JAIHS 2021; 1(1):16-23
DOI 10.52309/jai.2021.4

Derleme / Review

Covid-19 Pandemic and Investigation of Artificial Intelligence Applications Used in the Pandemic

Covid-19 Pandemisi ve Pandemi Sürecinde Kullanılan Yapay Zekâ Uygulamaları

Beşir Sefa MUMAY*[1], Ceren MUTLU[2]

ABSTRACT

It is certain that there have been dozens of pandemics in human history that caused mass deaths and destruction. Covid-19 disease has also turned into a pandemic with its rapid and intercontinental spread. According to some sources, the Covid-19 pandemic is one of the worst disasters in human history. Despite very serious precautions taken worldwide, Covid-19 continues to threaten health systems and human life. Under these conditions, humanity needs faster, cheaper, more efficient and more accurate diagnostic and treatment methods both in order to control the current pandemic and to be prepared for new pandemics. Undoubtedly, artificial intelligence technologies that are correctly designed and put into service will provide us with this support. In fact, many simultaneous vaccination studies, many applications that make life easier during the pandemic period, the use of artificial intelligence algorithms with foresight and predictive ability, have somewhat reduced the destruction of the pandemic. This study aims to evaluate the coronavirus-induced pandemics and SARS-CoV-2 virus in general in the light of current data and literature, to explain the features of artificial intelligence, and to present examples of artificial intelligence applications used in the pandemic period.

Keywords: Coronavirus, Covid-19, Pandemic, Artificial Intelligence, SARS-CoV-2

Received/Geliş : 11.03.2021
Accepted/Kabul: 26.03.2021
Publication date: 15.04.2021

Beşir Sefa MUMAY
[1]İstanbul University, Institute of Health Sciences, Department of Pharmaceutical Technology, İstanbul, TURKEY.
ORCID: 0000-0002-5097-8395

Ceren MUTLU
[2]İstanbul University, Faculty of Pharmacy, İstanbul, TURKEY.
*sefamumay@gmail.com
ORCID: 0000-0003-2839-0146

ÖZ

İnsanlık tarihinde toplu ölümlere ve yıkımlara sebep olan onlarca pandemi yaşandığı kuşkusuzdur. Hızlı ve kıtalar arası sınır tanımayan yayılımıyla Covid-19 hastalığı da bir pandemiye dönüşmüştür. Covid-19 pandemisi, bazı kaynaklara göre insanlık tarihinin başına gelen en büyük felaketlerden biridir. Dünya genelinde alınan çok ciddi önlemlere rağmen Covid-19 sağlık sistemlerini ve insan yaşamını tehdit etmeye devam etmektedir. Bu şartlar altında hem mevcut pandemiyi kontrol altına almada hem de yeni pandemilere karşı hazırlıklı olma noktasında insanlık daha hızlı, daha verimli, daha düşük maliyetli ve daha fazla doğruluğa sahip tanı ve tedavi yöntemlerine ihtiyaç duymaktadır. Hiç kuşkusuz doğru tasarlanmış ve hizmete sunulmuş yapay zekâ teknolojileri bize bu desteği sağlayacaktır. Öyle ki, eş zamanlı yürütülen birçok aşı çalışması, pandemi döneminde hayatı kolaylaştıran birçok uygulama, öngörü ve tahmin yeteneği olan yapay zekâ algoritmalarının kullanımı gibi durumlar, pandeminin yıkılıcığını bir miktar azaltmıştır. Bu çalışmanın amacı; güncel veriler ve literatür ışığında, koronavirüs kaynaklı pandemileri ve SARS-CoV-2 virüsünü genel olarak değerlendirmek; yapay zekanın özelliklerini açıklayarak pandemi sürecinde kullanılan yapay zekâ uygulamalarına örnekler sunmaktır

Anahtar Kelimeler: Koronavirüs, Covid-19, Pandemi, Yapay zekâ, SARS-CoV-2

Introduction

Pandemic is a term that means “affecting all humanity”, which is a combination of the words “pan” meaning “all” and “demos” meaning “people” in the ancient Greek language (1). The World Health Organization (WHO) defines a pandemic as “non-seasonal and rapidly spreading infectious diseases in which the human population does not have immunological resistance” (2 In pandemics, people experience not only health problems but also social and economic problems. Every epidemic in history has ended with great damage. Every pandemic in history has ended with a lot of damage.

According to some sources, the Covid-19 pandemic is one of the biggest disasters in human history. The current number of cases and deaths proves the seriousness of the situation to us every day. If this pandemic had occurred at a time when science and technology were not as advanced as this time, the power of destruction has been much greater. In fact, many simultaneous vaccination studies, many applications that make life easier during the pandemic period, the use of artificial intelligence algorithms with foresight and predictive ability, have somewhat reduced the destruction of the pandemic. Disruptive technologies and artificial intelligence are the key factors in making all these happen.

The concept of artificial intelligence first emerged in the 1950s. It has become widespread since 2010; After 2015, it started to be talked about in all areas of life. Artificial intelligence is a concept that we all need to adapt to and understand. In this study, the artificial intelligence applications used in the pandemic period were examined by explaining the Covid-19 Pandemic and the concept of artificial intelligence.

Examination of coronavirus related pandemics

Although the coronavirus that caused the pandemic didn’t sound familiar at first, it is likely that most people have encountered milder strains of this virus family before, as four strains of coronaviruses are responsible for approximately 20% of common cold cases (4). This pathogen, which has not been detected in humans before, has been identified as a new type of coronavirus. The causative virus was first named as 2019-nCoV (2019-novel coronavirus) and then SARS-CoV-2 due to its 70% similarity to SARS-CoV. WHO declared Covid-19 as a pandemic on March 11, 2020 (8, 9).

20 years ago, since coronaviruses cause only mild illnesses in humans, coronaviruses were not the focus of research. In 2003, it was discovered that the pathogen causing the SARS (Severe Acute Respiratory Syndrome) pandemic was the type of coronavirus, and researchers began to focus on this issue (4). The cause of SARS pandemic in China has been determined as “SARS-CoV” and the virus infected 8000 people around the world and killed approximately 800 people (5). About 10 years later, in 2012, another coronavirus strain caused the MERS (Middle East Respiratory Syndrome) outbreak. The strain that caused the MERS Pandemic originating from Saudi Arabia was named MERS-CoV, has spread to 27 different countries in 4 continents, killing 791 people (5, 6). In Table 1, epidemiological comparison of viral respiratory diseases as of March 2020 is given.

The WHO China Country Office reported cases of pneumonia of unknown cause in Wuhan, China, on December 31, 2019 (7). Most of these early cases were associated with the Huanan seafood market, where livestock and seafood were sold. Later, in studies to find the origin of the virus, the most similar gene sequences were found in coronaviruses originating from bats. With these results, scientists thought that the virus was transmitted from bats. However, since bats were not sold in the Huanan seafood market, it was concluded that another animal species was an intermediate carrier in the transmission of the virus to humans (4).

Disease	Flu	Covid-19 S	ARS	MERS
Pathogen	 Influenza virus	 SARS-CoV-2	 SARS-CoV	 Mers-CoV
R_0 (Basic Reproduction Number)	**1.3**	**2.0 – 2.5***	**3**	**0.3 – 0.8**
DTR (Death to-case Ratio)	%0.05 – 0.1	~ %3.4*	%9.6 – 11	%34.4
Incubation Time	1 –4 day	4 – 14 day*	2 – 7 day	6 day
Possibility of Transmission	%10 – 20 %	30 – 40*	%10 -60	%4-13
Annual Number of Patients (Global)	~ 1 billion U	nknown (In 3.5 months 145.000+)*	8098 (In 2013)	420

Table 1. Epidemiological Comparison of Viral Respiratory Diseases

SARS-CoV-2 and covid-19

SARS-CoV-2 is a single-stranded, positive-polarity enveloped Ribonucleic asid (RNA) virus located in the Coronaviridae subfamily of the Nidovirales class (8). The virus contains four main structural proteins which are: Nucleocapsid (N) protein, Transmembrane (M) protein, Envelope (E) protein and Spike (S) protein. These structures are shown in Figure 1.

The S (spike) protein in the structure of the virus enables the virus to enter the target cell by recognizing the receptor. After binding to the receptor, the S protein undergoes a structural change and with this change, the virus can release its own RNA into the cell. New viruses, which are formed as a result of a series of reactions taking place inside the cell with virus RNA and viral proteins, are released from the host cell through exocytosis and thus cause infection (5, 10).

The structural S protein, which also gives the virus its major antigenic property, shows high affinity for the Angiotensin Converting Enzyme 2 (ACE2) receptor in humans. ACE2 enzyme is highly expressed in the human body primarily in the lung tissue and then in the heart, kidney, vascular endothelium and intestinal epithelium. The widespread distribution of the ACE2 enzyme in different vital tissues in the body also explains the multiple organ failure seen in patients (8).

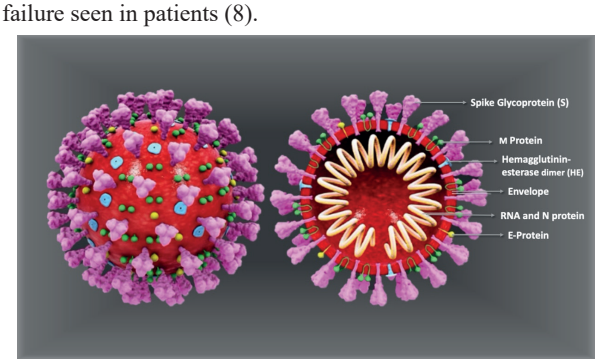

Figure 1. Schematic Representation of the SARS-CoV-2 Virus

The mechanism of these injuries caused by the SARS-CoV-2 virus in the body has not been fully discovered, but it is known that the disease begins with flu-like symptoms and the infection progresses with varying severity from person to person (5). The most common symptoms of Covid-19 so far are dry cough, high fever, and fatigue. The disease progresses with loss of taste and smell, diarrhea, headache, nasal congestion, and rashes on the body. At the same time, in severe cases, the disease can turn into pneumonia and respiratory support may be needed. The infection has a more severe course especially in elderly individuals who are considered high-risk group as well as those with underlying chronic diseases. Babies, children, and young people also have the possibility of contracting and transmitting Covid-19 (6).

It is known that the disease is transmitted from person to person through droplets. Regardless of whether the patient is symptomatic or asymptomatic, the virus enters the body and spreads as a result of contact with droplets spreading from infected individuals through the mouth, nose, or eye mucosa (6). The period from infection with the virus to the onset of symptoms is called the incubation period. The most critical point is that people can transmit the disease in this presymptomatic stage (11).

Numerous clinical studies are ongoing in which new agents and drugs currently used for different indications are being tested in the treatment of Covid-19 (8). At the same time, scientists are competing with each other to develop vaccines to control this pandemic. It took a year for various vaccines to enter the application phase, and there are no curative treatments or drugs yet.
Despite very serious precautions taken worldwide, Covid-19 continues to threaten health systems and human life. Under these conditions, humanity needs faster, cheaper, more efficient and more accurate diagnosis and treatment methods, both to control the current pandemic and to be prepared for future pandemics. Surely, artificial intelligence technologies that are correctly designed and put into service will provide us with this support.

The concept of artificial intelligence (AI)

The clearest definition of the concept of AI in the literature is "Digital technology and/or applications that have the ability to imitate human beings, interact, learn, adapt and apply by expanding their experience" (12). AI is arguably the most popular topic of computer sciences and technology.

The first article about AI was written by Turing in 1950. In this article, rather than technical and hardware information; The philosophical dimension of the issue was discussed by posing the question "Can a machine think like a human?" (3). The main purpose of AI applications is to understand and apply the human mindset and decision-making mechanism of the mind. The first event that brought the ability of a machine to think and therefore the concept of intelligence to the literature and made these concepts recognized worldwide was International Business Machines's (IBM) virtual chess player, Deep Blue, defeating even the toughest players. AI algorithms occur with;

- Learning and understanding experiences,
- Evaluating the results,
- Ability to detect similarities between different situations (13).

The concept of artificial intelligence has many categories. AI categorization can be examined under three sections (14-16):

1. Rule-Based AI (Expert Systems, Decision Support Systems, Algorithms etc.)
2. Decision-Maker AI (Genetic Algorithm Code, Text Mining etc.)
3. Learning AI (Artificial Neural Networks, Deep Learning etc.)

The systems that AI algorithms decide by thinking like an expert in any subject are called expert systems. The concept of expert system can briefly be described as "Getting the information ready to be processed or making it processable and then its combination with machine learning." AI algorithms in expert systems are the basis of the decision mechanism (17, 18). It receives the information necessary to make a decision from the expert person and interprets it according to the information provided by the person who will use the system. Data is added to the database by experts, and outputs are taken by non-experts. AI is currently used in fields such as medical diagnosis, construction, coding, banking, transportation, and defense industry, and it is predicted that it can be used in almost every field in the future (13).
Although expert systems seem very complex in structure, when examined, they are actually simple systems. The information taken from the expert source specific to the subject under consideration passes through the decision-making mechanism and provides an output. The basic structure of expert systems is given in Figure 2. An expert system should include these parts;

- Database,
- Exit mechanism,
- Advanced chaining mechanism,
- User interface (19).

When we approach AI algorithms not technically but systematically, four main elements stand out: Verification, validity, security and supervision. These are described in Table 2 (20-24).

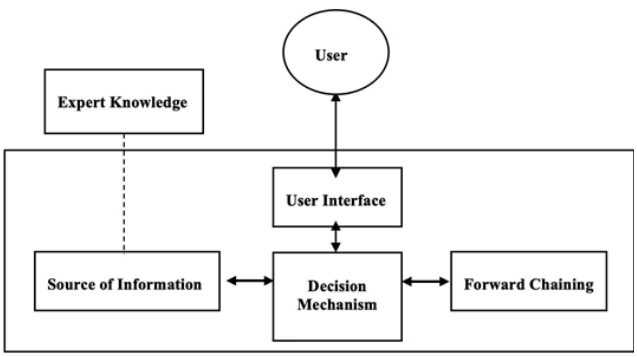

Figure 2. Fundamental Structure of Expert Systems

Elements	Definition
Verification	It is described as "proving or measuring the conformity of certain systems and / or applications to certain standards in a satisfactory and desired manner". The verified system is the systems in which no deviation occurs while the input is reflected in practice. In this way, artificial intelligence algorithms can be kept updated and effective.
Validitiy	Making sure that the system is set up correctly, shows the validity of that system. With this element, it is understood whether the system is suitable for the procedure or not.
Security	In areas where the use of artificial intelligence algorithms is critical, such as the defense industry, the security element plays an important role.
Control	Artificial intelligence algorithms can create their own self-control, but human control is constantly required. Because errors in such systems can produce very bad results.

Table 2. Systemic Elements of Artificial Intelligence Algorithms and Explanations of These Elements

Artificial neural networks (ANN)

ANNs are information processing systems that mimic biological neural networks that form the parts of the brain and the thinking structure (25). ANN performs the desired tasks by learning from the examples given. For example, after reviewing sample photos labeled “dog” or “not dog”, they can learn to identify dogs in other pictures. They analyse the image pixel by pixel and generate distinctive features from the given and processed samples (26).
Figure 3 shows a structure created using ANN. There may be more than one network connection in the middle outside the input and output areas. The example given in the figure is a single-link structure.

Artificial intelligence applications used during the pandemic process

1- Predicting and reporting the spread of the pandemic

One of the biggest challenges in the fight against Covid-19 is the lack of data and the uncertainty it brings. AI technology is one of the tools that can be used to eliminate some of these uncertainties. AI technologies accompanied by machine learning are able to achieve much faster and more consistent results than humans in processing existing information, processing data sets, establishing contextual relationships between data and decision-making processes (27). When these data analyses are used well, the transmission chains of the coronavirus can be broken, the domain of the pandemic can be reduced and even future outbreaks can be predicted.

Bluedot, a platform developed in Canada, is one of the companies using AI technology to protect humanity from infectious diseases. This platform managed to warn the Canadian government and its users about the “unusual pneumonia” that occurred in Wuhan, China, approximately 1 month before the WHO in December 2019. This platform, which examines international news reports, animal and plant disease networks, and official notifications with an AI-based algorithm, also points to new systems that can be used to ensure early measures to be taken by predicting future pandemics (27).

Various countries struggling with the virus at the point of controlling the spread of the outbreak have developed mobile applications that use different technologies such as Bluetooth, Global Positioning System (GPS), contact information, card transactions, and network-based Application Programming Interface (API). All these digital applications collect personal data and analyze them with artificial intelligence tools and thus help report the level of transmission of the disease. Studies show that more than 36 countries use these practices successfully (28, 29). South Korea, one of these 36 countries, has implemented a contact tracking system known as “Covid-19 Short Message Service (SMS)”. This system, which monitors the movements of individuals diagnosed with Covid-19, with data such as security camera images and credit card records, actively monitors people’s compliance with quarantine for 14 days. The system also sends notifications to people who may have been exposed to Covid-19 by contacting these individuals before diagnosis. South Korea was able to contain the spread of the outbreak in this way (30, 31).
In China, “Outbreak Prediction Technology” developed by the Alibaba is used. This structure, which is basically a cloud system, provides 98% prediction accuracy by using data such as flight information, number of new cases, number of close contacts, contact date. With this system using AI and machine learning, an effective outbreak strategy has been developed (27). Other countries and applications using digital contact tracking applications are as shown in Table 3 (28).

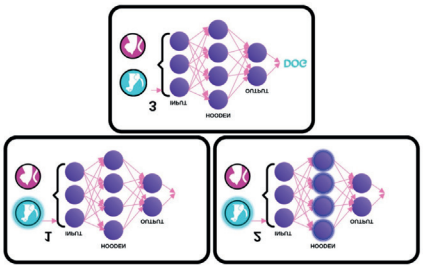

Figure 3. Example of Artificial Neural Networks

2- Control and detection of cases

Whether it is contagious or not, early diagnosis of any disease is important for early treatment and saving more lives (28). When it comes to combating pandemics such as Covid-19, these rapid screening and diagnosis processes become an important factor affecting the future of societies. AI technology have been shown to help in the diagnosis of cases using medical imaging Technologies such as Computerized Tomography (CT), and Magnetic Resonance Imaging (MRI) (29).
In a retrospective and multi-center study, a deep learning model that can detect Covid-19 from volumetric chest CT has been developed. This system, called the Covid-19 Perception Neural Network (COVNet), has been fed with 4356 chest CT exams taken from a total of 3322 patients. COVNet trained with a data group, which includes both Community-Acquired Pneumonia (CAP) and non-pneumonia CT samples, could distinguish Covid-19 from Community-Acquired Pneumonia and other lung diseases with 90% sensitivity and 96% specificity (32). The performance of COVNet is shown in Table 4.
A new Covid-19 diagnostic system that uses artificial intelligence and deep learning techniques has been developed in Turkey. The data set of the system consists of coronavirus, pneumonia, and normal CT X-ray images. It has been shown that this model can make an effective contribution in the detection of Covid-19 by achieving 99.27% success in classification (33).
In the United States of America (USA), a software developed with artificial intelligence at the Massachusetts Institute of Technology (MIT) can detect individuals with Covid-19 only using their cough sounds. MIT researchers discovered that the coughing characteristics of these individuals, even if they are asymptomatic, are different from healthy individuals. Then they trained artificial intelligence with cough samples and vocal words to detect cases. This software has been proven to detect up to 100% of asymptomatic cases correctly (34).
Considering that asymptomatic individuals are of critical importance in the transmission between individuals, it can be said that the widespread use of this software will be of great importance in the control of the pandemic.

The “Covid-19 Test Home Collection Kit”, in partnership with Kroger Health and Gauss companies in the USA, offers people the opportunity to make test in a home. Test kit is also supported by a mobile application. The test kit is analyzed in the laboratory and all steps of process can be controlled by the AI-based mobile application. Patient who would like to get tested follow step-by-step video instructions in this mobile application. Working with an AI-based technology, the application gives test results. According to results of a clinical trial submitted to the Food and Drug Administration (FDA) by the companies, the testing solution demonstrated a 93% positive correlation and 99% negative correlation compared to high-sensitivity, emergency-use-au-

thorized Polymerase Chain Reaction (PCR) tests. Covid-19 Test Home Collection Kit has been authorized for emergency use by FDA under an Emergency Use Authorisation (EUA) (35). This test promises great potential in reducing the workload of health-care professionals.

SI. No	Country	Contact Tracing App	Location Tracking	Launch on
1	Australia	COVIDSafe	BlueTrace protocol: Bluetooth	April 14,2020
2	Austria	Stopp Corona	Bluetooth, Google/Apple	March, 2020
3	Bahrain	BeAware Bahrain	Bluetooth & GSM	March 31, 2020
4	Bulgaria	ViruSafe	GSM	May, 2020
5	China	Conjunction with Alipay	GPS, GSM, credit-card-transaction-history	Very little info
6	Cyprus	CovTracer	GPS, GSM	May, 2020
7	Colombia	CoronApp	GPS	April 12, 2020
8	Czech Republic	eRouska (eFacemask)	BlueTrace protocol: Bluetooth	April 15, 2020
9	Estonia	Estonia's App	Google/Apple, DP-3T, Bluetooth	April, 2020
10	Finland	Ketju	DP-3T, Bluetooth	May, 2020
11	France	StopCovid	Bluetooth	May, 2020
12	Germany	CoronaApp	Bluetooth, Google	May, 2020
13	Ghana	GH Covid-19 Tracker App	GPS	April 12, 2020
14	Hungary	VirusRadar	Bluetooth	May 13, 2020
15	Iceland	Rakning C-19	GPS	April, 2020
16	India	Aarogya Setu	Bluetooth & location-generated social graph	April 2, 2020
17	Iran	Mask.ir	GSM	May, 2020
18	Ireland	HSE Covid-19 App	Bluetooth, Google/Apple	May, 2020
19	Israel	HaMagen	Standard location APIs	March, 2020
20	Italy	Immuni	Bluetooth, Google/Apple	May, 2020
21	Jordan	AMAN App-Jordan	GPS	May, 2020
22	Latvia	Apturi Covid	Bluetooth	May 29, 2020
23	Malaysia	MyTrace	Bluetooth, Google/Apple	May 3, 2020
24	Mexico	CovidRadar	Bluetooth	May, 2020
25	New Zealand	NZ COVID Tracer	Contact details and physical address	May 20, 2020
26	North Macedonia	StopKorona	Bluetooth	April 13, 2020
27	Norway	Smittestopp	Bluetooth and GSM	April 16, 2020
28	Poland	ProteGO	Bluetooth	May, 2020
29	Qatar	Ehteraz	Bluetooth and GSM	May, 2020
30	Saudi Arabia	Corona Map	Bluetooth	April 3, 2020
31	Singapore	TraceTogether	BlueTrace protocol: Bluetooth	March 20, 2020
32	South Korea	Non-app-based	Mobile device tracking data and card transaction data	May, 2020
33	Switzerland	SwissCovid	DP-3T protocol, Bluetooth, Google/Apple	May 20, 2020
34	Turkey	Hayat Eve Sığar	Bluetooth, GSM	April, 2020
35	UAE	TraceCovid	Bluetooth	May, 2020
36	UK	NHS Covid-19 App	Bluetooth	May, 2020

Table 3. Digital Contact Tracking Application

3- Biochemical test analysis

For people who have had Covid-19 disease, it is important to perform a blood test after the disease and to interpret the test results. Previous research has shown that, it is possible to read and interpret biochemical test results with AI (36, 37). Biochemical tests performed before and after a person's death can be compared and interpreted with the help of AI. In addition, thanks to AI algorithms, the reasons for which each out of limit value may arise can be analyzed and the highest probability case solutions can be made in this way.

4- Treatment, drug and vaccine development studies

Technology is used in drug and vaccine development studies. A traditional drug development process requires many years and very high costs. In fact, it is necessary to experiment with at least 10.000 similar molecules until the ideal molecule is found. AI can help with shortening these processes. Researchers use AI-based technologies to find new chemical molecules. AI-based technologies are important for finding the molecule with optimum properties (27). Researchers are working to identify and use AI-based innovative methods.

Considered to be the world's most powerful supercomputer, IBM Summit, with 200 quadrillion calculations per second, simulated 8000 different molecules available in the market in a short time and identified 77 molecules that could cure the infection by the virus. Under normal conditions, it is not possible to carry out such a study in such a short time. Experimental studies are needed to determine the molecule that gives the best results out of these 77 molecules (38).

The United Kingdom-based company Benevolent AI has proposed several compounds that are predicted to be effective when combined with molecular modeling based on the genomes of the relevant virus proteins (39).

Hong Kong-based Insilico Medicine has announced that it uses artificial intelligence infrastructure to design a molecule that can inhibit the ability of virus to reproduce. It was announced by the company officials that 100 molecules were determined among 100,000 molecules to be synthesized and tested by machine learning technique, and a 7-molecule component determined among these 100 molecules could be used for drug production. It is stated that with the help of the deep learning technique called Generative Tensorial Reinforcement Learning (GENTRL), new molecular structures with optimized properties can not be found using standard calculation methods (40, 41). Insilico Medicine company is one of the most active companies in the fight against Covid-19.

Another company working in this field is StoneWise. This firm announced that it obtained more than 1400 nucleoside components with the AI-based combination of nucleoside-based RNA polymerase inhibitors (42). All of these 1400 compounds are likely to be therapeutically useful compounds.

5- Patient data collection and storage

AI can also help create an electronic archive that can hold all medical transactions, records, assets and reports. With the increasing speed of storage capacity expansion such as flash disks, hard drives, optical media, flash drives that can hold huge volumes of information, it is becoming increasingly difficult for researchers to keep and analyze all this information (26). AI can be a reasonable resource for storing, interpreting, and using this type of data. It is important to set up these systems not only to store but also to use the information stored in the warehouse. With the help of a decision-maker AI algorithm, information can be compared and new rules can be found. According to IBM, AI can be useful in examining patients' past health records and establishing correlations between patients (43).

	Sensitivity %	Specificity %	AUC	P-value
Covid-19	90 (114 of 127) [83, 94]	96 (294 of 307) [93, 98]	0.96 [0.94, 0.99]	<0.001
CAP	87 (152 of 175) [81, 91]	92 (239 of 259) [88, 95]	0.95 [0.93, 0.97]	<0.001
Non-Pneumonia	94 (124 of 132) [88, 97]	96 (291 of 302) [94, 98]	0.98 [0.97, 0.99]	<0.001

Note: *Values in parentheses are the numbers fort he percentage calculation. Values in brackets are 95% confidence intervals [95%CI, %]. AUC=area under the receiver operating characteristic curve, Covid-19 = coronavirus disease 2019, CAP=community acquired pnemonia, COVNet=Covid-19 detection neural network.*

Table 4. Performance of COVNet, the Deep Learning System, in the Independent Test Set

Conclusion and discussion

There have been many pandemics in human history such as The Plague, Ebola, Spanish Flu and Acquired Immune Deficiency Syndrome (AIDS). It is a fact that new pathogens will keep emerging in the future that will lead to new pandemics.

In addition to causing serious health problems and mass death, pandemics also cause irreparable damage to social life, economy, and education. Therefore, the prevention and control of pandemics go beyond being a medical problem (2).

Covid-19, which has spread to more than 200 countries since its detection in China, continues to cause more and more deaths every day. Humanity, who seeks a solution to the virus that brings human life to a standstill, actively uses AI in prevention, diagnosis, and treatment. Surely, AI technologies that are properly designed and put into service; can increase productivity for new projects, reduce costs for health services, and provide greater accuracy and precision during diagnosis and treatment.

Some questions remain unanswered for now: "When will the Covid-19 pandemic end?" or "Can an effective drug or treatment be found for the virus?" However, with this pandemic, it has been seen that the whole world should be more prepared for possible future pandemics. In the light of these lessons learned with AI in the Covid-19 process, it is a need, even a necessity, to focus on studies for possible new pandemics.

Acknowledgements

Thanks to Pharm. Selin PALABIYIKOĞLU for her support to the study.

References

1- Aslan R. Tarihten Günümüze Epidemiler, Pandemiler ve Covid-19. Ayrıntı Dergisi. 2020 Apr;8:85.

2- Özkoçak V, Koç F, Gültekin T. Pandemilere antropolojik bakış: koronavirüs (covid-19) örneği. Turkish Studies. 2020 Apr;15(2):1183-1195. doi: 10.29228/TurkishStudies.42679

3- Turing AM, 2009. Computing Machinery and Intelligence, In: Parsing the Turing Test, Ed; Epstein R, Roberts G, Beber G, First edition, Springer, Dordrecht, Netherlands, pp; 23-65. doi: 10.1007/978-1-4020-6710-5_3

4- Ak Ö. Küresel Kabus: Coronavirüs ve Covid-19 [Internet]. Turkey: TÜBİTAK Bilim ve Teknik Dergisi; 2020 Mar [cited 2020 Dec 12]. Available from: https://bilimteknik.tubitak.gov.tr/makale/soguk-alginligindan-olumcul-salgina-kuresel-kabus-coronavirus-ve-covid-19

5- Uludağ Ö. Koronavirüs enfeksiyonları ve yeni düşman: Covid-19. ADYÜ Sağlık Bilimleri Dergisi. 2020 Apr;6(1):118-127. doi: 10.30569/adiyamansaglik.716011
6- Budak F, Korkmaz Ş. COVID-19 Pandemi Sürecine Yönelik Genel Bir Değerlendirme: Türkiye Örneği. Sosyal Araştırmalar ve Yönetim Dergisi. 2020 May;1:62-79. doi: 10.35375/sayod.738657
7- Hasöksüz M, Kılıç S, Saraç F. Coronaviruses and SARS-COV-2. Turk J Med Sci. 2020 May;50:549-556. doi: 10.3906/sag-2004-127
8- Alp Ş, Ünal S. Yeni koronavirüs (SARS-CoV-2) kaynaklı pandemi: Gelişmeler ve güncel durum. FLORA Dergisi. 2020 May;25:69574. doi: 10.5578/flora.69574
9- Samancı M. Küresel Bir Salgın: Covid-19. Samsun Sağ Bil Der. 2020 June;5(1):6-11.
10- Ulasli M, Verheije MH, de Haan CA, Reggiori F. Qualitative and quantitative ultrastructural analysis of the membrane rearrangements induced by coronavirus. Cellular microbiology. 2010 May;12(6):844-861. doi: 10.1111/j.1462-5822.2010.01437.x
11- Mavi D, İnkaya AÇ. Covid-19: İmmün patogenez. FLORA Dergisi. 2020 May;25:69606. doi: 10.5578/flora.69606
12- Oxford Insights, Government Artificial Intelligence Readiness Index [internet], England, Oxford Insights and the International Development Research Centre; 2019 Nov [cited 2021 Jan 11]. Available from: https://www.oxfordinsights.com/ai-readiness2019
13- Atav A. İlaçların diğer ilaçlar ile etkileşimlerinin uzman sistem ile belirlenmesi [master thesis]. [İstanbul (Turkey)]: Maltepe University, 2020.
14- Turban E, Aronson JE, Liang TP. Decision Support System And Intelligent System, 7th ed., Prentice Hall Inc, New Jersey, 2005. p.300-357.
15- Turban E. Decision Support and Expert Systems: Management Support Systems, 4th ed., Prentice Hall Inc, New Jersey, 1995, p435-675.
16- Kliegr T, Bahnik S, Fürnkranz J. A review of possible effects of cognitive biases on interpretation of rule-based machine learning models. Artificial Intelligence. 2021 Jan;295:103458. doi: 10.1016/j.artint.2021.103458
17- Shrestha YR, Ben-Menahem SM, von Krogh G. Organizational Decision-Making Structures in the Age of Artificial Intelligence. California Management Review. 2019 July;61(4):66-83. doi:10.1177/0008125619862257
18- Dimiduk DM, Holm EA, Niezgoda SR. Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering. Integr Mater Manuf Innov. 2018 Aug;7:157–172. doi: 10.1007/s40192-018-0117-8
19- Liao SH. Expert system methodologies and applications—a decade review from 1995 to 2004. Expert Systems with Applications. 2005 Jan;28(1):93-103. doi: 10.1016/j.eswa.2004.08.003
20- Russell S, Dewey D, Tegmark M. Research Priorities for Robust and Beneficial Artificial Intelligence. AI Magazine. 2015 Dec;36(4):105-114. doi: 10.1609/aimag.v36i4.2577
21- Russel S, Hauert S, Altman R, Veloso M. Ethics of artificial intelligence. Nature. 2015 May;521:415-418.
22- Tamer HY, Övgün B. Yapay Zeka Bağlamında Dijital Dönüşüm Ofisi. Ankara Üniversitesi SBF Dergisi. 2020 May;75(2):775-803. doi: 10.33630/ausbf.691119
23- Thierer AD, O'Sullivan AC, Russell R. Artificial Intelligence and Public Policy. Mercatus Research Paper, 2017 Aug. Available at SSRN: https://ssrn.com/abstract=3021135. doi: 10.2139/ssrn.3021135
24- Scherer MU. Regulating Artificial Intelligence Systems: Risks, Challenges, Competencies, and Strategies. Harvard Journal of Law&Technology. 2016 Sep;29(2):354-400. doi: 10.2139/ssrn.2609777
25- Lipmann RP. An Introduction to Computing with Neural Nets. IEEE ASSP Magazine. 1987 Apr;4(2):4-22. doi: 10.1109/MASSP.1987.1165576.
26- Gupta S, Sharma V, Johri P. Artificial Intelligence in Forensic Science. International Research Journal of Engineering and Technology. 2020 May;7(5):7181-7184.
27- Uzun MM. Covid-19 ile Mücadelede Yapay Zekâ Uygulamaları. ULİSA12. 2020 May;2:45-51.
28- Lalmuanawma S, Hussain J, Chhakchhuak L. Applications of machine learning and artificial intelligence for Covid-19 (SARS-CoV-2) pandemic: A review. Chaos Solitons Fractals. 2020 Oct;139:110059. doi: 10.1016/j.chaos.2020.110059
29- Vaishya R, Javaid M, Haleem KI, Haleem A. Artificial Intelligence (AI) applications for COVID-19 pandemic. Diabetes&Metabolic Syndrome. 2020 Apr;14(4):337-339. doi: 10.1016/j.dsx.2020.04.012
30- Worldmeters. The counter of coronavirus case in South Korea [internet]. South Korea, Government of South Korea; 2020 Dec [cited 2020 Dec 10]. Available from: https://www.worldometers.info/coronavirus/country/south-korea/
31- Lin L, Hou Z. Combat COVID-19 with artificial intelligence and big data. Journal of Travel Medicine. 2020 May;27(5):1-4. doi: 10.1093/jtm/taaa080
32- Li L, Qin L, Xu Z, Yin Y, Wang X, Kong B, Bai J, Lu Y, Fang Z, Song Q, Cao K, Liu D, Wang G, Xu Q, Fang X, Zhang S, Xia J, Xia J. Artificial Intelligence Distinguishes COVID-19 from Community Acquired Pneumonia on Chest CT. Radiology. 2020 Mar;200905. doi: 10.1148/radiol.2020200905
33- Toğaçar M, Ergen B, Cömert Z. Covid-19 detection using deep learning models to exploit Social Mimic Optimization and structured chest X-ray images using fuzzy color and stacking approaches. Computers in biology and Medicine. 2020 June;121:103805. doi 10.1016/j.compbiomed.2020.103805
34- Chu J. Artificial intelligence model detects asymptomatic Covid-19 infections through cellphone-recorded coughs [internet]. USA, MIT News Office; 2020 Oct [cited 12 Jan 2021]. Available from: https://news.mit.edu/2020/covid-19-cough-cellphone-detection-1029
35- FDA. Emergency Use Authorization Summary The Kroger Health Covid-19 Test Home Collection Kit [internet]. USA, FDA; 2021 Feb [cited 2021 Feb 24]. Available from: https://www.fda.gov/media/139683/download
36- Jonker CM, Snoep JL, Treur J, Westerhoff HV, Wijngaards WC. Putting intentions into cell biochemistry: an artificial intelligence perspective. Journal of Theoretical Biology. 2002 Jan;214(1):105-134. doi: 10.1006/jtbi.2001.2444
37- Zimmerman DE, Kulikowski CA, Huang Y, Feng W, Tashiro M, Shimotakahara S, Chien C, Powers R, Montelione GT. Automated analysis of protein NMR assignments using methods from artificial intelligence. Journal of molecular biology. 1997 June;269(4):592-610.
38- Smith DM, Smith JC. Repurposing Therapeutics for COVID-19: Supercomputer-Based Docking to the-SARS-CoV-2Viral Spike ProteinandViral Spike Protein-Human ACE2 Interface. Chemrxiv, preprint. 2020 Mar. doi: 10.26434/chemrxiv.11871402.v4
39- Richardson P, Griffin I, Tucker C, Smith D, Oechsle O, Phelan A, Rawling M, Savory E, Stebbing J. Baricitinib as potential treatment for 2019-nCoV acute respiratory disease. Lancet. 2020 Mar;395(10223):30-31. doi: 10.1016/S0140-6736(20)30304-4
40- Scudellari M. Five Companies Using AI to Fight Coronavi-

rus [internet]. USA, Spectrum IEEE; 2020 Mar [cited 2021 Jan 13]. Available from: https://spectrum.ieee.org/thehuman-os/artificial-intelligence/medicalai/companies-ai-coronavirus
41- Zhavoronkov A, Aladinskiy VA, Zhebrak A, Zagribelnyy B, Terentiev V, Bezrukov DS, Polykovskiy D, Shayakhmetov R, Filimonov A, Orekhov P, Yan Y, Popova O, Vanhaelen Q, Aliper A, Ivanenkov YA. Potential 2019-nCoV 3C-like Protease Inhibitors Designed Using Generative Deep Learning Approaches. ChemRxiv, preprint. 2020 Mar. doi: 10.26434/chemrxiv.11829102
42- StoneWise. StoneWise Latest Devolopment [internet] China, StoneWise; 2020 Feb [cited 2021 Jan 17]. Available from: http://www.stonewise.cn/Report_en
43- IBM. Artificial intelligence in medicine [internet]. USA, IBM Watson Health; 2020 Oct [cited 2021 Jan 18]. Available from: https://www.ibm.com/watson-health/learn/artificial-intelligence-medicine