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Investigation of Artificial Intelligence Applications Used in Scientific Studies in Healthcare

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Abstract

The term artificial intelligence is largely used in the processes of developing systems equipped with intellectual processes that have features such as reasoning, meaning finding, generalization or learning from past experiences. Over time, some programs have reached the performance levels of human expertise and professionals to perform certain specialization tasks, so that over time, developing artificial intelligence (AI) could be used in a variety of applications such as medical diagnostics, computer-based search engines, and voice or handwriting recognition. However, classical analysis methods may be insufficient in medical research. The main reason for this is that often the evaluation of the research should be done before the patients die or the outcome examined, otherwise it may take years to determine which treatment method is better and the factors affecting the disease. For this reason, attempts have been made to develop computer programs that can serve as consultants. The researchers then began to examine specialist physicians to gain detailed information on the basic nature of clinical problem solving. The results obtained from such studies later became the basis for computational models of cognitive phenomena, and these models can be converted into artificial intelligence programs. With this review, it is aimed to provide information to researchers about the development and use of artificial intelligence especially in healthcare. Thus, it is aimed to contribute to the spread of artificial intelligence technology, which is one of the most important sectors for human life, which is accepted by scientists to reach a widespread use in our future. Thus, artificial intelligence technology, which is accepted by scientists to reach a widespread use in our future, It is aimed to contribute to the spread of artificial intelligence technology in healthcare, which is one of the most important sectors for human life.

Keywords: *Artificial Intelligence, Healthcare, Machine learning, Deep learning.*

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1. INTRODUCTION

1.1. Artificial Intelligence

As the amateur or professional participation in the sport increases, the sporty AI is the science of doing things that require learning [1]. Artificial intelligence studies are generally aimed at analyzing human thinking methods and developing similar artificial instructions [2].
Since the development of the digital computer in the 1940s, it has been shown that computers can be programmed to perform very complex tasks such as discovering proof for mathematical

theorems or playing chess. Even so, despite continued advances in computer processing speed and memory capacity there is no program to meet human flexibility in larger areas or jobs that require daily knowledge [1].

Artificial intelligence (AI), sometimes called by the name “machine intelligence” in computer science, unlike the natural intelligence exhibited by humans and animals, it is the intelligence shown by machines. The term “artificial intelligence” is used to describe machines among people that mimic “cognitive” functions that associate people with other human minds such as “learning” and “problem solving” [3].

The mental capacity of human beings is very important for our daily lives and our self-perception. Artificial intelligence tries to understand intelligent beings, so we need to do research to learn more about ourselves. Even at this early stage of development, AI has produced many important and impressive products. Although no one can predict the future in detail, it is clear that computers with human (or superhuman) intelligence will have a major impact on our daily life and future civilization process.

1.2. History of Artificial Intelligence

The history of the concept “artificial intelligence” is as old as modern computer science.In the 1940s, scientists made the explanation of the decision-making mechanism of the human with a ball and fire based on their research on the electrical collisions of neurons. Alan Mathison Turing opened machine intelligence to discussion with revealing the question, "Can machines think?" During the World War II in 1943, the concepts of computer science and artificial intelligence were born through the electromechanical devices produced with Crypto analysis requirements.In this way, artificial intelligence studies started in the 1950s [4].

In these years, Alan Turing carried out the Turing Test to test the ability of a machine to imitate people.Alan Turing was one of the most famous mathematicians trying to decipher the password algorithm of the Nazi's Enigma machine. The work started with the purpose of decryption in Bletchley Park, England, the computer prototypes formed by Turing's principles, Heath Robinson, the Bombe Computer and Colossus Computers, have formed the concept of Machine Intelligence with data processing logic based on Boolean algebra.

The main purpose of the Turing Test is to measure the machine's ability to relate to people during an interview. If the machine performs less badly than human, it is considered successful and has passed the test.If the machine performs less poorly than human it is considered successgul and has passed the test. The term “artificial intelligence” was used for the first time in a summer school organized by John McCarthy at Massachusetts Institute of Technology in 1956 and by Allen Newell and Herbert Simon at Carnegie-Mellon University. In 1959, after Arthur Samuel made his checkers program, the way to learn machine was opened.

After these years, studies such as abstract intelligence and knowledge-based systems were carried out until 1980s and this process was named as “artificial intelligence winter”. In the 1990s, with the development of game technologies, artificial intelligence and machine learning studies increased rapidly. Nowadays, artificial intelligence and machine learning are used in many research and study fields [5].

The content of the Turing Test is briefly as follows; A group of subjects, consisting of several people who do not know each other, chat for a valid time with each other and with an artificial intelligence dialogue system. At the end of this conversation, which is done by correspondence without seeing each other face to face, the participants are asked to determine which subject is human and which machine intelligence with the questions asked. Interestingly, in some of the tests done so far, people thought machine intelligence is human, while real people are machine.

These ancestors of modern computers and their programming logic were actually inspired by human intelligence. However, later, our modern computers became more widespread in the fields of use to solve the problems of our daily lives with programs that we can call expert systems. Companies such as Microsoft, Apple, Xerox, IBM, which were major computer manufacturers in the 1970s, generalized and popularized the computers. Artificial intelligence studies continued to be developed by a narrower research environment.

Today, in order to encourage these studies, the Turing Test, known as Turing's name, is applied on software with machine intelligence under the name of Loebner awards in the USA and awards are distributed to successful software. One of the best known examples of artificial intelligence dialogue systems on earth is the A.L.I.C.E., written by Dr. Richard Wallace from Carnegie University. The reason why this project and similar software gets criticized is that the programs are mainly dialogue systems (chatbot) since the criteria on which the test is measured are based on speech.
Classical analysis methods may be insufficient in medical research. The main reason for this is that often the evaluation of the research should be done before the patients die or the outcome examined, otherwise it may take years to determine which treatment method is better and the factors affecting the disease. The second reason is that treatments of patients do not applied at the same time. Life analysis methods give more appropriate results in such studies [6]. Studies on the statistical analysis of failure or death time of people and their surrounding units started with the help of life table. These studies were later developed and named as failure model or hazard model. These models were used to analyze the time of occurrence or observation of any well-defined event. Life analysis studies, which started in the 20th century, made great progress during the second half of this century.

The most effective developments in this field;
- Used to estimate life functions “Kaplan-Meier method” [7],
- Used to compare two life distributions “Log-rank Test Statistics” [8],
- Used to measure the effects of explanatory variables on life span “Cox Regression Model” [9],
- Started with the “Counting Process Martingale Theory”, which provides a unified structure to reveal the small and large sampling characteristics of life analysis statistics, and has survived to the present day [10].

Deep Learning was discovered by the architecture of the neuron depths in brain. Researchers have spent years trying to train multi-layered deep neural networks. None of these researches and experiments has been successful until 2006. Studies conducted until 2006 have been able to train two or three layer neural networks, but studies on more layers have failed. In 1960, the first generation neural networks were discovered by Frank Rosenblatt. This structure, which combines all features and finds the weight vector to recognize objects and uses a hand-made feature layer, is called Perceptron. In 1985, Geoffrey Hinton, using the Perceptron foundation, replaced the fixed and single feature layer with several hidden layers, thus creating the second generation neural network. In 1995, Vladimir Vapnik et al. discovered SVM (Support Vector Machines). SVM was focused on statistical learning cores, and unlike Perceptron, the fixed property layer was processed after converting the single layer into a multi-dimensional space, not directly. Although SVM has a simple structure, learning was fast and easy. Although SVM solved many problems in artificial intelligence, it had significant shortcomings and was a superficial architecture. In the mid-2000s, Geoffrey Hinton and Ruslan Salakhutdinas showed how to effectively train multilayered-fed neural networks in an article they published. In 2006, his work called "Deep Belief Network" showed how multi-layered deep structures work and how to complete self-completing features and this artificial neural network is called Deep Learning [11].

1.3. Usage Areas of Artificial Intelligence

Some examples of application areas of artificial intelligence are as follows:
- Suggestive Systems: Suggest new content based on users past behavior. For example, new friends on social media sites, another product in stores, other news suggestions in the newspaper.
- Machine Translation: Translating the sentence expressed in one language into another. For example, online tools such as Google Translate, Microsoft Translator and Yandex.
- Signal Processing: Information extraction by processing signals such as sound and image.

● Procedural Content Generation: Producing artificial content using stochastic methods. For example, procedural worlds in productive music and video games.
● Regression Analysis: Estimating the future value of a variable based on historical data. For example, economic projections, production quantity.

Sub Branches

● Machine Intelligence (Symbolic Artificial Intelligence)
● Artificial Neural Networks (Cybernetic Artificial Intelligence)
● Natural Language Processing (Thinking with the language)
● Speech Synthesis (Artificial Speech)
● Speech Comprehension (Speech Analysis)
● Expert systems
● Pattern Recognition
● Genetic Algorithms
● Genetic Programming
● Fuzzy Logic
● Multiple Instance Learning [12]

1.4. Use of Artificial Intelligence in Healthcare

AI in the field of health; preventing physicians from misdiagnosing and diagnosing and directing them to the right treatment choice, determining the factors and related causes affecting the disease, preventing waste of time, increasing the quality of life of patients with the right treatment and examinations, planning of diagnosis-treatment, patient follow-up processes, helping diagnosis and treatment of data in chronic and critical diseases.

AI in healthcare emerged in the 1960s, from new approaches to represent expert knowledge with computers developed by biomedical researchers Joshua Lederberg and Carl Djerassi and AI researchers Edward Feigenbaum and Bruce Buchanan from the Stanford University at the Heuristic Dendral Project [13, 14]. The Dendral team was originally motivated by Lederberg's interest in foreign matter and species derived from the first space research of the time, and was focused on scientific discovery and theory formation rather than clinical decision making [15].

Starting in the 1950s and throughout the 1960s, there was a parallel tendency to research, inspired by Weiner's cybernetics and McCulloch and modeling of Pitts's neural networks, leading to European initiatives and conferences on cybernetics [16]. Therewithal, these studies have not gone too far for learning in people who have turned out to be largely theoretical and speculative in the proposed models for the complex problems of feedback control in biology and both technologically and scientifically early. Instead, clinical documentation and medical systems developed in both Europe and the USA proved to be the first computer-based experimental software systems that promised routine clinical practice in the recording and analysis of clinical data, as shown at the first international conference in Elsinore, Denmark in 1966 [17]. Instead, as mentioned above, statistical approaches were the norms for medical data analysis and decision modeling. After the article of Ledley and Lusted appeared in Science in 1959 [18], the Bayesian paradigm provided the basic modeling approach to clinical reasoning. Nevertheless, the clinical study of time shows practical support for clinical data collection and analysis [19] and decision support, which was soon discussed and summarized [20, 21, 22].

Artificial intelligence is a branch of computer science that can analyze complex medical data. Potentials to use meaningful relationships in a data set can be used in many clinical scenarios to predict diagnosis, treatment and outcomes. The adequacy of artificial intelligence techniques has been researched in almost every field of medicine. While artificial neural network is the most widely used analytical tool, other artificial intelligent techniques such as fuzzy expert systems, evolutionary calculations and hybrid smart systems have all been used in different clinical settings [23].

They conducted a compilation study aiming to present a global and historical table of research on artificial intelligence in health and medicine. 28,497 articles published between 1977 and

2018 (85% 2008-2018) were taken from the Web of Science platform (Table 1). It has been observed that the number of cancer-related publications is highest, followed by heart diseases, stroke, visual impairment, Alzheimer's and depression [24].

Table 1. The most productive countries in AI in the field of Health and Medicine

No.	Nations	Number of Articles	Article Rate (%)	Citation Count
1	USA	10623	30.8	232669
2	China	2617	7.6	27997
3	Italy	1834	5.3	29485
4	Germany	1553	4.5	31219
5	Canada	1312	3.8	2,608
6	France	1308	3.8	22687
7	India	1264	3.7	12871
8	Spain	1029	3.0	14653
9	Australia	910	2.6	17413
10	Japan	841	2.4	11054
11	Turkey	787	2.3	9058
12	Iran	713	2.1	7438
13	Holland	640	1.9	14811
14	Switzerland	554	1.6	10197
15	Thailand	543	1.6	6213
16	Brazil	489	1.4	6097
17	Israel	384	1.1	6393
18	Sweden	382	1.1	6220
19	Belgium	365	1.1	7269
20	Singapore	349	1.0	5378

Table 2. Number of Articles about AI Techniques

Title	Robotic	ML	ANN	AI	NLP	DL	FES	EC	Clinical Application	Treatment	Prediction	Diagnosis	Total
Cancer	1774	767	366	144	103	0	5	6	28	209	1008	82	4492
Hearth Diseases	263	357	166	75	33	59	11	3	11	19	331	33	1361
Defect of Vision	543	264	81	101	57	1	4	5	19	27	189	21	1312
Stroke	543	99	45	16	9	0	0	2	13	32	119	5	883
Alzheimer	17	314	70	18	8	0	0	1	5	2	210	48	693
Depression	71	232	29	33	24	0	1	0	7	39	178	6	620
Kidney	293	64	38	14	9	0	2	0	1	17	125	9	572
Diabetes	38	159	86	34	20	0	4	3	1	6	176	21	548
Respiratory	119	104	64	20	16	2	0	0	1	9	136	6	477
Substance Use	75	101	57	17	35	7	0	0	2	20	120	4	438
HIV	24	114	35	28	21	6	0	2	6	10	113	4	363
Injuries	162	32	9	9	5	0	1	0	5	7	30	1	261
Asthma	12	60	29	6	12	1	2	0	0	0	62	4	188

Tuberculosis	8	42	17	12	2	2	0	0	1	2	42	15	143
Congenital	64	24	14	5	1	3	0	0	3	6	19	3	142
Cirrhosis	11	23	24	6	2	0	0	0	2	4	38	2	112
Malaria	4	38	9	8	1	0	1	0	1	0	42	2	106
Suicide	0	43	1	3	10	0	0	0	1	1	34	1	94
Chronic Obstructive Pulmonary Disease	5	32	7	3	3	0	1	0	0	0	29	1	81
Newborn	7	22	8	5	4	3	1	0	0	0	22	1	73
Hearing	7	11	9	6	0	0	0	1	0	1	14	3	52
Back Pain	18	5	9	2	1	0	0	0	2	2	11	0	50
Headache	0	0	0	0	0	6	0	0	0	0	0	0	6
Diarrhea	1	0	0	0	0	0	0	0	0	0	0	0	1
Total	4059	2907	1173	565	376	90	33	23	109	413	3048	272	13068

Zhang et al. report the following in their study "Variable-weighted Survival Learning Machine for COPD Failure Prediction" in 2019: Chronic Obstructive Pulmonary Disease (COPD), High rates of failure such as death and readmissions to hospitals in the United States, Canada and the world. COPD failure imposes a serious social and economic burden on society and predicting this failure is crucial for early intervention and decision making, this makes it a very important research topic. Current analysis methods address all risk factors in medical records without discrimination and therefore often suffer from ineffectiveness in real practice, because many of these factors are poorly related to foresight. Numerous studies have been conducted on the selection of factors for survival analysis, but their natural deficiencies make these methods impractical for failure prediction in the context of unknown and complex correlation models between risk factors. These challenges have enabled us to design a new Cox based learning machine that incorporates feature weighting technique into failure prediction. To increase the estimated accuracy, we suggest two weighting criteria to maximize the area under the ROC curve (AUC) and the fit index (C-index) respectively. At the same time, we carry out a Dirichlet-based arrangement on weights, which makes the differences between factor relevance clearly visible while maintaining the model's estimation as accurately as possible. Experimental results on real-life COPD data collected from hospitalized patients at Center Hospitalier Universitaire de Sherbrooke (CHUS) show the effectiveness of our learning machine and it shows great capability in clinical practice [25].

In their study titled “Machine learning practices in cancer prognosis and prediction” in 2014, Kourou et al. established an ML model on detecting the factors affecting cancer, modeling the progression and treatment of the disease, by evaluating cancer cases where early diagnosis is vital. Given the increasing trend in the application of ML methods in cancer research, they commented that these techniques can [26].

Lin et al. conducted a retrospective, multicenter ML study to predict the development of myopia, a common cause of vision loss among Chinese school-age children, using electronic medical records in 2018. In total, 17.113 follow-up records of 3.215 participants from 129.242 people in the ophthalmic center-based electronic medical record databases were included in the study. As a result, they have achieved success rates in the range of 0.752-0.985 [27].

Awan et al. developed an ML model for heart failure related death-recovery estimation in 2019. Using 10757 patient data, they observed respectively 0.55, 0.53, 0.58 and 0.54 AUC scores for random forest, decision trees, logistic regression and support vector machines models [28].

1.5. Artificial Intelligence Learning Algorithms

There are a wide variety of learning formats applied to artificial intelligence. Trial and error method is the simplest way to progress. For example, a simple computer program to solve chess problems can try random moves until a match is found. The program then can store the solution

with the position so that the computer will remember the solution the next time it encounters the same position again. It is relatively easy to implement on a computer to simply memorize individual items and procedures (known as learning by memorization). The difficult one is the problem of applying what is called generalization. Generalization involves applying past experiences to similar new situations. For example, a program that barely learns past tense of English verbs, cannot produce the past time of a word like jump, unless it has been previously presented with jumped, whereas a program that can generalize can learn. Based on the "add ed" rule and similar verbs, it creates a past tense.

2. MACHINE LEARNING

Learning has been defined by Simon as 'the process of improving behaviour through the discovery of new information over time'. The realization of the learning in this definition by the machine is called machine learning. The concept of improvement is the event to find the best solution for future problems by gaining experience and experience from the examples existing in the machine learning process [29]. With the advancement of information technologies over time, the concept of 'big data' has emerged. The concept of big data is defined as very large and raw datasets that have no limits and continue to accumulate and cannot be solved by traditional database methods [30].

Works performed using algorithms on the computer are carried out according to a certain order without any tolerance. However, unlike the commands created to obtain the output from the data entered in this way, there are also cases where the decision making process takes place based on the sample data already available on computers. In such cases, computers can make wrong decisions such as mistakes that people can make in the decision making process. In other words, machine learning is gaining the ability to learn by making use of data and experiences in a similar way to the human learning process [31]. The primary purpose of machine learning is to create models that can train themselves to develop themselves, perceive complex patterns and create solutions to new problems based on historical data [32].

Machine learning and data oriented approaches are becoming crucial in many areas. Smart spam classifiers protect our emails by learning from large amounts of spam data and user feedback. Advertising systems learn to match the right ads with the right content; Fraud detection systems protect banks from harmful intruders; Anomaly event detection systems help experimental physicists to find events that lead to new physics. There are two important factors driving these successful practices: The use of effective (statistical) models that capture complex data dependencies and scalable learning systems that learn the model of interest from large datasets.

After the stratified sampling, the data set is divided into test-education data at rates such as 70-30%, 80-20%. Most of it is used for education. The training is carried out using various machine learning algorithms.

The test data is the remainder of the training data. The confusion matrix is checked to calculate the success of the model used at the end of the test process. This matrix is a useful table that summarizes the real state and the predicted state.

3. DEEP LEARNING TECHNIQUE

Deep Learning was discovered by influencing the neuron depth architecture of the brain. The self-complementary learning technique of multi-layered deep structures modeled and features that are not fully completed is called deep learning. Recently, the Weibull time (WTTE-RNN) technique has been proposed for the recurring neural network event for customer escape analysis. This technique is used to predict the next recurrence time of the event when recurring situations are mentioned. In addition, this model is trained with the log-likelihood-loss function for censored data, which is frequently used in life analysis. Weibull distribution is simple enough to prevent heterogeneity and overfitting. The predicted Weibull parameters can be used to estimate the expected value and duration of the next event. WTTE-RNN is defined using a general structure for censored data. This model can be easily expanded with other distributions

and applied for multivariate prediction. In addition, in a study, the Proportional Hazard Model and the Weibull Accelerated Failure time model were found to have a special case [33].

Table 3. Types of Machine Learning

Supervised Learning		Unsupervised Learning		
Classification	Regression	Condensation		
k-Closest Contiguity Naive Bayes Support Vector Machine	Decision Tree Linear regression Artificial Neural Networks Logistic Regression Support Vector Regression	k-means, k-medoids Fuzzy c-means Hierarchical Gaussian Mixture Artificial Neural Networks Hidden Markov Model	Size Reduction	Reinforced Learning

4. CONCLUSION

There are many different artificial intelligence techniques that can solve various clinical problems. It is observed that the interest in automatic problem solving is increasing with the recognition of the difficulties of heuristic approaches, more traceable and expressive decision support mechanisms. However, it is vital that more randomized controlled trials are needed to prove the effectiveness of AI systems in medicine. There is strong evidence that medical AI can play a vital role in helping the clinician deliver healthcare efficiently in the 21st century. There is little doubt that these techniques will serve to develop and complement the future "medical intelligence" of the clinician. Artificial intelligence techniques have the potential to be applied in almost any medical field.

There are indications that AI can contribute to problems and help develop relatively undiscovered limits in decision making. Due to the increased interaction among disciplines, great advances can be expected in both AI and healthcare. We hope this article will assist these advances. It is particularly suitable for the application of AI tools due to the natural opportunities for the richness of available data in intensive care, emergency services, and increased efficiency in applicant patient care. A variety of new AI tools are expected to be available in the future, which can serve as smart assistants for clinicians, constantly monitor electronic data streams for important trends or adjust bedside devices. Integration of these decision support mechanisms in health units can be expected to reduce costs and improve patient outcomes.

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