассмотрен класс интеллектуальных систем, решающих информационную задачу распознавания и мониторинга, представлена система, ориентированная на решение задачи распознавания неотложного состояния при предъявлении признаков заболеваний, под которыми следует понимать анамнестические, клинико-лабораторные проявления. Использование искусственного интеллекта в диагностическом процессе повысит надежность диагностического обеспечения и повысит надежность клинической диагностики в диагностических системах поддержки принятия решений.*

Ключевые слова: *здравоохранение, медицина, искусственный интеллект, медицинские информационные системы, база данных, база знаний.*

Annotatsiya: *Maqolada sun'iy intellekt texnologiyalaridan sog'liqni saqlash, tibbiy diagnostika va davolashda bemorlarga xizmat ko'rsatish sifati va ishonchliligini oshirish uchun foydalanish istiqbollari muhokama qilinadi. Sun'iy intellekt axborot texnologiyalarining alohida fani sifatida tibbiyotning turli sohalarida qo'llaniladi hamda qishloq xo'jaligi sohasida ham rivojlanmoqda. Tibbiy axborot tizimlarida sun'iy intellektdan foydalanish tibbiyotning har bir aniq* *sohasi uchun muammoli vaziyatlar va ularning belgilarining maxsus tuzilgan ma'lumotlar bazasi, shuningdek, tegishli tibbiy harakatlar bo'yicha bilimlar bazasi bilan ta'minlanadi. Maqolada aniqlash va monitoring qilishning axborot muammosini hal qiladigan aqlli tizimlar sinfi ko'rib chiqiladi, anamnestik, klinik va laboratoriya ko'rinishlari sifatida tushunilishi kerak bo'lgan kasallik belgilari paydo bo'lganda favqulodda holatni tan olish muammosini hal qilishga qaratilgan tizim taqdim etiladi. Diagnostika jarayonida sun'iy intellektdan foydalanish diagnostik yordamning ishonchliligini oshiradi va diagnostika qarorlarini qo'llab-quvvatlash tizimlarida klinik diagnostika ishonchliligini oshiradi.*

Kalit so'zlar: *sog'liqni saqlash, tibbiyot, sun'iy intellekt, tibbiy axborot tizimlari, ma'lumotlar bazasi, bilimlar bazasi.*

Recently, there has been an increasing interest in artificial intelligence, caused by increased requirements for information systems. We are steadily moving towards a new information revolution, comparable in scale to the development of the global set, whose name is artificial intelligence.

Artificial Intelligence (AI) is a field of research that aims to study and model the principles and mechanisms of human intellectual activity. AI as a science is located at the intersection of computer science, linguistics, psychology and philosophy. In addition, specific specialized knowledge from the relevant field is also used in the areas of AI application, such as natural sciences, law, economics, and medicine.

The idea of creating an artificial human likeness to solve complex problems and simulate the human mind has been in the air since ancient times. For the first time, the idea of creating an artificial human likeness was expressed by R. Lully (c. 1235-c. 1315), who in the XIV century tried to create a machine for solving various problems based on the universal classification of concepts [9].

In the eighteenth century, G. Leibniz (1646-1716) and R. Descartes (1596-1650) independently developed this idea by proposing universal classification languages for all sciences. These ideas formed the basis of theoretical developments in the field of creating artificial intelligence. The birth of artificial intelligence as a scientific field occurred only after the creation of computers in the 40s of the XX century. At the same time, Norbert Wiener created his seminal works on the new science of cybernetics.

The term artificial intelligence was proposed in 1956 at a seminar with the same name at Stanford University (USA). The seminar was devoted to the development of logical, not computational problems. Thus, research in the field of artificial intelligence is focused on the development and implementation of computer programs that can emulate those areas of human activity that require thinking, a certain skill and accumulated experience. These include tasks of decision-making, pattern recognition, and understanding human language.

Researchers working in the field of AI have found that they are grappling with very complex problems that go far beyond traditional computer science. It turned out, that primary it is necessary to understand the mechanisms of the learning process, the nature of language and sensory perception. It turned out that to create machines that mimic the work of the human brain, you need to understand how billions of its interconnected neurons work. Most of the researchers came to the conclusion that perhaps the most difficult problem facing modern science is to understand the processes of functioning of the human mind and not just imitate its work, which directly affected the fundamental theoretical problems of psychological science.

Indeed, it is difficult for scientists to even come to a single point of view regarding the very subject of their research - intelligence. **Some** believe that intelligence is *the ability to solve complex problems*; **others** consider it as *the ability to learn, generalize and analogize;* **still others** - as *the ability to interact with the outside world* through communication, perception and awareness of what is perceived.

Nevertheless, many AI researchers are inclined to accept the machine intelligence test proposed in the early 50s by the outstanding English mathematician and computer scientist Alan Turing. A computer can be considered intelligent, Turing argued, if it can make us believe that we are not dealing with a machine, but with a person.

However, it was only after the Second World War that devices appeared that seemed to be suitable for achieving the cherished goal of modeling intelligent behavior; these were electronic digital computers. The "electronic brain," as the computer was then enthusiastically called, startled US television viewers in 1952 by accurately predicting the results of the presidential election hours before the final data was received. This" feat " of the computer only confirmed the conclusion that many scientists came to at that time: the day will come when automatic computers, so quickly, tirelessly and accurately performing automatic actions, will be able to imitate non-computational processes inherent in human thinking, including perception and learning, pattern recognition, understanding everyday speech, etc. letters, making decisions in uncertain situations when not all the facts are known. This is how a kind of "social order" for the development of AI systems was formed "in absentia" [1-4].

Currently there are six main areas of AI research:

- knowledge representation;
- manipulation of knowledge and search for solutions;
- communication systems;
- perception systems.
- machine learning;
- modeling intelligent behavior.

The emergence of AI as a scientific field is associated with an increase in the capabilities of computer technology and increased requirements for the mathematical support of computers. Many scientists consider Arthur Turing as the founder. In 1950 Turing's article “Computing Machinery and Intelligence”(“Mind” English magazine) offers a criterion for whether a machine has thinking abilities (Turing test).

The problem domain of an intelligent system is defined by the subject area and the tasks solved in it. A subject area can be characterized by describing the area in terms of the user, and tasks can be characterized by their type. From the developer's point of view, static and dynamic subject areas are distinguished. A subject area is called static, if the source data describing it does not change over time. In this case, derived data (derived from the original data) can reappear and change (without changing the original data). If the initial data describing the subject area changes during the task solution, then the subject area is called dynamic [6,7,8].

Medical diagnostics refers to the dynamic and clinical diagnosis process is vital; if developers do not understand the diagnostic process correctly, then it is no less likely that they may develop any used software in medical diagnostics. A clinical diagnosis is specialized knowledge that can only be understood correctly with some essential medical knowledge. Doctors study the diagnostic process using knowledge from many medical branches such as human anatomy, medical biochemistry, medical physiology, pathology, microbiology, parasitology, forensic medicine, medicine, epidemiology, surgery, ENT, ophthalmology, pediatrics, radiology, pharmacology, and forensic medicine. Ideally, the developer should have some knowledge in these medical industries. Although there are many defined principles and guidelines for medical diagnosis, the diagnostic process is still seen as an art form that can only be learned through medical knowledge and experience. Doctors' help in the development process is very important. Choice of clinical situations, if you want to develop a clinical diagnostic system that solves all medical diagnostic processes (for example, requesting a patient, examining a patient, taking ultrasound images, X-rays and processing them, and so on), you will probably never need to release a product until you have an infinite number of resources [11, 12, 17].

Choosing a clinical area is very important. Selecting a small area results in developing a small tool; while selecting a very large clinical area and domain will be difficult to develop and require a huge amount of resources and decades of human life. Commercial suppliers should analyze the commercial value of the product. At the moment, clinical diagnosis support systems are not very successful in the commercial software market. Even if it is most major clinical trials are supported[5].

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The analysis of modern literature has shown that currently, there is experience in creating technologies and designing, and creating expert systems (ES), including systems related to solving problems of medical and technical diagnostics. Goodall A. states, that in a typical ES, approximately 70% of the time is spent on developing the interface, which takes up an average of 44% of the code, while the logical output machine takes up 8% of the code, the knowledge base 22%. The reasons for these are the presence of a large number of domain concepts that characterize the initial data of the problem, as well as the joint design of the interface with the knowledge base and the output machine [10]. A typical ideal ES should have the following basic properties: competence; the ability to reason; the ability to solve non-trivial unformalized problems from real subject areas; the ability to self-awareness.

The architecture of a typical expert system includes the following main components: a knowledge base (KB); database (DB); a goal base; a working memory or working knowledge base; a decision inference subsystem; intelligent interface subsystem; a support and debugging subsystem; a digital modeling subsystem; a decision explanation subsystem; and a coordination and management subsystem.

The main task of intelligent systems is knowledge processing. Most often, intelligent systems are used to solve complex problems, where the main complexity of the solution is associated with the use of poorly formalized knowledge of practitioners, and where logical (or semantic) information processing prevails over computational. For example, understanding natural language, analyzing visual information, supporting decision-making in difficult situations, making a diagnosis, and making recommendations on treatment methods [9, 11, 12, 18, 20, 21].

The question of what should be the formal model of knowledge representation in an intelligent system is not fully resolved. For example, the created "empty" ES, which initially contained well-known methods (frames, products, or semantic networks) for representing knowledge and the reasoning mechanism, were not effective and not so convenient in software implementations. Studies have shown that each problem area should have its own rigid definition of the model of knowledge representation and the method of obtaining a solution. Knowledge representation models deal with information received from experts, which is often qualitative and often contradictory. However, due to the specific functioning of the computer, such information should be reduced to an unambiguous formalized form. Knowledge representation as a methodology for modeling and formalizing conceptual knowledge, focused on computer processing, is one of the main and most important topics related to knowledge engineering.

One of the most important problems is the problem of knowledge representation. This is explained by the fact that the form of knowledge representation has a significant impact on the characteristics and properties of the system. In the natural and technical sciences, the following traditional way of presenting knowledge is adopted. In natural language, the basic concepts and relations between them are introduced. In this case, previously defined concepts and relationships are used, the meaning of which is already known. Next, a correspondence is established between the characteristics (most often quantitative) of the concepts of knowledge and the appropriate mathematical model.

Knowledge may not always be described accurately - so-called "fuzzy" knowledge is often encountered. When trying to formalize human knowledge, researchers soon encountered a problem that made it difficult to use traditional mathematical tools to describe it. There is a whole class of descriptions that use qualitative characteristics of objects: many, few, strong, very strong, and so on. These characteristics are usually vague and cannot be clearly interpreted, but they contain important information, such as" One possible sign of tick-borne encephalitis is a high temperature.

In addition, problems solved by intelligent systems often involve using inaccurate knowledge that cannot be interpreted as completely true or false. There is knowledge, the reliability of which is expressed by some intermediate figure.

To represent fuzzy knowledge in the early 70s, the American mathematician Lofty Zadeh proposed the formal apparatus of fuzzy algebra and fuzzy logic (L. A. Zadeh, Fuzzy Sets, Information and Control). L. Zadeh's theory is based on a subjective fact - subjective ideas about the goal are

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always fuzzy. But he also takes the next step-he believes that all the subject's estimates and constraints that he works with are also usually fuzzy, and sometimes even devoid of quantitative characteristics in their initial form. L. Zadeh introduced one of the main concepts in fuzzy logic - the concept of a linguistic variable. A linguistic variable is a variable whose value is determined by a set of verbal characteristics of a certain property. For example, the linguistic variable " pain" is defined as a set (ear, cutting, aching, shooting, sharp, blunt, burning). There are many different ways to perform operations with fuzzy knowledge expressed using linguistic variables. These methods are mostly heuristics. Strengthening or weakening of linguistic concepts is achieved by introducing special quantifiers. For inference on fuzzy sets, special relations and operations on them are used. One of them is Approximate Theory.

The theory of approximate reasoning was created by Lofty Zadeh in 1979. This theory provides a powerful tool for implementing logical inference with fuzzy and uncertain information. The central idea of this theory is to represent logical statements in the form of statements that assign fuzzy sets to variables as values [9].

Despite the above studies, most of the clinical cases still rely on manual clinical diagnosis. Manual clinical diagnosis is a very complex, cumbersome and error-prone process; even very experienced doctors are sometimes unable to correctly diagnose a clinical condition at an early stage. The purpose of this paper is to investigate software support for automating diagnostic decision-making in medical information systems for healthcare and medicine, and an algorithm-based approach that can improve clinical systems support diagnostic decision-making, also examines the diagnostic process, clinical reliability support for diagnostic decision-making system software, and explores and suggests a new path the development will improve and increase the reliability of clinical diagnostics in system support of diagnostic decision-making.

At the initial stage of intellectualization of medical information systems (MIS), we, together with experienced doctors in the relevant fields of medicine, created and implemented in clinical practice a system for intellectual support of the doctor during the examination of patients, similar to [19], but for urgent pathologies. At the same time, we have developed BZS of this system for the areas of emergency abdominal surgery and emergency medicine that operate in a multidisciplinary hospital.

Taking into account the fact that в timely and prompt identification (forecasting)is of paramount importance in emergency medicine- life-threatening emergency condition-problem situation (PS), as well as taking adequate emergency measures to eliminate them, we have developed methods, algorithms and software for automatic detection of PS in the patient's body from the data of his electronic medical history (EIB), as well as the implementation of intellectual support for medical services in the next stage of the MIS intellectualization process solutions to get out of this situation. Naturally, such situations have different natures in different pathological conditions of organs and the body as a whole and require appropriate adequate approaches to their elimination.

Such developments are relevant and necessary especially for the fields of medicine, where the elements of subjectivity are very significant, and the responsibility for making decisions is great, which is typical, in particular, for surgery, especially for emergency abdominal surgery.

The paper considers a class of intelligent systems that solve the information problem of recognizing, monitoring a problem situation, and selecting the level of assistance from available resources that would ensure the minimum probability of realizing a threatening state. And in the work [11], a system is presented that is focused on solving the problem of recognizing an emergency condition in children in terms of a syndrome or several syndromes (characterizing their conditions, which reflect the degree of severity of the syndrome) when presenting signs of diseases, which should be understood as anamnestic, clinical and laboratory manifestations. In the most general case, the intellectualization of decision - making processes involves providing existing medical information systems with the following additional capabilities:

- planning a chain of events from the current state of the patient to the desired result (recovery) for a given treatment program;

- assessment of information on the degree of materiality and their corresponding sorting under the specified criteria for selecting information;
- search for medical solutions in the context of incomplete and unclear information, using the specified "heuristics" and the experience of subject area experts.

As a result of the operation of the smart module, three types of situations can be identified:

- the first type of situation, when there is an objective need for urgent adoption of an appropriate specific medical decision, taking into account the patient's condition;
- the second type of situation, when it is predicted that some medical decision will need to be made urgently in order to prevent the occurrence of the first type of situation in the future;
- the third type of situation is when there is no need to make a medical decision, and the doctor simply takes note of the results of the analysis of information.

If the first two types of situations can be formalized in order to automatically detect such situations and develop a certain set of optimal medical decisions, then the third type of situations is difficult to formalize, since the doctor is not required to make any decision.

To detect PS, the existing medical information system must be supplemented with a subsystem with the following modules:

- modules for entering and correcting signs of PS, as well as corresponding sets of medical decisions;
- PS detection module;
- a module for selecting a set of optimal medical decisions and, in some cases, making (executing) these decisions;
- module for evaluating the effectiveness of decisions made;
- a module for maintaining a history for each specific PS, and if necessary, use it in the future when making a decision.

The functioning of the support system is provided by a specially compiled database of problem situations and their signs, for each specific field of medicine, as well as a knowledge base on relevant medical actions. The main task in building the system of intellectualization of MIS, of course, is to create a database containing information about the relationship of signs of the patient's body with certain problem situations [13-17].

When creating the database and BZ of the system developed by us, we used the features of the clinical picture in various PS identified as a result of analyzing the medical history of 388 patients operated on in the emergency department of abdominal Surgery of the Ferghana branch of the Republican Center for Emergency Medical Care in the period 2007-2012. They present the identified PS and their relationship with various signs of the body's condition. Out of 388 patients with abdominal acute surgical diseases that threaten the patient's life, PS occurred in 76, including 65, associated with the development of various complications of the underlying disease, such as acute diffuse purulent peritonitis, bleeding, post-hemorrhagic or post-traumatic shock, hypovolemic shock, acute cardiovascular, respiratory failure, liver failure, etc. 11 patients with life-threatening PS developed non-underlying pathologies associated with anaphylactic shock or concomitant pathologies such as CHD, diabetes mellitus, chronic non-specific lung disease, etc. In 37 patients with PS, a life-threatening condition of the patient occurred preoperatively, 38 patients in the postoperative period. The number of signs in the form of precursors of PS was 96, reliable signs including complaints of patients, objective data and results of instrumental and laboratory studies were 502. The clinical manifestation of life-threatening PS in the patient was characterized mainly by a sharp drop in blood pressure, cardiac arrhythmia, tachycardia, bradycardia, respiratory arrhythmia, convulsive state, loss of consciousness, hyperthermia, hypovolemia and also a corresponding change in laboratory criteria.

In the process of functioning of the subsystem "Intellectualization of medical decisions", the main source of primary and reference information is the electronic patient history data contained in the MIS. At the same time, the subsystem maintains its own database, where the following data is stored:

- a list of all registered pss in the system;
- signs that can be used to detect PS.
- a set of optimal medical solutions for the resolution of a specific PS;
- criteria that should be used to evaluate the effectiveness of individual solutions to eliminate a specific PS;
- history of medical decisions made for each specific PS.

When entering a new PS into the system, first of all, you must specify the signs by which the PS detection module would be able to recognize this PS. The next step when entering a new PS into the knowledge base is to establish a specific set of medical solutions to eliminate this problem.

To implement the above methodology, algorithms for detecting PS were compiled from the patient's medical history data and a BZ for clinically justified optimal medical actions in these situations was developed. Software has been created that implements the functioning of the developed subsystem in the MIS structure. An automated workplace of an expert doctor with a user-friendly interface has been developed, and the previously created doctor's workstation has been supplemented with a special dialog box for the doctor to interact with the system.

With the inclusion of the subsystem "Intellectualization of medical decisions" in the MIS, the technology of solving medical and diagnostic problems is radically changing. If with traditional technology, a doctor starts searching for solutions only after a certain PS occurs and, as a rule, in conditions of an acute shortage of time, then in intelligent information systems, a specialist doctor can form a knowledge base on PS in advance with the help of an expert doctor's workstation developed by us, without haste and thoroughly, and in the future the system itself will monitoring the occurrence of PS and the search for acceptable medical solutions [5]. At the same time, a problem entered into the knowledge base can be solved repeatedly as it occurs. Moreover, taking into account the results of previous solutions, the system gradually becomes not only more experienced, but even "smart" with the expansion of the knowledge base.

This approach to the intellectualization of medical decision-making processes makes it possible to make significant changes in the technology of developing intelligent systems to support the doctor's activities. Now it is enough for developers to create tools that allow a specialist from any field of clinical medicine-an expert-to create and maintain their own database and knowledge on PS. And, finally, following the famous thesis that it is necessary to give the machine-the machine, the person-the human, the proposed intelligent information system provides for an optimal distribution of responsibilities in the decision-making process between the system and the doctor. Medical specialists form databases of data and knowledge in their field and make the final decision, and the system will do all the other complex computational, analytical and logical work. The main advantages of the proposed approach to intellectualization of medical decision-making processes are:

- development of a single tool for solving many non-standard problems in various areas of medicine;
- during the operation of information systems, self-learning of the system with the replenishment of the knowledge base also takes place;
- flexibility in solving problems by combining ready-made and proven medical solutions;
- the implementation of the intellectualization module does not require stopping or redesigning the existing information system.

Thus, the "intelligent support" system developed by us, which contains two databases and KB and two software blocks, using clinical information from the MIS patient's electronic medical history database, provides prediction and recognition of problematic situations in the patient's body, in particular with abdominal emergency surgical pathology, and contributes to making effective medical decisions to eliminate them or prevention.

The experience of recent years has shown that applying one method to solve complex problems and problems does not always lead to success. In a hybrid architecture that combines multiple paradigms, the effectiveness of one approach can compensate for the weakness of the other. By combining different approaches, you can avoid the disadvantages inherent in each of them individually. Therefore, one of the leading trends in modern computer science is the development of integrated, hybrid and synergistic systems. Such systems consist of various elements (components) combined to achieve their goals. Integration and hybridization of various methods and technologies allows you to solve complex problems that cannot be solved on the basis of any individual methods or technologies.

References

1. Минаев Ю.Л., Головинова В.Ю., Панин П.Ф. и др. Практическая медицинская деятельность и искусственный интеллект // Известия Самарского научного центра Российской академии наук, т. 12, №1(6), 2010
2. Carlo Combi, Yuval Shahar, Ameen Abu-Hanna (2009) Artificial Intelligence in Medicine (Lecture Notes in Computer Science): Springer. [This book constitutes the refereed proceedings of the 11th Conference on Artificial Intelligence in Medicine in Europe, AIME 2007]
3. Paul Taylor (2006) From Patient Data to Medical Knowledge: The Principles and Practice of Health Informatics: WileyBlackwell. [This book provides information regarding IT is transforming the way we think about medicine and medical research]
4. Гильфанов Н.М. Медицинские аспекты разработки искусственного интеллекта Кыргызско-Российский (Славянский) Университет Медицинский факультет Студенческая конференция-1999.
5. Комарцова Л.Г., Кадников Д.С. Сравнительный анализ генетических алгоритмов поиска оптимального решения МГТУ им. Н.Э. Баумана 2010 г.
6. Попов Э.В. и др. Искусственный интеллект. Т.1. – М.: Радио и связь, 1990.
7. Нильсон Н. Искусственный интеллект: Пер. с англ. -М.: Мир, 1973.
8. Адаменко А.Н., Кучуков А.М. Логическое программирование и Visual Prolog. – СПб: БХВ-Петербург, 2003
9. Лапина А.В Интеллектуальные информационные системы // Учебное пособие Россия 2014 г. 204 с.
10. Нурматов А.А. «Программное и математическое обеспечение экспертной системы дифференциальной диагностики» 05.13.11-Математическое и программное обеспечение вычислительных машин, комплексов и компьютерных сетей. Диссертация на соискание учёной степени кандидата технических наук.
11. Abdumanonov A.A. Intellectualization of medical information systems/ XXIII Международная научно-практическая конференция Современные проблемы гуманитарных и естественных наук. Россия. 2015 г. 28-30 с.
12. Абдуманонов А.А., Карабаев М., Махмудов Н.И. Об интеллектуализации медицинских информационных систем // Modern informatization problems in modeling and social technologies Proceedings of the XVIII-th International Open Science Conference (Lorman, MS, USA, January 2013), 244-250с.
13. Abdumanonov A.A., Abdumo'minov A.A. Technologies for electronic generation of medical records in medical information systems // Academicia An International Multidisciplinary Research Journal ISSN: 2249-7137 Vol. 11, Issue 5, May 2021 Impact Factor: SJIF 2021 = 7.492 - 1227-1242 p. DOI: 10.5958/2249-7137.2021.01541.X
14. Abdumanonov A.A., Xalilov D.A., Jumaboyeva N. Research of methods of application of neuroinformation networks in medicine // Scientific ideas of young scientists Pomysly naukowe mlodych naukowcow International scientific and practical conferences January, 2021 Warsaw, Poland 53p.

15. Абдуманонов А.А. Касалликларни ташхислашда билимларни шаклланитиришни продукцион модели // Фарғона политехника институти илмий – техника журнали 2020. Том 24. № 3, -60-68 б.
16. Abdumanonov A.A., Zokirov S.I. Kasalliklarni tashxislash qarorlarini qabul qilish tizimlarida neyron tarmoqlarni o‘qitish algoritmlari // Scientific-technical journal (STJ FerPI, ФарПИ ИТЖ, НТЖ ФерПИ, 2022, спец.выпуск №3), 49-57 b.
17. Абдуманнонов А.А., Карабаев М.К., Хошимов В.Г. Информационно-коммуникационные технологии для создания единого информационного пространства лечебных учреждений //Врач и информационные технологии. – 2012. – №. 1. – С. 75-78.
18. Ферsucc В.М., Латкин А.П., Иванова В.Н. Современные подходы к использованию искусственного интеллекта в медицине // Территория новых возможностей. Вестник Владивостокского государственного университета экономики и сервиса. 2020. Т. 12, № 1. С. 121-130.
19. Черненко О.В., Лакман И.А., Шкель О.А., Падукова А.А., Нафиков Ш.Р., Шабанова К.И. Применение алгоритмов искусственного интеллекта для оценки эффективности терапии, назначаемой диализным пациентам // J. Healthcare management: news, views, education. Bulletin of VSHOUZ Том 7, № 2 (24), 2021 -с. 103-113.
20. Алексеева М.Г., Алексеева М.Г., Зубов А.И., Новиков М.Ю. Искусственный интеллект в медицине // Журнал. - 2022. - №7 (121), -с.10-14, - doi: 10.23670/IRJ.2022.121.7.038
21. Комков А.А., Мазаев В.П., Рязанова С.В., Самочатов Д.Н., Базаева Е.В. Основные направления развития искусственного интеллекта в медицине // Научное обозрение. Медицинские науки. – 2020. – № 5 – С. 33-40.