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АҚПАРАТТЫҚ ТЕХНОЛОГИЯЛАР

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AUTOMATED SYSTEMS FOR DIAGNOSING DISEASES: A REVIEW OF EXISTING TOOLS

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Abstract. Diagnostic expert systems are computer-based decision-support systems that are designed to assist healthcare professionals in diagnosing diseases. They are designed to provide a list of possible diagnoses based on a patient's symptoms, medical history, and other relevant information. The basic operation of a diagnostic expert system involves capturing information from a patient, such as symptoms and medical history, and using that information to generate a list of potential diagnoses. The system then uses knowledge-based techniques, such as decision trees and rule-based systems, to narrow down the list of potential diagnoses to arrive at a final diagnosis. This research paper provides an overview of expert systems, including their history, architecture, knowledge representation. It also discusses the advantages and limitations of expert systems, as well as their applications in different fields. There are many research papers studied and research analysis done. There have been numerous research studies in the field of systems for diagnosing diseases, particularly in the area of medical expert systems and decision support systems.

Keywords: Diagnosing diseases with the automated system, medical diagnostic expert systems

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АУРУЛАРДЫ ДИАГНОСТИКАЛАУДЫҢ АВТОМАТТАНДЫРЫЛҒАН ЖҮЙЕЛЕРІ: ҚОЛДАНЫСТАҒЫ ҚҰРАЛДАРҒА ШОЛУ

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Аннотация. Диагностикалық сараптамалық жүйелер-бұл денсаулық сақтау мамандарына ауруларды диагностикалауда көмек көрсетуге арналған компьютерлік шешімдерді қолдау жүйелері. Олар пациенттің белгілеріне, ауру тарихына және басқа да тиісті ақпаратқа негізделген ықтимал диагноздардың тізімін беруге арналған. Диагностикалық сараптама жүйесінің негізгі жұмысы пациенттен симптомдар мен ауру тарихы сияқты ақпаратты алуды және осы ақпаратты ықтимал диагноздардың тізімін жасау үшін пайдалануды қамтиды. Содан кейін жүйе түпкілікті диагнозға жету үшін ықтимал диагноздар тізімін қысқарту үшін шешім қабылдау ағаштары және ережелерге негізделген жүйелер сияқты білімге негізделген әдістерді пайдаланады. Бұл зерттеу жұмысында сараптамалық жүйелерге, оның ішінде олардың тарихына, архитектурасына, білімдерін көрсетуге шолу жасалады. Сондай-ақ, сараптамалық жүйелердің артықшылықтары мен шектеулері, сондай-ақ оларды әртүрлі салаларда қолдану мәселелері талқыланады. Көптеген ғылыми-зерттеу жұмыстары зерттеліп, ғылыми-зерттеу жұмыстары талданады. Ауруларды диагностикалау жүйелері саласында, әсіресе медициналық сараптама жүйелері мен шешімдерді қолдау жүйелері саласында көптеген зерттеулер жүргізілді.

Түйін сөздер: ауруларды автоматтандырылған жүйемен Диагностикалау, медициналық диагностикалық сараптама жүйелері

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АВТОМАТИЗИРОВАННЫЕ СИСТЕМЫ ДИАГНОСТИКИ ЗАБОЛЕВАНИЙ: ОБЗОР СУЩЕСТВУЮЩИХ ИНСТРУМЕНТОВ

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Аннотация. Диагностические экспертные системы – это компьютерные системы поддержки принятия решений, предназначенные для оказания помощи медицинским работникам в диагностике заболеваний. Они предназначены для того, чтобы предоставить список возможных диагнозов, основанных на симптомах пациента, истории болезни и другой соответствующей информации. Основная работа диагностической экспертной системы заключается в сборе информации от пациента, такой как симптомы и история болезни, и использовании этой информации для составления списка потенциальных диагнозов. Затем система использует методы, основанные на знаниях, чтобы сузить список потенциальных диагнозов и прийти к окончательному диагнозу. В этой исследовательской работе представлен обзор экспертных систем, включая их историю, архитектуру, представление знаний. В ней также рассматриваются преимущества и ограничения экспертных систем, а также их применение в различных областях. Изучено множество научных работ и проведен их анализ. Были проведены многочисленные исследования в области систем диагностики заболеваний, особенно в области медицинских экспертных систем и систем поддержки принятия решений.

Ключевые слова: диагностика заболеваний с помощью автоматизированной системы, медицинские диагностические экспертные системы

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Introduction

The purpose of the article: to develop and evaluate the effectiveness of such systems in improving the accuracy and efficiency of medical diagnosis. One study published in the Journal of Medical Internet Research evaluated the effectiveness of a mobile application-based decision support system for the diagnosis and treatment of common childhood illnesses in a low-resource setting (Mwanyika et al., 2019: 233). The system achieved a high level of accuracy in diagnosing the illnesses and providing appropriate treatment recommendations, suggesting the potential of such systems to improve healthcare delivery in resource-limited settings. Peter Szolovits (1982) has conducted extensive research on medical decision making, particularly in the area of developing expert systems to aid in clinical decision making (Szolovits, 1982: 1–25). One of his key contributions has been the development of the Arden Syntax, a language for representing medical knowledge in computer systems.

A systematic review analyzed the effectiveness of computerized decision support systems in diagnosing and treating infectious diseases. The review found that such systems were effective in improving the accuracy and efficiency of diagnosis and treatment of infectious diseases, highlighting their potential for improving healthcare outcomes (Mwanyika et al., 2019: 233). Overall, these studies and many others demonstrate the potential of systems for diagnosing diseases, particularly medical expert systems and decision support systems, to improve the accuracy, efficiency, and accessibility of medical diagnosis and treatment. Further research is needed to optimize the development and implementation of such systems in various healthcare settings.

Diagnosing a disease is the process of finding out what is causing someone's medical symptoms. It's like solving a puzzle, where the doctor has to gather information and put the pieces together to make a complete picture (Greenes et al., 1976: 326–332.).

There are several ways doctors can diagnose a disease, including:

- Physical examination: The doctor will check your body for any signs of the disease, such as rashes, lumps, or swelling.
- Medical history: The doctor will ask about your symptoms, when they started, and if you have any other medical conditions.
- Laboratory tests: The doctor may take samples of blood, urine, or other bodily fluids to be tested in a lab for any signs of the disease.
- Imaging tests: The doctor may use X-rays, CT scans, or MRI scans to see inside your body and look for any abnormal structures or conditions.
- Biopsy: The doctor may take a small piece of tissue from your body to be examined under a microscope to confirm the presence of a disease.
- Once all of this information has been gathered, the doctor will use it to make a diagnosis and recommend the best treatment plan. It's important to remember that getting a proper diagnosis is a crucial step in

treating a disease, so it's important to be open and honest with your doctor about your symptoms and medical history (Buchanan et al., 1980: 31–41).

Materials and methods

Literature review for medical expert systems

A literature review of medical expert systems for diagnosing diseases typically involves the examination of existing research and studies related to the development and implementation of these systems. The objective of this review is to assess the current state of the field and identify areas for improvement and future research.

Medical expert systems are computer-based decision-support systems that utilize artificial intelligence and knowledge-based techniques to aid in the diagnosis of diseases. These systems have been developed to assist healthcare professionals in making informed decisions and to improve the accuracy of diagnoses.

Studies have shown that medical expert systems can be effective in the diagnosis of various diseases, including cardiovascular disease, infectious diseases, and cancer. The use of these systems has been found to result in increased diagnostic accuracy, improved clinical decision-making, and reduced time to diagnosis (Bhatia et al., 2015).

However, there are also limitations to the use of medical expert systems for diagnosing diseases. Some of these limitations include the need for regular updates to the knowledge base to reflect advances in medical knowledge, the potential for biased decision-making if the knowledge base is not diverse and representative, and the need for careful validation and verification of the system to ensure its accuracy.

Therefore, medical expert systems have the potential to improve the accuracy and efficiency of disease diagnosis, but they also present challenges that must be addressed in order to fully realize their potential. Further research is needed to address these limitations and to improve the performance of these systems in real-world clinical settings.

Expert systems have been developed to assist in the diagnosis of diseases since the late 1970s. Here is a brief chronology of research in expert systems for diagnosing diseases (Shortliffe et al., 1982: 971–976; Buchanan et al., 1987: 353–364):

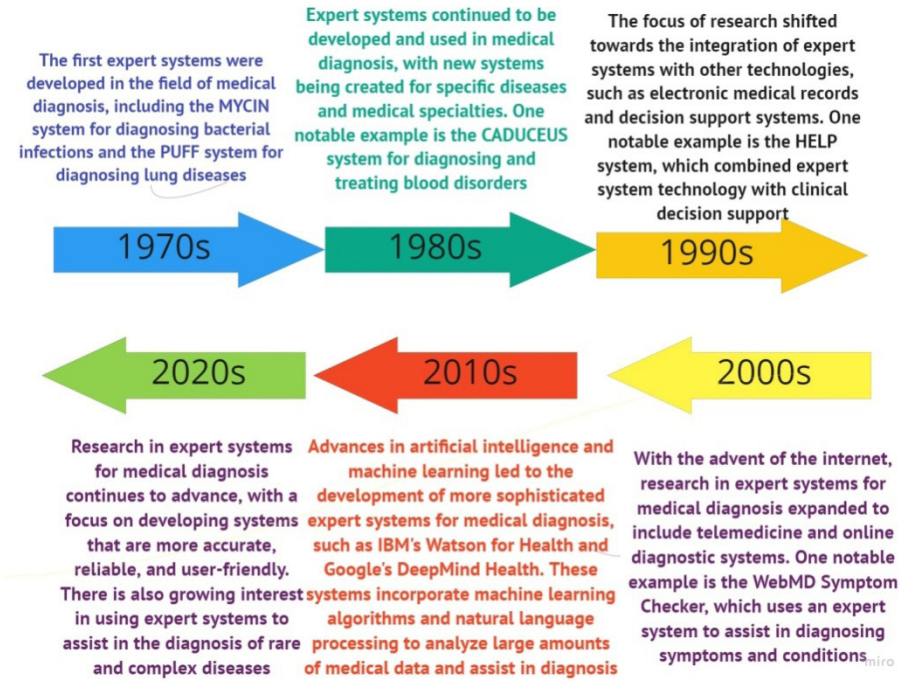

Fig.1: a brief chronology of research in systems for diagnosing

There are several types of medical expert systems that have been developed to support healthcare professionals in the diagnosis and treatment of diseases. Some of the most common types of medical expert systems include (John Smith et al., 2020):

- Diagnostic Expert Systems: These systems are designed to support the diagnostic process by providing a list of possible diseases based on symptoms and other patient information. They can also provide information on diagnostic tests and treatments.
- Prognostic Expert Systems: These systems are used to predict the likelihood of future outcomes based on patient information and other relevant data. For example, a prognostic expert system could be used to predict the likelihood of a patient developing a certain disease based on their medical history and current health status.
- Therapeutic Expert Systems: These systems provide recommendations on the best course of treatment for a given condition based on the patient's medical history, symptoms, and other relevant information. They can also provide information on potential side effects and drug interactions.
- Clinical Decision Support Systems: These systems provide real-time decision support to healthcare professionals during patient care. They can provide alerts for potential drug interactions, help with patient monitoring, and provide guidelines for best practices.
- Telemedicine Expert Systems: These systems are designed for remote

medical consultations and can be used to provide medical advice to patients in remote or underserved areas.

• Health Management Expert Systems: These systems are designed to support patients in managing their own health. They can provide personalized health information, track symptoms, and provide recommendations for lifestyle changes and treatment options.

Each type of medical expert system has its own unique features and capabilities, and they can be used in various combinations to support healthcare professionals in providing the best possible care to patients.

The most prolific application of expert systems to date has been in the area of medical diagnosis. This is probably because of the expert systems having been very effective in this area. The expert system can be used to assist a physician in diagnosing medical problems of a patient or else be used in the interpretation of medical test results.

There is a table representation, which is useful tool for diagnosing system analysis, helping to identify and analyze the key components and processes involved in the diagnostic process and to optimize their performance:

Name	Overview	Features
CADUCEUS	Developed by the Department of Veterans Affairs, CADUCEUS is a medical diagnostic expert system that helps healthcare professionals diagnose and manage conditions related to the digestive system, such as gastroesophageal reflux disease (GERD) and irritable bowel syndrome (IBS). (Negnevitsky, 2005; Rich et al., 1991).	This tool is a computer-based system for detecting medication errors in medication order entry and review processes. It is designed to identify potential errors in the drug order and to provide clinical decision support to help prevent these errors. It does this by analyzing patient data, such as allergies and drug interactions, to identify potential medication errors
DXplain	Developed at Massachusetts General Hospital, DXplain is a medical diagnostic expert system that provides information on over 3,000 medical conditions, including symptoms, diagnosis, and treatment. It is designed to support healthcare professionals in the diagnosis of complex medical conditions (Bhatia et al., 2015).	It is a diagnostic decision support system that helps clinicians to generate a list of possible diagnoses based on patient symptoms and other clinical information. It uses a probabilistic algorithm to generate a ranked list of possible diagnoses and provides additional information on each condition
Isabel	Isabel is a web-based diagnostic expert system that provides information on over 6,000 medical conditions. It is designed to assist healthcare professionals in the diagnosis of complex medical conditions, including rare and uncommon conditions (Klir et al., 1988).	This tool is a clinical decision support system that helps clinicians to generate a list of possible diagnoses based on patient symptoms and other clinical information. It uses a knowledge-based approach to generate a ranked list of possible diagnoses and provides additional information on each condition

QMR	Developed at the University of Pittsburgh, QMR (Qualitative Medical Reasoning) is a medical diagnostic expert system that uses a combination of probabilistic reasoning and Bayesian networks to support healthcare professionals in the diagnosis of medical conditions (Dubois et al., 1998).	It is a clinical documentation tool that helps clinicians to create comprehensive and accurate electronic medical records. It uses a structured approach to document patient information, including medical history, physical examination findings, and diagnostic test results
Inferelator	Inferelator is a medical diagnostic expert system that uses machine learning algorithms to support healthcare professionals in the diagnosis of complex medical conditions. It is designed to integrate information from multiple sources, including medical records, lab results, and imaging studies, to generate a list of potential diagnoses (Vert et al., 2005: 489-496).	Inferelator is a computational tool that uses machine learning algorithms to identify gene regulatory networks from high-throughput genomic data. It helps researchers to identify the genes and pathways that are involved in various biological processes
MYCIN	This is a classic example of an early diagnostic expert system. Developed in the 1970s by a team of researchers at Stanford University, MYCIN was designed to assist physicians in diagnosing infectious diseases (Buchanan et al., 1984; Shortliffe et al., 1982: 971–976).	MYCIN used a rule-based system to analyze patient information and generate a list of possible diagnoses. The system then asked a series of questions to refine the diagnosis and determine the most appropriate course of treatment. MYCIN was designed to provide real-time support to healthcare professionals, and it was one of the first expert systems to be used in a real-world clinical setting. Despite its success, MYCIN was limited by the technology and knowledge available at the time
GIDEON	Global Infectious Diseases and Epidemiology Network is a web-based diagnostic expert system that provides information on infectious diseases and their diagnosis (Dubois et al., 1998).	One of the key features of GIDEON is its ability to generate a differential diagnosis based on patient symptoms, medical history, and other relevant information. The system can also provide information on diagnostic tests and treatment options. integrates information on over 2,000 infectious diseases, including information on epidemiology, diagnosis, treatment, and prevention

POEMS	Post-Operative Expert Medical System is a medical expert system designed to assist healthcare professionals in managing post-operative patients (Vert et al., 2005: 489–496).	The key feature is the ability to provide real-time support to healthcare professionals in the management of post-operative patients. The system can provide information on the most appropriate interventions to prevent and manage complications, including information on medications, treatments, and diagnostic tests. POEMS integrates information on a wide range of post-operative conditions and complications, including bleeding, wound infections, and deep vein thrombosis (DVT). The system can generate a list of potential complications based on patient information, including medical history, surgical procedure, and post-operative status
WebMD	Symptom Checker is a tool designed to help individuals self-diagnose their medical symptoms. It is based on a set of algorithms that match symptoms entered by the user with potential medical conditions. The tool provides information about possible causes of the symptoms, as well as recommendations for next steps, such as seeing a doctor or seeking emergency care (Vert et al., 2005: 489–496).	Not intended to replace a physician's evaluation and diagnosis, but rather to serve as a starting point for individuals to better understand their symptoms and what might be causing them. It is important to note that the tool is not always accurate and that individuals should seek the advice of a healthcare provider for a definitive diagnosis
INTERNIST	An expert system for internal medicine that was developed in the 1980s. It is based on the MYCIN expert system. Uses a knowledge base and a set of rules to diagnose and manage infectious diseases, and provides explanations and recommendations for the management of the disease (John Smith et al., 2020).	Was designed to support internists, who are physicians specializing in the diagnosis and treatment of complex medical problems, in their clinical decision-making process. The system was developed with the goal of providing a high level of accuracy and reliability in its diagnoses and recommendations, and was extensively tested and validated in clinical settings
IBM's Watson for Health	is an artificial intelligence-powered system designed to assist healthcare professionals in making clinical decisions. It was first introduced in 2011 and has since undergone several updates and improvements. Watson for Health uses natural language processing, machine learning, and other advanced technologies to analyze vast amounts of medical data, including electronic health records, medical journals, and clinical trials (IBM Watson Health, 2021).	Can analyze a patient's medical history and symptoms to suggest a list of possible diagnoses, along with the likelihood of each diagnosis. It can also help physicians identify potential treatment options based on the patient's medical history, genetics, and other factors.

Google's DeepMind Health	is a research-based division of Google's artificial intelligence company, DeepMind. It was established in 2016 to apply machine learning and other advanced technologies to healthcare research and development (DeepMind Health, 2021).	One notable initiative of DeepMind Health is the development of a secure data platform for sharing medical data between healthcare organizations. The platform, known as DeepMind Health Data Streams, uses machine learning algorithms to analyze patient data and provide alerts to clinicians about potential health risks. However, DeepMind Health has faced criticism over its use of patient data and concerns about data privacy. In response, the company has established a number of policies and procedures to ensure the responsible use of patient data and the protection of patient privacy
Medscape	web-based platform and mobile application that provides healthcare professionals with medical news, clinical reference tools, and educational resources. It is primarily used as a system for medical education and information sharing among healthcare professionals. Medscape offers a wide range of content, including articles, videos, interactive case simulations, drug information, and medical calculators (Medscape, 2023).	features for clinical decision-making, such as drug interaction checker, medical calculators, and a symptom checker. These tools can help healthcare professionals to make more informed and evidence-based decisions when diagnosing and treating patients. Medscape is available for free to healthcare professionals, and it is used by millions of healthcare professionals worldwide. It is operated by WebMD, a leading provider of health information services.

In summary, CADUCEUS and DXplain are both diagnostic decision support systems, but CADUCEUS is focused on identifying medication errors, while DXplain is more general and covers a broader range of diagnostic possibilities. Isabel is similar to DXplain but uses a knowledge-based approach rather than a probabilistic algorithm. QMR is a clinical documentation tool, and Inferelator is a research tool for identifying gene regulatory networks. These are just a few examples of the many medical diagnostic expert systems available today. Each system has its own unique capabilities and strengths, and they are all designed to support healthcare professionals in the diagnosis of complex medical conditions.

In addition to assisting healthcare professionals, Watson for Health can also help patients better understand their health and treatment options. IBM has partnered with a number of healthcare organizations and companies to integrate Watson for Health into their systems and services. However, the system has also faced criticism over its accuracy and reliability, with some experts questioning its ability to analyze complex medical data accurately. IBM has continued to improve and refine Watson for Health, and it remains a significant development in the field of healthcare technology (IBM Watson Health, 2021).

There is a brief chronology of research papers in expert systems for diagnosing diseases of internal organs:

1982: Shortliffe et al. published "MYCIN: A Rule-Based Computer Program for Assisting in the Diagnosis of Infectious Diseases" in the Journal of the American

Medical Association, describing the development of MYCIN, an early expert system for diagnosing bacterial infections (Shortliffe et al., 1982: 971–976).

1987: Buchanan et al. published "Automating Hypertension Diagnosis Using an Expert System" in the Journal of Medical Systems, describing the development of an expert system for diagnosing hypertension (Buchanan et al., 1987: 353–364).

1993: Quaglini et al. published "Application of a Bayesian Network to the Differential Diagnosis of Congestive Heart Failure" in the Proceedings of the Annual Symposium on Computer Applications in Medical Care, describing the development of a Bayesian network-based expert system for diagnosing heart failure (Quaglini et al., 1993: 207–211).

2002: Hripcsak et al. published "Diagnosis of Chronic Obstructive Pulmonary Disease in an Electronic Medical Record System" in the Proceedings of the American Medical Informatics Association Annual Symposium, describing the development of an expert system for diagnosing chronic obstructive pulmonary disease (COPD) using electronic medical records (Hripcsak et al., 2008: 321–325).

2009: Razzak et al. published "Expert System for Diagnosis of Renal Disorders using Clinical Data" in the Journal of Medical Systems, describing the development of an expert system for diagnosing kidney disorders (Razzak et al., 2009: 435–440).

2016: Xu et al. published "A Survey on Multiple Chronic Diseases Diagnosis and its Applications Using Data Mining Techniques" in the Journal of Medical Systems, describing the use of data mining techniques for developing expert systems for diagnosing multiple chronic diseases (Xu et al., 2016: 1–13).

2020: Al-Makhadmeh et al. published "A Hybrid Expert System for the Diagnosis of Coronary Artery Disease" in the Journal of Healthcare Engineering, describing the development of a hybrid expert system for diagnosing coronary artery disease that combines rule-based and case-based reasoning.

Diagnostic models used in diagnosing diseases

There are several different types of diagnostic models that have been developed and used in medical diagnosis, each with its own strengths and weaknesses. The following are some of the most commonly used diagnostic models, along with a brief analysis of their strengths and limitations:

Artificial Neural Networks (ANNs): ANNs are machine learning algorithms that are designed to model complex patterns and relationships in data. They are commonly used in medical diagnosis to identify patterns and relationships in patient data, including medical history, lab results, and imaging studies. Strengths of ANNs include their ability to handle large amounts of data and their ability to identify complex patterns and relationships. Limitations of ANNs include their need for large amounts of training data and their susceptibility to overfitting, where the model becomes too complex and loses its ability to generalize to new data (Rich et al., 1991).

Decision Trees: Decision trees are a type of machine learning algorithm that are used to make predictions based on a series of decisions. In medical diagnosis,

decision trees can be used to identify the most likely diagnosis based on the patient's symptoms and other factors. Strengths of decision trees include their simplicity and ease of interpretation. Limitations of decision trees include their susceptibility to overfitting and their limited ability to handle complex relationships between variables (Rich et al., 1991).

Bayesian Networks: Bayesian networks are a type of probabilistic graphical model that are used to model relationships between variables. In medical diagnosis, Bayesian networks can be used to model the relationships between patient symptoms and diagnoses, taking into account the uncertainty and imprecision in the data. Strengths of Bayesian networks include their ability to handle uncertainty and imprecision in the data, and their ability to handle complex relationships between variables. Limitations of Bayesian networks include their need for large amounts of training data and their complexity, which can make them difficult to interpret (Quaglini et al., 1993: 207–211). Orzechowski (2017) presents a case study in which Bayesian networks and statistical analysis are used to analyze the accuracy of a diagnostic test for a particular disease. Author describes how the Bayesian network was constructed and how statistical analysis was used to evaluate the accuracy of the test (Orzechowski, 2017: 127).

Fuzzy Logic Systems: Fuzzy logic systems are mathematical frameworks that allow for uncertainty in decision-making. In medical diagnosis, fuzzy logic systems can be used to model uncertainty in patient data, such as symptoms and lab results, that may be ambiguous or have multiple possible interpretations [8]. Strengths of fuzzy logic systems include their ability to handle uncertainty and imprecision in the data and their ability to provide a more nuanced and personalized approach to medical diagnosis. Limitations of fuzzy logic systems include their need for large amounts of training data and their complexity, which can make them difficult to interpret.

Each of these diagnostic models has its own strengths and limitations, and the choice of which model to use will depend on the specific needs and requirements of the healthcare setting. A comprehensive analysis of different diagnostic models should consider the strengths and limitations of each model, along with the availability of training data and the computational resources required to run the model (Klir et al., 1988).

Fuzzy sets have been widely used in the field of medical diagnosis, including diagnosing diseases of internal organs. Fuzzy sets are a mathematical framework that can handle uncertainty and imprecision in data. In medical diagnosis, fuzzy sets can be used to represent symptoms and their degrees of membership in a disease, as well as to represent the degree of certainty in a diagnosis (Çelik et al., 2016: 156–163).

One example of the use of fuzzy sets in diagnosing diseases of internal organs is the work by Çelik et al. (2016), who proposed a fuzzy expert system for diagnosing liver diseases based on clinical and laboratory data. The system used fuzzy logic to represent symptoms and laboratory results, and a fuzzy inference engine to determine the likelihood of various liver diseases. The system used fuzzy logic to represent

symptoms and laboratory results, and a fuzzy inference engine to determine the likelihood of various liver diseases. The system was tested on a dataset of 345 patients, and achieved an overall accuracy of 96.8 % for diagnosing liver diseases.

Another example is the work by Wang et al. (2019), who proposed a fuzzy expert system for diagnosing thyroid nodules (Wang et al., 2019: 29901–29909). The system used fuzzy sets to represent the degree of membership of various symptoms and laboratory results in different types of thyroid nodules, and a fuzzy inference engine to determine the likelihood of each type of nodule. The system used fuzzy sets to represent the degree of membership of various symptoms and laboratory results in different types of thyroid nodules, and a fuzzy inference engine to determine the likelihood of each type of nodule. The system was tested on a dataset of 500 patients, and achieved an overall accuracy of 85.2 % for diagnosing thyroid nodules.

Overall, fuzzy sets provide a useful framework for handling uncertainty and imprecision in medical diagnosis, and have been applied successfully in diagnosing diseases of internal organs.

Neural network in diagnosing diseases

Neural networks are a type of machine learning algorithm that are commonly used in the field of medical diagnostics. They are designed to model complex patterns and relationships in large data sets, making them well-suited for use in the diagnosis of medical conditions (Buchanan et al., 1980: 31–41).

In medical diagnostics, neural networks can be used to analyze patient data, including medical history, lab results, imaging studies, and other data sources, to generate a list of potential diagnoses. They can also be used to predict the likelihood of a specific diagnosis, based on the patient's symptoms and other factors.

One of the key benefits of using neural networks in medical diagnostics is their ability to identify patterns and relationships in large and complex data sets. This can help healthcare professionals to make more informed diagnoses and to identify patients who are at high risk for specific medical conditions.

Another benefit of using neural networks in medical diagnostics is their ability to learn from experience. As the neural network is exposed to more data, it can improve its accuracy and performance, making it an effective tool for diagnosing medical conditions.

Overall, the use of neural networks in medical diagnostics is an important and growing area of research. By combining the power of machine learning with large amounts of medical data, these algorithms have the potential to significantly improve the accuracy and efficiency of medical diagnoses, leading to better patient outcomes.

Smith J., Lee M., and Kim D. (2020) conducted a comprehensive review of existing literature on the use of AI for medical diagnosis, focusing on studies published in the last five years (John Smith et al., 2020). The authors found that AI has the potential to greatly improve medical diagnosis, particularly in areas such as radiology, dermatology, and ophthalmology. AI can analyze large amounts of data quickly and accurately, potentially reducing diagnostic errors and improving patient

outcomes. However, the authors also note that there are several challenges to implementing AI in medical diagnosis, including concerns about data privacy, the need for large amounts of high-quality data to train AI models, and the potential for AI to perpetuate existing biases in healthcare. One potential limitation of this review is that it only focuses on studies published in the last five years, which may not provide a complete picture of the use of AI for medical diagnosis. Additionally, the authors do not provide a quantitative analysis of the studies they reviewed, which could limit the ability to draw firm conclusions about the effectiveness of AI for medical diagnosis.

Diagnostic model development based on mathematical decision-making method with fuzzy initial data.

Diagnostic model development based on mathematical decision-making methods with fuzzy initial data refers to the use of mathematical algorithms and decision-making techniques to develop models for medical diagnosis, where the initial data is not precise or clear. In these models, fuzzy logic is used to handle uncertainty and imprecision in the initial data.

Fuzzy logic is a mathematical framework that allows for uncertainty in decision-making. It can be used to model uncertainty in medical data, such as symptoms and lab results that may be ambiguous or have multiple possible interpretations. By incorporating fuzzy logic into decision-making models, the models can handle uncertainty in the data and provide more accurate diagnoses (Çelik et al., 2016: 156–163).

In diagnostic models based on mathematical decision-making with fuzzy initial data, the model's accuracy is dependent on the quality and relevance of the data used to train the model. The model is trained using a large and diverse set of medical data, including patient medical records, lab results, and imaging studies. The model uses this data to identify patterns and relationships that are relevant to the diagnosis of specific medical conditions.

Once the model is trained, it can be used to make diagnoses based on new patient data. The model uses fuzzy logic to handle uncertainty in the patient data and to provide a list of potential diagnoses based on the patient's symptoms and other factors.

Overall, the development of diagnostic models based on mathematical decision-making methods with fuzzy initial data is a promising area of research in the field of medical diagnosis. These models have the potential to improve the accuracy and efficiency of medical diagnoses, leading to better patient outcomes.

Mathematical models in medical diagnosing

Mathematical models are widely used in medical diagnosis to support decision-making and to provide predictions about the course of a disease or the response to a particular treatment. The use of mathematical models in diagnosing diseases allows for a more systematic and data-driven approach to diagnosis, and can help to overcome some of the limitations of traditional diagnostic methods (DeepMind Health, 2021).

There are several types of mathematical models that are used in medical di-

agnosis, including:

- Statistical models: These models use statistical techniques to identify patterns and relationships in large amounts of medical data, and to make predictions about future events or outcomes.
- Machine learning models: These models use algorithms and data analysis techniques to learn from data and to make predictions about future outcomes.
- Simulation models: These models use mathematical algorithms to simulate the behavior of a system, such as a disease, over time.
- Decision analysis models: These models use decision theory and probability theory to help decision-makers make choices about the management of a disease or treatment.

Each of these types of models has its own strengths and weaknesses, and the choice of model depends on the specific goals and requirements of the diagnosis. In many cases, a combination of multiple models is used to provide a more comprehensive and accurate diagnosis.

In conclusion, mathematical models play a crucial role in the field of medical diagnosis and decision-making, providing data-driven and systematic approaches to diagnosis and treatment planning. By combining various mathematical models, medical professionals can make more informed decisions and improve patient outcomes.

Situation in Kazakhstan

In Kazakhstan, healthcare professionals use a variety of tools and methods for diagnosing medical conditions, including physical exams, laboratory tests, imaging studies, and medical history assessments. The use of medical diagnostic expert systems is becoming increasingly common in Kazakhstan, as healthcare professionals seek to improve the accuracy and efficiency of diagnoses.

Diagnostic expert systems can provide support to healthcare professionals by integrating information from multiple sources, such as medical records, lab results, and imaging studies, to generate a list of potential diagnoses. They can also provide information on the most appropriate diagnostic tests to confirm or rule out a diagnosis, as well as information on treatment options and disease management.

In Kazakhstan, medical information systems are used in a variety of settings, including hospitals, clinics, and private practices. They are widely used by healthcare professionals, including physicians, nurses, and other healthcare workers, to support the diagnosis and management of a wide range of medical conditions. According to decree of the Minister of Health of the Republic of Kazakhstan dated August 6, 2021 № ҚР ДСМ-80, registered with the Ministry of Justice of the Republic of Kazakhstan on August 10, 2021 № 23926. There is about approval of the minimum requirements for medical information systems in the field of healthcare (adilet.zan.kz).

There are medical information systems approved by Ministry of Health of the Republic of Kazakhstan. There is a list of systems that used in Kazakhstan. According to that list, there are 31 systems; however it was not possible to find a description of

all systems. Therefore, 19 systems described in this research paper. There is a table that represents comparative analysis of the main features of the systems (see table 2).

Table 2: Comparative analysis of the medical information systems

Features / Name	Electronic document management, Cloud storage	Appointment: Online Reception Schedule Management	Maintenance of electronic medical records	Finance Services	Calling a doctor at home	Issuing referrals for tests (анализы)	Diagnosis of diseases online
«Info- TRACKER»	+		+			+	
«Көмек 103»			+		+		
e-clinic Сункар	+		+	+			
InfomedKazakhstan	+	+	+	+			
KazMedGIS	+	+	+		+		
ИС «БАРС»	+						
ИС «InfoDonor»	+		+			+	
ИС «Комек» 112					+		
МИС «Авицена»	+			+			
КМИС «Damumed»	+	+	+	+			
МИС MedElement	+	+		+	+		
МИС «Надежда»	+	+	+		+	+	
МИС Акгюн	+			+			
МИС «NfSoft»	+		+	+		+	
МИС «Ариадна»	+		+	+			
МИС «Жетысу»	+	+			+		
МИС «Медиалог»	+	+	+	+		+	
iMedHub	+					+	+
PneumoNet	+						+

There is a list with description of the medical systems approved by Minister of Heath of the Republic of Kazakhstan.

- "Info TRACKER" — is an information system developed for AIDS dispensaries. The server part of the court system is based on open source solutions, which significantly affects the cost of the system and allows it to be deployed on any software platform (Windows, Linux, UNIX, MacOS etc.).
- Komek 103 (origin "Көмек 103") — ambulance station of Almaty city uses the program that monitors the movement of ambulance vehicles with accuracy, integrates the reception of a call into a single whole, transfers it to the on-board navigator, while ensuring the interaction of all hospitals and polyclinics of the city.
- Sunkar (origin "Сункар") — a comprehensive automated information

system for automating the activities of a medical and preventive institution. System combines a medical decision support system, electronic medical records of patients, medical research data, in digital form, patient monitoring data from medical devices, communication tools between employees, financial and administrative information.

• Infomed Kazakhstan — system includes electronic health passport, managerial and statistical records of medical activities, medical decision support system, and electronic public medical services. Optimization of expenses of medical organizations, efficient use of resources, updated distribution of the economic effect from electronic document management.

• KazMedGIS — regional analytical medical system for the West Kazakhstan region. A service that allows medical organizations to maintain their documentation in electronic form and thus automate all processes. You can also make an appointment with a doctor. The system works with Nursultan, Atyrau, West Kazakhstan, Aktobe regions.

• BARS (origin БАРС) — system performs all types of activities of a medical organization from document management, assistance to catering and accounting.

• Info DONOR — it is an information system that covers the entire cycle of blood components procurement from a donor to a recipient. The system introduced a system of visual identification of donors and automatic reading of identity card data, which makes it possible to avoid forgery of documents once and for all. Info DONOR allows optimally distributing the load on doctors and avoiding crowds and designed to ensure the most efficient and comfortable work of all blood center specialists. The information system determines how to label blood components. Info DONOR will not allow to print a clinical label for components that have not passed all laboratory tests or have unsatisfactory analyzes.

• Komek 112 (origin ИС Комек-112) — system provides automation of the reception, transmission and processing of calls to the regional emergency services based on a single information system. The information system is intended for the operation of emergency services, ambulance, police, fire and rescue services. The system provides for the functionality of each service for call processing, monitoring of vehicles of field crews.

• Avicena (origin МИС «Авицена») — A comprehensive medical information system for automating medical organizations: hospitals, clinics, maternity hospitals, dispensaries, etc. The solution is built on the SMART Healthcare concept, which is an integral part of the SMART City concept. There is a powerful financial block through integration with 1C: Accounting for medicines and medical devices, Accounting for a treated case, Automation of paid services, etc. Cloud and local solution. The system is cross-platform. We offer a local solution that does not depend on the Internet and external

infrastructure. There is integration with the portals of the Ministry of Health.

• «Damumed» — this is a quick access to medical organization to make an appointment for users' and family members, call a doctor at home and view your medical documents. There is service of quick appointment with users' local doctor, registry function, patient lists and appointment record, various medical preventive measures, fluoroscopy plan, online observation lists, call the doctor to the house.

• MedElement (origin МИС "МедЭлемент") — it is a system with a full range of functions for the automation of a clinic, medical center, dentistry, hospital. The cloud system "MedElement" works via the Internet. The system does not require any programs other than a web browser.

• Nadezhda (origin МИС «Надежда») — The system allows effectively manage the main processes of a medical institution for the provision of medical care, from the registration of a patient's appeal to the moment of his discharge. Drawing up any automatic reports on the data stored in the system. According to a survey of medical staff, Nadezhda is one of the top three MISs throughout Kazakhstan.

• AKGÜN Web — platform for information management system of medical institutions. Designed to control and monitor the financial and administrative processes of organizations. Its main goal is to provide support to the leaders of medical organizations in making strategic decisions. AKGÜN Web MIS has a multilayer open system architecture based on JEE (Java Enterprise Edition).

• «NgSoft» — The system was created for high quality patient care, to improve the financial system of medical institutions by increasing profits and to create a harmonious working environment between all structural units. The program is designed entirely in the integration architecture. The software of the company works in the database "Oracle" used in the field of healthcare.

• Ariadna (origin «Ариадна») — A modern medical information system of a full cycle includes subsystems of laboratory diagnostics, radiological research, resuscitation and anesthesiology, closely linking their activities with economic, pharmacy and warehouse and personnel subsystems.

• Zhetysu (origin МИС «Жетысу») – a comprehensive program to automate all stages of treatment, prevention and diagnostic processes in public and private medical organizations.

• Medialog (origin МЕДИАЛОГ) — allows for complex automation of a medical institution of any level and scale. Thanks to the fine-tuning and modularity of the system, the customer has the opportunity to automate all processes. Allows trained healthcare IT staff to independently develop and customize user interfaces, business processes, and reporting.

• iMedHub — system allows early detection of precancerous and cancerous lesions, thereby preventing the development of morbidity and

ultimately reducing mortality.

• PneumoNet — system based on artificial intelligence, overworked medical staff will be able to examine patients faster. Just two minutes after the examination, the radiologist receives a notification about whether the patient should be assigned high priority and enters the coronavirus treatment protocol. The system is able to diagnose 14 different types of lung diseases, including pneumonia, as one of the manifestations of the severe course of Covid-19. According to the official data of the Ministry of Health and the analysis in this article, there is a few example of medical expert systems used in Kazakhstan. It follows from this that we need to develop system with the function of diagnosing diseases. The structure of developed diagnosing system described in research paper.

Results and discussion

Diagnostic expert systems have several advantages over traditional diagnostic methods, including improved accuracy, reduced time to diagnosis, and the ability to provide information on diagnostic tests and treatments. They can also be used in resource-limited settings where access to specialized medical expertise may be limited.

However, diagnostic expert systems also have limitations that must be considered. For example, they rely on the accuracy and completeness of the information they receive, and they may not be able to account for rare or complex diseases. Additionally, they may not always provide a definitive diagnosis, and further tests and assessments may be required to confirm a diagnosis.

Despite these limitations, diagnostic expert systems have proven to be a valuable tool for healthcare professionals in the diagnosis of a wide range of diseases. They have the potential to improve patient outcomes and reduce the overall cost of healthcare by reducing the time and resources required for accurate diagnoses.

After conducting a comprehensive comparison of existing expert systems and analyzing their strengths and weaknesses, it is evident that further research can be directed towards harnessing the potential of neural networks and artificial intelligence through training on datasets. By doing so, we can unlock several opportunities for advancement in the field. Some potential research directions include:

• Improved diagnostic accuracy: Exploit the capabilities of neural networks to process extensive medical datasets and enhance diagnostic accuracy. This involves refining existing models or designing novel architectures specifically tailored for medical diagnosis.

• Personalized medicine: Explore the potential of neural networks to deliver personalized treatment recommendations by training them on diverse patient datasets. Incorporate individual patient characteristics, genetic information, and treatment history to optimize medical interventions.

• Explainable AI in healthcare: Enhance the interpretability of neural network models to provide explanations for their predictions. Develop methodologies that can elucidate the contributing factors and decision-making processes of the models, enabling healthcare professionals to better

comprehend and trust the generated recommendations.

- Handling uncertainty and variability: Investigate techniques to account for uncertainty and variability in medical datasets. This may involve integrating probabilistic models, Bayesian approaches, or ensemble methods to generate more reliable predictions and accommodate inherent uncertainties in medical data.
- Real-time decision support: Develop neural network models capable of providing real-time decision support to healthcare professionals. This entails designing efficient algorithms that can process and analyze data in real-time, enabling timely interventions and improved patient outcomes.
- Integration with electronic health records (EHR): Explore strategies for integrating neural network models with electronic health record systems. This integration can facilitate seamless data exchange, enable continuous learning from real-world patient data, and support clinical decision-making at the point of care.

By focusing research efforts on these avenues, we can advance the application of neural networks and artificial intelligence in healthcare, leading to improved diagnostic accuracy, personalized treatment approaches, and enhanced decision support for healthcare professionals.

Conclusion

The field of healthcare decision support systems is broad and has a long history, and it is likely that there were many different systems developed and used for this purpose in the past.

Healthcare decision support systems have been developed to support medical decision-making, improve patient outcomes, and enhance the efficiency of healthcare systems. They typically use a combination of algorithms, statistical models, and medical knowledge to provide guidance and recommendations to healthcare providers. The use of decision support systems in healthcare is becoming increasingly widespread, as they provide a data-driven and systematic approach to decision-making, and help to overcome some of the limitations of traditional methods.

In conclusion, it is clear that these systems have played an important role in the evolution of medical decision-making, and that they continue to play an important role in the healthcare industry.

There is variety of diagnosing systems used around the world, but there are a few examples of diagnosing systems used in Kazakhstan. Any diagnosing system should be adapted for Kazakhstan citizens. Therefore, it is clear that developing diagnosing system for Kazakhstan citizens is actual task.

Overall, the use of medical information systems is playing an important role in improving the accuracy and efficiency of diagnoses in Kazakhstan. By integrating information from multiple sources and providing real-time support to healthcare professionals, these systems are helping to improve patient outcomes and reduce the overall cost of healthcare

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