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Tıpta ve veteriner tıpta yapay zeka

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Artificial Intelligence in Medicine

Abstract:
Even though the very idea of artificial intelligence, which was put forward with the imagination of imitating human intelligence by machines, is perceived as a homogeneous and simple concept, there are different types of systems working and aiming for different purposes including expert systems, fuzzy logic and genetic algorithms. One of the most drastic progress in this field is the implementation of artificial neural networks as the closest point to biological neural networks of human intelligence. The use of artificial intelligence in medicine enables the opportunity to protect and prolong life and improve the quality of life even further. With the help of developed artificial intelligence applications, health management and monitoring will improve both health professionals and patients' life significantly. In other words, with the efficient and widespread use of artificial intelligence in medicine, there will be plenty of health benefits. In this review, it is aimed to give information about the history and the progress of artificial intelligence and novel applications in both human and veterinary medicine

Keywords: Yapay Zeka, Biyoteknoloji, Tıp, Veteriner Tıp

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Özet:
İnsan zekasının makineler tarafından taklit edilmesi hayali ile ortaya konulan yapay zeka fikri, ilk bakışta homojenik bir kavram gibi algılansa da aslında farklı sistemlerin farklı amaçlarla çalıştığı birden çok türü mevcuttur. Uzman sistemler, bulanık mantık ve genetik algoritmalar gibi zekanın farklı özelliklerini farklı bir modelleme ile taklit etmeyi hedefleyen türleri vardır. Bu alandaki en çarpıcı ilerleme ise; makinelerin insan zekasına en çok yaklaştığı alan olan ve biyolojik sinir ağlarını taklit eden yapay sinir ağlarının pratiğe dökülmesi ile olmuştur Teknolojinin sağlık alanında aktif kullanımı canlıların hayatını koruma ve uzatma, hayat kalitesini iyileştirme şansını daha da ileriye taşımaktadır. Yapay zekanın sağlık alanında kullanılması ile canlıların hayat ve sağlık standartlarının iyileştirilmesine yönelik etkisinin olumlu yönde olacağı yalın bir gerçektir. Tıpkı insan zekası gibi yapay zekanın da etkin kullanımı sağlık alanında yeni atılımları da beraberinde getirecektir Bu derlemede yapay zekanın insan ve hayvan sağlığı alanında kullanımı ve uygulamaları hakkında bilgi verilmesi amaçlanmıştır.

Anahtar kelimeler: Artificial Intelligence, Biotechnology, Medicine, Veterinary Medicine

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Giriş

Can machines think? The idea of artificial intelligence (A.I.) came up with Alan Turing's famous question (Turing, 2009), and it became a reality after it was named "Artificial Intelligence" during a workshop in 1956. (Haenlein and Kaplan, 2019). Inspired by the success of the Bombe, the first known electromagnetic computer deciphering Enigma codes, Alan Turing defines how intelligent machines can be created and how their intelligence can be tested by manifesting the Turing Test (Haenlein and Kaplan, 2019). Turing Test, which simply evaluates the success of an A.I., is performed by whether a person understands an intelligence belongs to a human or a machine and it is considered an important criterion even today (Turing, 2009). Consequently, even though a perfect A.I. is yet to be created, Deep Blue computer system of IBM defeated Kasparov in a chess game and gained the first victory against humanity (Gezer, 2019).

The idea of A.I. encompasses scientific research into robotics, collaborative robotics, and quantum computers, but in the public eye it is seen as a machine acquiring traits unique to the human brain, such as mimicking thought processes, learning from examples and experiences, recognizing objects, generalizing, deciding, and problem-solving (Haenlein and Kaplan, 2019).

The advancing technology enables to use of A.I. efficiently in medicine, especially when it comes to challenges with infectious diseases. There are various kinds of fields and biomedicine through bio-informatics is one of the most prominent applications. Even though biomedicine typically bases its work on human medicine, animals are increasingly being considered in assessments since they serve as reservoirs for diseases that have affected human health throughout human evolution and history. Thus new A.I. methodologies and technologies target human and animal health altogether (Yesil, 2019).

AI is a multidisciplinary informatics field that aims to transfer characteristics of people defined as intelligence to a computer -based object. In fact, AI is a simulation of human intelligence imitated by machines and programmed by humans.

There are two types of AI. One of them, weak AI, covers many applications that surround us today. It is trained and focused to perform certain tasks.

The other is strong AI. The other is strong AI which automatically chooses the problem without any human intervention and replicates the autonomy of the human brain in a more sophisticated way. Strong AI has no practical utilization today and exists only in theory. One of the examples of artificial superintelligence is the fictional superhuman computer assistant HAL from 2001: A Space Odyssey.

Applications of artificial intelligence

Expert systems (ES)

Expert systems dating back to the 1960s, emerge as a result of J. Lederborg's work on computer-based interpretations of spectrograph data and are considered as an advisory software system modeling the reasoning and decision-making process of one or more real experts with capabilities of improving expertise over time (Nabiyev, 2005). The areas where an expert's experience is needed are the most common utilization fields of expert systems. A successful expert system is the result of experience and facts. Furthermore, in order to create a successful expert system, it needs to be developed in a specific field. Heavily preferred expert system utilization areas are foresight, planning, diagnosis, design, monitoring, testing and debugging, inspection, training, recognition and interpretation (Baykal and Beyan, 2004).

Fuzzy logic

Fuzzy logic, different from classical logic systems, aims to model irregular reasoning processes that play a role in the decision-making ability of humans in event of uncertainty. When the data is insufficient to process, it is possible to find a meaningful solution by applying fuzzy logic rules (Baykal and Beyan, 2004). There are two main reasons why classical logic systems cannot cope with incomplete or imprecise information. First, they cannot interpret statements expressed in a natural language because the meaning is not precise. Secondly, they cannot interpret the symbolic meanings of the statements expressed in a language. However, the human mind can reason and make decisions in situations such as uncertainty, incomplete or contradictory information, objective reality and probability; in other words, in an environment of imperfect information. It can perform various physical and mental tasks without measuring and calculating. Fuzzy logic is an attempt to execute these abilities of the human mind (Zadeh, 2008).

Genetic algorithm

The genetic algorithm describes a sub-branch of artificial intelligence with a similar structure to Darwin's theory of evolution in biology and is one of the first evolutionary algorithms that paved the way for modern evolutionary computation. A genetic algorithm is a research method technique that was created to find the absolute truth or approximate truth in the solutions of search and optimization problems based on natural selection and heredity rules. It is created by collecting many solution proposals similar to individuals coming together to form a population (Zadeh, 2008).

Machine learning

Tom Mitchell, taking a modern approach to the definition of machine learning, named the tasks coded in a computer program as T, the performance of the program on executing these tasks as P, and the experience of the program as E and suggested that a program can show a better P by learning from E on executing T. There are two main machine learning algorithms: supervised learning and unsupervised learning (Ng, 2011). In supervised learning, a training set containing input-output data is given to the system for learning. In unsupervised learning, only problem-based input data is given to the system and output data corresponding to the input data is expected.

Deep learning

Deep learning, as a subset of machine learning, is inspired by the structure of the human brain. Deep learning algorithms constantly analyse data with a certain logical structure and try to reach similar conclusions like the human brain would. To achieve this, deep learning uses a multi-layered algorithm structure called artificial neural networks. The design of the neural network is based on the structure of the human brain (Nabiyev, 2005). Single layers of neural networks are similar to a deduction filter working from general knowledge to a certain conclusion. This increases the probability of detecting and giving the correct result. Each node layer is trained on a different feature set according to the output of the previous layer. The further advancement through the neural network makes the recognizable features above the node layers more complex. This is described as a hierarchy of features and is actually a hierarchy of increasing complexity and abstraction (Nicholson, 2020).

Artificial neural networks

Artificial neural networks are a computing structure consisting of processing elements with individual memory. It is a structure created as an imitation of biological neural network and there are nerve cells such as inputs, weights, gathering function, activation function and outputs similar to biological neural networks (Nabiyev, 2005). Artificial neural networks applications can be integrated into different areas such as optimization, classification, pattern recognition, clustering, function approach and prediction (Abiodun et al., 2018).

Use of artificial intelligence in medicine

Even though the early applications of AI emerged in the 1950s, limited computer technologies and software produced with these technologies prevented the comprehensive application of AI in the field of medicine until the beginning of the 2000s and therefore, the adaptation progressed gradually. Early applications were usually about transferring data to the virtual environment. For example, as an important digital database resource, Medical Literature Analysis and Information Extraction System (MEDLINE) and PubMed, a web-based search engine, were designed in the 1960s (Kaul et al., 2020). The first examples of artificial intelligence applications in the field of medicine are a CASNET-based glaucoma consultation program and the expert system called MYCIN (Weiss et al., 1978).

Particularly with the advancement of deep learning after the 2000s, AI systems are used in many areas such as risk assessment, more accurate identification and diagnosis and development of work-flow schemes, especially in clinical practice, since they can process complex algorithms and learn by themselves (Kaul et al., 2020). Furthermore, with use of predictive models which is a machine learning technique based on processing historical and statistical data to calculate possible outcomes and compatible decisions in the future, it has begun to be used in areas such as diagnosing diseases, predicting therapeutic response, applying for preventive medicine by preventing disease potentials, and performing sensitive operations (Ruffle et al., 2019).

Use of expert systems in medicine

Medical expert systems provide clinical decision-making support by mimicking the human decision-making process and help the improvement of healthcare in this way. The aim of the ES is to assist the user to analyse the current situation better than the user or the system can do alone. It helps to make more accurate diagnoses, to ensure that the treatment plan is created on a more scientific basis, to eliminate potential medical errors in the whole disease follow-up process, and to inform the clinician about the patient's condition (Zhou and Sordo, 2020). Some of the examples of medical ES designed to assist in the clinical decision process of medical diagnosis are the Leeds Abdominal Pain System, HELP, INTERNIST-I, Quick Medical Reference, Caduceus and DXplain.

Leeds Abdominal Pain System assists in the diagnosis of abdominal pain by using symptoms and laboratory test results (Kulikowski, 2019). DXplain, on the other hand, generates differential diagnoses by using input symptoms and is also used as an electronic medicine book (Amisha et al., 2019). ONCOCIN is used to prepare chemotherapy protocols for cancer patients. Likewise, an antibiotic consultation program integrated into the hospital information system (HELP) assists to identify the “probable” pathogen carried by the patient by accessing the medical records of the patient and processing it with the information entered by the physician. This program has been reported to provide %17 better results than physicians in predicting the pathogen and treatment of the related pathogen (Zhou and Sordo, 2020).

The use of fuzzy logic in medicine

Fuzzy logic is a soft computing technology that can tolerate uncertainty in logic and thus produce better solutions. Essentially, fuzzy logic provides a characterization of transition values between evaluations such as yes or no or true or false. Disease diagnosing procedure includes various uncertainties and unclear situations. For example, some type of disease may occur with different symptoms in different patients or two different diseases with similar symptoms may be seen. Also, the treatments of these diseases may provide different outcomes. There are also indefinite factors such as the patient's subjective medical history or possible errors in diagnostic tests. These uncertainties have led to the inclusion of expert systems with fuzzy logic in the field of medicine instead of expert systems with classical propositional logic (Baykal and Beyan, 2004; Ozsahin et al., 2020).

CADIAG, a hospital information system, is one of the first successful examples of fuzzy expert systems in the field of medicine. It takes medical records, process them, codes them according to certain rules and turns them into medical information. Then, the system was improved to CADIAG-2. CADIAG-2 is applied in the fields of rheumatology, gastroenterology and hepatology. More recently, optimal drug therapy in HIV seropositive patients has been discussed using the fuzzy cost function (Caetano et al., 2008). Another example is the fuzzy optimization technique for the prediction of coronary heart disease using the decision tree algorithm (Persi Pamela and Gayathri, 2013).

The Use of Genetic Algorithm in Medicine

An algorithm is a well-defined set of rules and instructions that describe a set of operations. Metaheuristic methods are a problem-solving technique based on searching and optimization of the problem space and used to solve complex problems faster or to find an approximate solution when classical methods cannot find an exact solution. These methods are inspired by various events including ant colonies inspired by ant behavior, artificial bee colonies inspired by bees' behavior, grey wolf optimizers inspired by grey wolves' behavior, artificial neural networks, river formation dynamics inspired by the river formation process, artificial immune system and genetic algorithm. Metaheuristic approaches are frequently used in other fields of science including engineering, math and computer programming where it is necessary to solve complex problems or make optimal decisions.

Genetic algorithms can be used in every field including radiology, oncology and infectious diseases in medicine. One of the prior applications of genetic algorithms in radiology is breast cancer screening using mammography. Karnan and Thangavel (2007) used a genetic algorithm to detect micro-calcifications in mammograms suggesting breast cancer. Duraipandian et al. (2011) performed Raman spectroscopy from the cervical region by using colposcopy to develop a non-invasive technique for cervical cancer detection and analysed obtained biomolecular information with a genetic algorithm to differentiate between normal and dysplastic cervix. This system was able to distinguish dysplasia from the normal cervix with %72 sensitivity and %90 specificities. Elveren and Yumusak (2011) designed artificial neural networks trained by genetic algorithm for the diagnosis of tuberculosis. This system provided a high accuracy rate (%95) and better performance compared to other algorithms.

The Use of Artificial Neural Networks in Medicine

Artificial neural networks are one of the most interesting branches of AI and are widely used in the field of medicine. Nowadays, artificial neural networks emerge as a more useful and reliable method instead of algorithm-based systems for solving complex problems. Various studies have been conducted around the world using artificial neural networks, demonstrating the applications of pattern recognition, classification, prediction, data analysis, drug design, medical diagnosis and prognosis in the field of medicine.

In a study conducted by Banner et al. (2006), respiratory rate per minute and power were determined non-invasively in patients with respiratory failure using artificial neural networks without using an invasive oesaphageal catheters.

In addition, there are other studies in neurology and artificial neural networks that are researched through clinical trials. One of the studies has evaluated the accuracy of artificial neural networks in classifying the positive or negative response given to the cholinesterase inhibitor donepezil in a group of patients with Alzheimer's disease, by comparing them with the discriminant analysis. According to the results of the study, it is found that artificial neural networks are more effective than discriminant and other methods in distinguishing between responders and non-responders (Mecocci et al., 2002).

Fogel et al. (1995) used artificial neural networks to detect breast cancer from histological data. Their results showed that artificial neural networks performed better than other methods.

In addition, many reports have been presented showing that artificial neural networks perform accuracy and survival prediction in colon cancer classification when compared with other statistical or clinicopathological methods (Ahmed, 2005).

Use of artificial intelligence in veterinary medicine

Although the applications of AI in veterinary medicine are not as extensive and widespread as those in human medicine, there are studies showing that AI can be used effectively in the near future. Machine learning based on provided regular input by clinical data, procures a wide range of utilization, from aggroupment, based classification and disease prediction studies, to generating regular data from irregular clinical data entry by natural language processors (Yesil, 2019).

In a study, a decision support system based on fuzzy logic has been developed to test whether it would be successful in the field of livestock and it has been implemented to determine the compatibility between the system and the decision taken by an expert. It was stated that the decision support system, designed by using the reproduction and milk yield records of Holstein Fresian dairy cows, made the correct classification with a rate of %92.6 and fuzzy logic decision support systems can be used successfully in animal husbandry (Akilli et al., 2016).

There are some other studies to investigate the utilization of AI. It was reported that the logistic regression method has performed well to predict conception success in dairy cows (Hempstalk et al., 2015). Takma et al. (2012) also investigated the effects of artificial neural networks and multiple linear regression models on the lactation period, calving season and service period on lactation milk yield and adaptation abilities of cows comparatively. Another study to classify and determine the effects of various factors such as season and natural selection on the fertilization of Japanese quail eggs by utilization of AI has been developed. This study has determined that %85 of quail eggs were productive and %15 had lower reproductive efficiency with a success rate of %99.7 (Küçükönder et al., 2014).

Recent research has been conducted using deep learning AI techniques to detect left atrial enlargement from thoracic radiographs of dogs and to compare these results with a diagnosis of physicians. The results of this research have revealed that AI can be used to diagnose left atrial enlargement as the data obtained by AI is correlated to the data obtained by physicians (Li et al., 2020).

In another study, it was reported that AI techniques accurately determined the necessity for surgical intervention and the probability of survival in horses with acute colic (Fraiwan and Abutarbush, 2020). In the same year, a veterinary consultation program was coded by changing an existing communication system so that patient owners could consult, and it was suggested that with this program, patient owners could be accurately informed about the health of their animals (Huang and Chueh, 2020).

The European Coordination Committee on Veterinary Training (ECCTV) provided a report in 2020 on the application of digital technologies and artificial intelligence in veterinary education and practice. In the report, a comprehensive literature review was executed, the effects of digital technologies and artificial intelligence on veterinary education and practice were evaluated, the advantages and disadvantages of the integration of such technologies were examined and variable recommendations weresubmitted (Avignon et al., 2020).

In another recently published article, Ezanno et al., (2021) evaluated the contributions of artificial intelligence to veterinary medicine research and practice, determined possible obstacles and challenges and prepared recommendations.

The advantages of digital transformation were reported in a recent review. In that review, the digital transformation in livestock farming and related improvements to animal health, detection of diseases, increasing productivity and solving problems were evaluated (Fuentes et al., 2022).

Likewise, Zuraw and Aeffner (2022) also evaluated and introduced emerging topics around artificial intelligence and machine learning in veterinary pathology.

Artificial intelligence and ethics in medicine

Even if an artificial ethical algorithm is created with artificial intelligence, some disadvantages and artificial ethical problems may arise in defining good or bad behaviors as a form of verifiable information (Cokar, 2019).

Ethics, as an intellectual activity, systematically examines the motives for good or bad behavior and aims to develop certain norms about how to behave. Various opinions have been proposed about the nature and meaning of ethical judgment throughout the history of philosophy. There are philosophers who justify that ethics is a phenomenon entirely related to the will, as well as those who claim that ethics is based on informational quality and that moral principles are mathematically precise.

An ontological dimension is added to the debate on the ethical -knowledge relationship, with AI applications expected to show similar behavior to human behaviour. If moral codes are mathematically precise, they can be inserted into AI algorithms. On the contrary, if moral codes are based on the will, the primary objective for AI should be learning the concept of will. Even if an artificial ethical algorithm is implemented in AI, disadvantages and artificial ethical problems (system functioning is a black box, not be legally liable for the results obtained by the system, the security of the information added into the system is controversial etc.) may arise with defining good or bad behaviours as a form of verifiable information (Cokar, 2019).

Conclucion

Considering the advancing technology, it is inevitable that AI systems will be implemented into our lives more and more in the near future. Even though the AI is objective and unbiased, data input to train AI is human-based. Inevitably, human-based data contains biased inputs and accumulating data will strengthen its subjectivity.

Furthermore, a moral codex of the trainer is necessary due to possible errors in the algorithm. However, such rules cannot avoid hijacking AI systems and using them for personality-based microtargeting. Additionally, deep learning algorithms used by AI systems complicate matters further. It is easy to assess the quality of the output data produced by such systems, yet the process is largely unclear and such opacity can be intentional.

Increasing utilization of AI in the work area is another important issue since it will cause the loss of blue-collar jobs, as well as less need for white-collar employees and even highly qualified professional staff. It is unclear whether new jobs will be created in other areas to accommodate such employees. All regulations indirectly raise an important question: "Who will supervise the supervisors?" Humanization movements of AI and robotics complicate the ethical dilemma since it forces us to confront what it means to be a human.

Nevertheless, free healthcare provided by AI and robots, lowering the cost of services, improved support for elder or vulnerable people, the idea of using artificial intelligence systems to solve significant problems such as disease and poverty and even introducing a universal healthcare system may bring lots of benefits for people, like creating spare time for creativity and altruistic pursuits. In fact, AI and robotics implementations in some industries may lead to a return to humanity, since humans will not be judged on efficiency and speed, but on altruism, empathy and creativity (Letheren et al., 2020).

Consequently, the accomplishments of the studies exhibited that AI is and will be needed in almost every field. Particularly, when the utilization of AI in medicine combined with future technologies will produce better results in healthcare and make a great contribution to the facilitation of human life.

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Author contribution

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