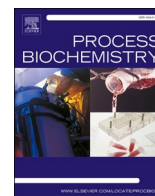




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Review

Artificial intelligence: Potential tool to subside SARS-CoV-2 pandemic



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ABSTRACT

Artificial intelligence (AI), a method of simulating the human brain in order to complete tasks in a more effective manner, has had numerous implementations in fields from manufacturing sectors to digital electronics. Despite the potential of AI, it may be obstinate to assume that the person administered society would rely solely on AI; with an example being the healthcare field. With the ever-expanding discoveries made on a regular basis regarding the growth of various diseases and its preservations, utilizing brain power may be deemed essential, but that doesn't leave AI as a redundant asset. With the years of accumulated data regarding patterns and the analysis of various medical circumstances, algorithms can be formed, which could further assist in situations such as diagnosis support and population health management. This matter becomes even more relevant in today's society with the currently ongoing COVID-19 pandemic by SARS-CoV-2. With the uncertainty of this pandemic from strain variants to the rolling speeds of vaccines, AI could be utilized to our advantage in order to assist us with the fight against COVID-19. This review briefly discusses the application of AI in the COVID-19 situation for various health benefits.

1. Introduction

Artificial intelligence (AI) being a method of simulating the biological human brain in order to complete tasks in a more effective manner could be used in various applications [1]. By simulating the cognitive abilities of the human brain, AI could be used to respond to input in a manner similar to that of humans. An example of that would be its ability to adapt and respond to differing situations accordingly, which in turn enables machines to solve problems more efficiently and on larger scales [2]. AI could be used in various applications, and some of the most useful sub-classes of AI are machine learning (ML), a network of computer systems that are able to extract patterns and information from data in order to solve problems in a similar manner to the human brain, and deep learning (DL), which is similar to ML but utilizes multiple layers of networks in order to exhibit its deeper machine learning capabilities (Fig. 1). Machine learning has been utilized in all sorts of automated systems; an example is advertisements targeted towards customers by analyzing their shopping habits. Deep learning utilizes multiple sorts of algorithms in order to form a more complex machine learning mechanism. Despite deep learning being a subclass of machine learning, both come with their distinct differences. The main difference between these two is that machine learning can be seen as a simpler learning algorithm, while deep learning utilizes an artificial neural network, which is similar to a human brain as more complex and multiple layers of algorithms are

used. The common machine learning algorithms are linear regression, logistic regression, random forest, naïve bayes and gradient boosting algorithms. The popular deep learning algorithms are convolutional neural networks (CNNs), Recurrent Neural Networks (RNNs), Long short-term memory networks and Generative Adversarial Networks (GANs). Both machine learning and deep learning algorithms are successfully utilized in various sectors of medical diagnosis. Developing AI requires the usage of complex mathematics as well as complex programming knowledge, where the implementations of algorithms such as clustering, regression and classification may be deemed essential in order to develop successful machine learning mechanisms [3]. Extracting the full potential of AI also subsequently requires big data, in which the current information on healthcare and COVID-19 would serve as an excellent source. DL as another subclass of AI utilizes multiple layers of algorithms, making its learning models even more complex in comparison to ML [4]. By utilizing multiple layers of compressed raw data, DL takes advantage of the multiple algorithms provided in order to produce the desired output [5]. With these AI mechanisms in mind, they could be applied to various industries, with one of the most important and relevant one being healthcare [6].

With the currently ongoing COVID-19 pandemic, several lives and the economy are currently being impacted and while a permanent solution is still in search, AI could prove to significantly impact and benefit the fight against COVID-19 from research studies to clinical trials [7–9].

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COVID-19, a respiratory disease consisting of transmissible properties (COVID-19 or 2019-nCoV or SARS-CoV-2) was initially discovered in China, thought to have first originated from bats. With an estimated 180 million cases and 3.9 million deaths as of July 2021 according to world meter, the various efforts being made have yet to bring an end to the global pandemic [10,11]. The COVID-19 causing virus is like other viruses and targets the healthy host cells for replicating. COVID-19 virus travels into our body and reaches the respiratory tract, where it could enter through the mouth or nose. A common symptom of COVID-19 is difficulty in breathing, a direct result of inflamed lungs. A build-up of fluid and mucus caused by the virus could also lead to this symptom. There have also been cases where the virus impacts the heart function, and in some cases, blood clots form. Despite these possible impacts on the body, there have also been several issues, such as temporary loss of taste, shortness of breath, and conjunctivitis. Despite numerous types of vaccines claiming to subside COVID-19, none have been declared to consist of certain effectiveness by the Food and Drug Administration, which indicates the urgency of the situation and the need for an efficient strategy to overcome this current issue. With this global pandemic impacting our society for the past two years, a more efficient and impactful solution could be derived from the various data that has been collected, not only from the patients and statistics regarding COVID-19 such as age, symptoms and location, but the amassed medical data gathered before the pandemic [12]. AI is one of the methods that could be employed in order to accumulate the data and output processed data which could be used to benefit countless situations.

2. Application of AI in healthcare system

AI has been effectively applied in various health care systems (Fig. 2). In most cases, it is utilized in three major areas, which include issues related to the nervous system, cardiovascular complications, and cancer [1–4]. AI techniques such as DL, ML and cognitive computers help indicate early developments of cardiovascular disease [5]. The reported health records have been stored as massive datasets and interpreted with the help of AI. Additionally, AI guides physicians with the help of clinical data in order to make better clinical decisions [6]. An example is ‘Internet of Things’ (IoT), which has been a game changer in issues revolving around the cardiovascular healthcare system. IoT

utilizes AI in order to send clinical data remotely to physicians and notifies them of the patient’s current situation. Another example is cardiac Computed Tomography (CT), which with the assistance of ML helps identify functional information beyond the characterization of atherosclerotic plaque [7–9]. AI applications could also prove to be helpful in identifying Alzheimer’s disease. Various AI bases as diagnostic approaches have been utilized to identify Alzheimer’s disease by using brain imaging along with the available data. Zhao et al. had employed AI techniques with the structural MRI images in order to detect Alzheimer’s disease. Since there is no specific treatment currently available for Alzheimer disease, early and smart identification helps improve the condition and development of the disease within the patient. A research group developed an algorithm with neuro imaging, which predicts the future possibilities of developing Alzheimer disease [10]. Apart from that, AI helps physicians and pathologists diagnose, predict the risk, treat, and predict the prognosis for various cancers. Clinical oncology has utilized AI-based strategies and next generation sequencing (NGS) in the past to generate high throughput data-set. An expert in oncology with a background in AI had designed suitable algorithms to identify selective biomarkers in order to reach the selected target sites. This will prove to be helpful in predicting cancer and its progression at its earlier stages [11].

3. AI application for COVID-19 surveillance

Humans and animals are vulnerable to viruses such as Influenza, SARS and current COVID viruses due to their transmittive nature [12,13]. In most cases wild birds are the source of these viruses and an efficient surveillance system within the bird population helps control the spread of these viruses to humans. Developing a suitable monitoring and diagnosing system is mandatory in controlling the spread of disease among humans. Unfortunately, active surveillance requires an abundance of resources, manpower, expenses and time. AI on the other hand, is an excellent tool in helping analyze the healthcare data with a suitable analytical technique and accelerating the process of diagnosing various diseases including the respiratory diseases mentioned earlier. Researchers have directed their focus in developing mobile-based applications using AI in order to predict the risk of various diseases and diagnose the condition of diseases based on analytical data. In

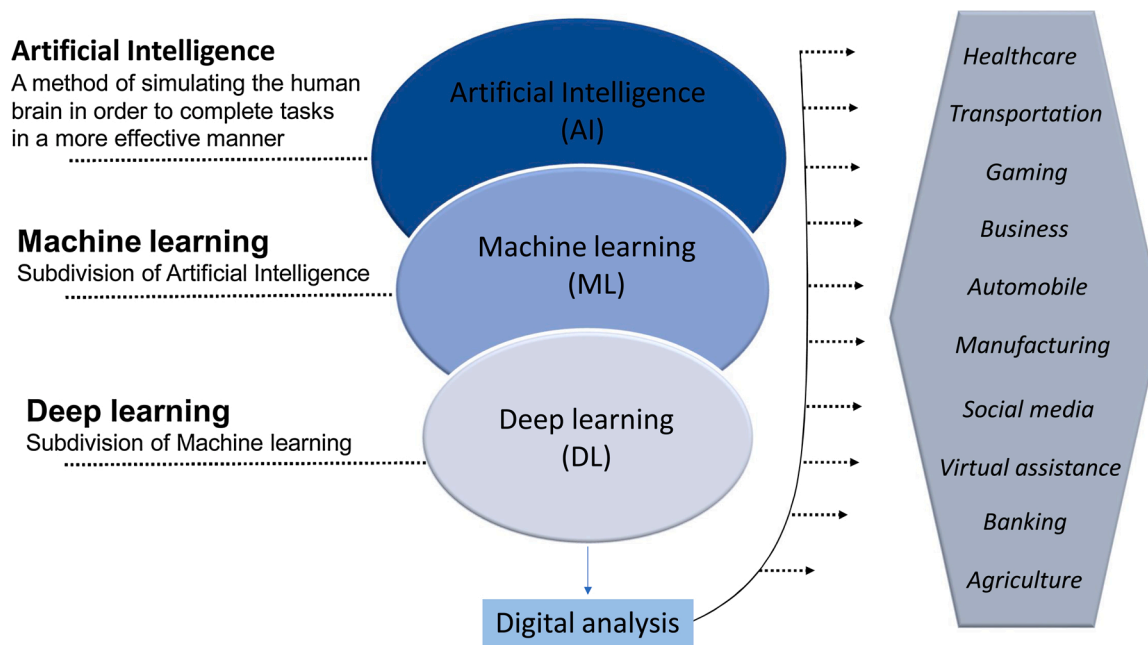


Fig. 1. Application of digital analysis with artificial Intelligence. Machine learning and deep learning are the subset of artificial Intelligence and the potential application of these for various healthcare applications are shown.

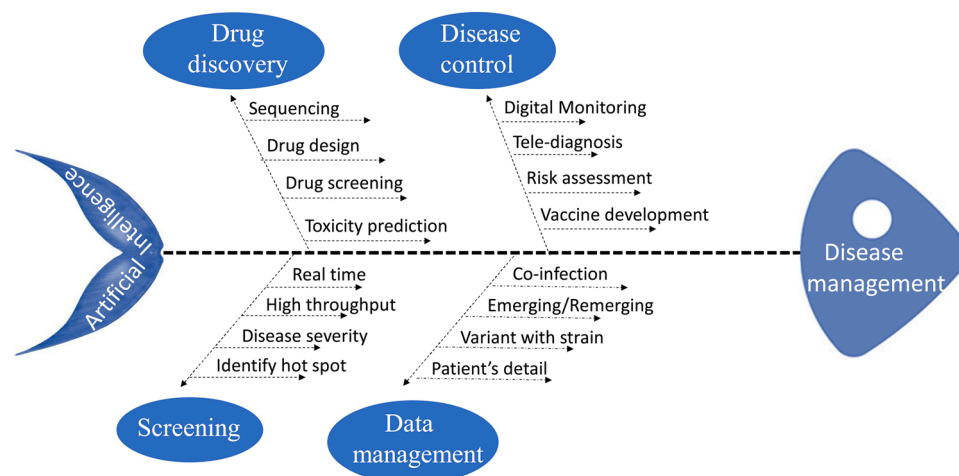


Fig. 2. Fish-bone diagram. Interpreting the correlation between AI and disease management, are connected by key elements including, screening, data management, drug-discovery, and disease control as displayed.

particular, this AI model serves as a crucial contributing factor in predicting the spread of diseases caused by viruses. As is currently known, COVID-19 is currently the most unpredictable and infectious disease around the world with no specific treatment, which makes preventive measures a crucial step in subsiding the number of COVID cases. AI helps analyze and assess information from reported cases and uses that to predict the situation regarding COVID-19. Yahya et al. used the geographic information system and developed an AI model with three artificial networks to predict the impact of COVID-19 in Iraq [14]. In addition, they predict the severity in which the virus would spread within the next 6 months and the average death case increase during the upcoming days, which helped develop a plan to combat the social effects of COVID 19 in Iraq. Similarly, Zhao et al. used SEIR (Susceptible, Exposed, Infected and recovery states) to predict the number of COVID cases in the future along with its transmission rate by using only a small number of assumptions in a single state in the US. They had discovered that the results shown were reasonably accurate and would be distributed similarly in the near future; These results had also assisted in predicting the rate of transmission [15]. Tuli et al. (2020) developed a mathematical model with a cloud-based AI framework to predict and analyze the growth of the COVID-19 epidemic. They collected data obtained from sources around the world and used the Robust Weibull model along with the Gaussian model to identify the current and future scenarios regarding the spread of COVID-19 [16].

4. AI application for imaging and diagnosis of COVID-19

AI applications in medical diagnosis provide various benefits to the healthcare industry. AI based applications can predict whether the patient has a particular disease prior to when the symptoms may appear. It often helps people sustain longer lives and avoid the need for hospitalization. In addition, using AI technologies help recognize patterns and analyse the images in order to create algorithms that help physicians diagnose diseases quicker and more accurately [13]. AI programs were also developed to spot signs of specific diseases in medical images, including X-rays, CT-scans and Magnetic resonance imaging (MRI). Various researchers are focused on developing an AI model that could be used to diagnose COVID-19 at its earlier stages, which could massively assist in lowering the rate of transmission. Borkowski et al. used AI techniques to diagnose COVID-19 by using chest X-rays. The researchers in that project used Microsoft CustomVision and an object detection system along with a widely available chest X-ray for patients infected with pneumonia from other etiologies, pneumonia with COVID-19, and normal chest X-rays as a dataset to train Microsoft Custom Vision. AI can help differentiate COVID-19 from other respiratory diseases, which

affect the lungs. Fig. 3 explains the flow-diagram of the process of COVID-19 classification by AI-mediated tools. As shown in figure, if the tool identifies the image as a COVID infection, then the treatment process for COVID will be started immediately until the patient becomes COVID-negative. If the image has been identified as negative for COVID, the pneumonia viral deep classification will be conducted by the AI tool. If it is positive, then the treatment for pneumonia needs to be provided. If it is negative, then the classification will be conducted for other bacterial infections (Fig. 3). These findings help with screening, monitoring and differentiation of the progression of COVID-19 and the diagnosing of COVID-19; This helps predict the risk of higher mortality and morbidity within patients [17]. Similar research had been done by Jiao et al. (2021) and had supported several of these applications. The researchers had collected the X-ray samples from 1834 patients and used the artificial chest X-rays to predict the progression and severity of the COVID-19 disease. It was found that the AI based chest X-rays had better diagnosis in comparison to radiologist derived severity scores and clinical data [18]. Furthermore, convolutional neural network (CNN) was used by researchers to analyse chest X-rays in order to identify COVID-19 and its conditions. They had proposed that CNN combined methods of machine learning, such as Bayes, K-nearest Neighbor, multilayer perceptron, random forest and support vector machine to detect COVID-19 [19]. Similarly, Kassani et al. had used the DL approach, which assisted CT images and X-rays to identify COVID-19 [20].

5. Role of AI in drug discovery

Drug discovery is an expensive and lengthy process, which could take up to 10–15 years just to develop a new molecular entity for the particular disease. Various steps are involved in the drug discovery and distribution process, which include preclinical research, clinical research, FDA review, and FDA safety monitoring. Apart from that, drug discovery is extremely time-consuming, laborious, and the output may not necessarily be effective. The clinical success rate is also very low and only about one in ten drugs reach the patients. Due to their lower efficacy, half of the discovered drugs end up unsuccessful. Researchers suggest that the main problem is choosing the right target for the disease. AI is a promising technique for drug discovery, which could potentially help shorten the time and accelerate the process by extracting the hidden patterns from the already available biomedical data, such as clinical, biological and open data (Fig. 4). Computer scientists, physicians and pharmaceutical scientists were adopting AI based tools to develop a new drug for various diseases. Furthermore, AI algorithms such as SMILES string and molecular descriptors help generate

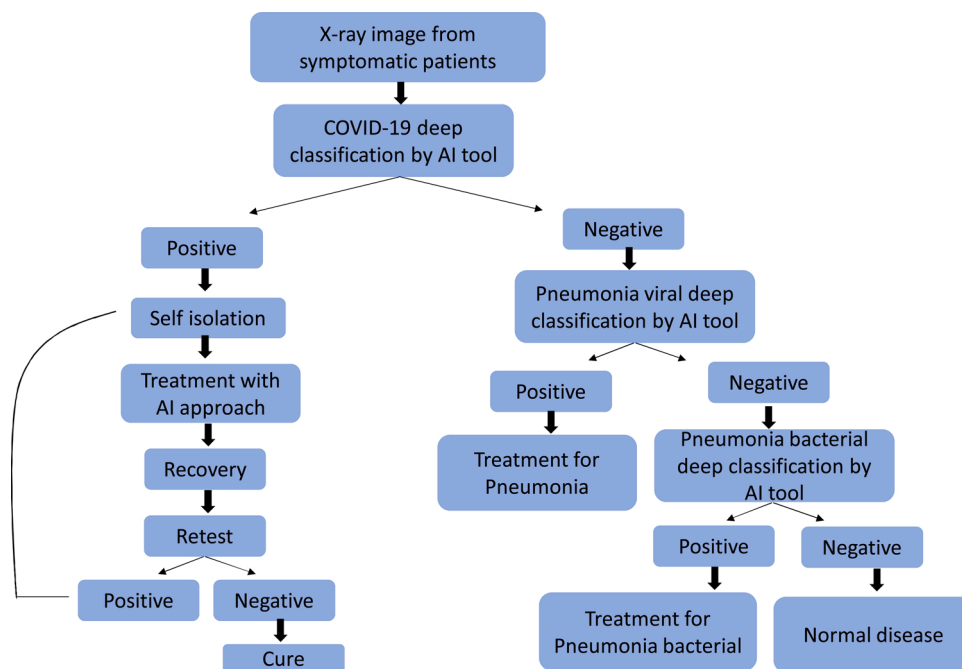


Fig. 3. COVID-19 identification by medical imaging. Figure explains the flow diagram of the process in COVID-19 classification by an AI tool. The tool identifies the image as a COVID-19, then the treatment process will be started immediately until the patient returns negative for COVID-19. If the image is identified as negative for COVID-19, then it is directed to other disease identifications and treatments.

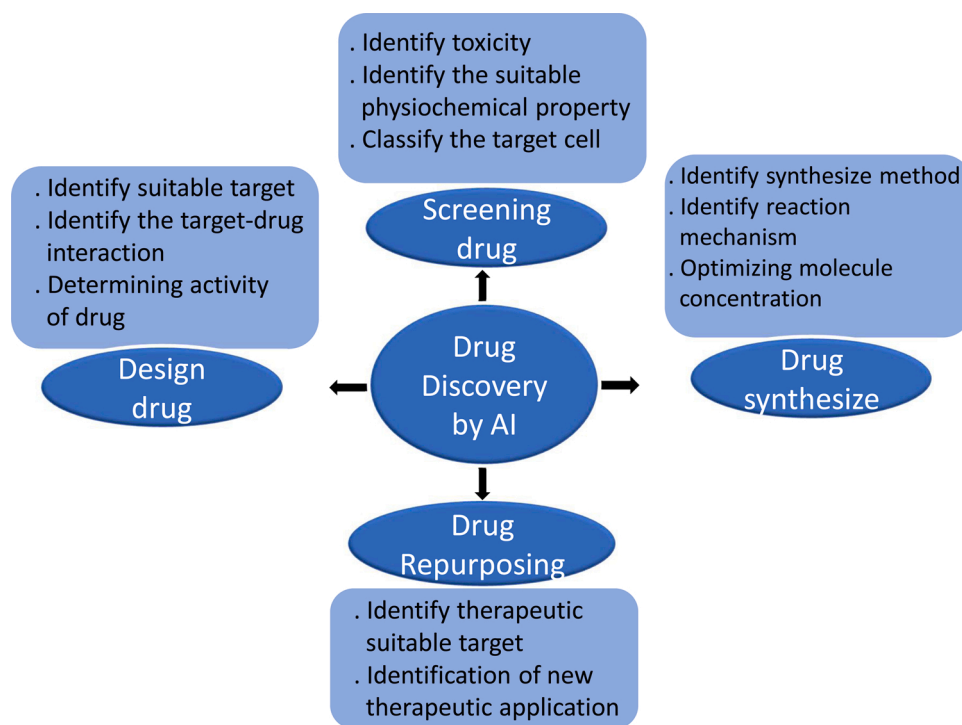


Fig. 4. Core of drug discovery with AI. AI helps various aspects of drug discovery such as designing, synthesizing, screening, and repurposing of drugs.

suitable molecules via DNN and have also proved to be helpful in predicting its properties [21]. In addition, physicochemical properties such as the degree of ionization, solubility, and intrinsic permeability of the drug highly impact the pharmacokinetics properties, which is important when designing a new drug. Various AI based techniques help predict the physicochemical properties, which help increase the rates of a successful drug discovery [22]. Pharmaceutical companies widely utilize AI for drug discovery and development [23]. Companies employ the

technology of DL screening from molecular structure data, research literature, disease databases, patient data, and phenotype data in order to assist in the drug discovery process. This in turn could further assist researchers who utilize AI technology to develop a drug using the reported outcome from a COVID-19 patient and evidence-based medical tools [24]. This technology helps accelerate the process of drug discovery for COVID-19 and clinical trials during vaccine development [17, 24]. COVID-19 requires a host of cellular factors, such as furin,

transmembrane serine protease, and angiotensin-I converting enzyme 2 for it to replicate during infection, thus targeting the host protein and its interaction helps develop an effective drug for COVID-19 along with the assistance of AI [25].

6. Remote digital monitoring and tele-medicine: prevents disease spreading

A very recent development in the field of medicine is ‘Remote digital monitoring’ and ‘Tele-medicine’. These involve a self-diagnosing system in which one end is with the patient and another end is with a medical practitioner connected to the patient through IoT (Fig. 5). ‘Remote digital monitoring’ and ‘Tele-medicine’ are highly connected to IoT and AI. The knowledge acquired through AI drastically reduces the tedious process behind medical diagnosis. With the involvement of AI, the diagnostic connects the obtained results and passes it onto the other end with the practitioner for the recommendation along with a programmed output. One of the perks that comes along with this is its ability to be used through a mobile-application, which a physician would be able to monitor/watch instantly. A similar approach could be established with COVID case management as a surveillance system. By coupling COVID cases screened using a remote digital monitoring, the spread of the disease could be drastically minimized. Diseases that may be emerging or re-emerging as an epidemic could be noticed earlier and prevent the formation of a pandemic. At the stage of the initial notification, the set-up of AI facilitates help control the disease through ‘tele-medicine’. These arrangements might be established in a regional-basis or through people assembling points, which could allow for a perfect controlling system to be formed wherever necessary (Table 1).

7. Improvement and future perspectives

Considering the current situation with how the epidemic and pandemic originated from different strains of COVID-19, the resumption of our regular lives remains unpredictable. People and researchers are taking several attempts in overcoming this situation; however, the mutations of viral strains keep changing in order to adapt to the human system. Even though different vaccines were generated by cutting-edge technologies, the current situation is still prolonging. With several ideas in the pipe-line, fast clinical phase-trials and optimization of high-throughput analyzing systems are currently taking place. However, there still is a necessity for smart-system coupled bioinformatics such as

Table 1
AI applications in disease identification/monitoring.

Disease	Algorithm/ Method	Source	Sensitivity/ Accuracy	Refs.
COVID-19	Deep learning	X-ray and CT-imaging	99 % accuracy	[20]
Alzheimer’s Disease	Deep learning	Fluorine-18-fluorodeoxyglucose PET of the brain	82 % specificity and 100 % sensitivity	[10]
Oral cancer	Bayesian Network	Clinical data, blood genomic	100 % accuracy	[27]
Cardiovascular risk prediction	Support vector machine	Population and clinical data	–	[28]
Breast cancer	Support Vector Machine	Population and clinical	95 % accuracy	[29]
Acute Ischemic stroke	Deep learning	CT imaging	93 % accuracy	[30]
Colon cancer	Semi supervised learning algorithm	Gene expression	76.7 %	[31]
Cardiovascular disease prediction	Deep convolutional neural network	Myocardial perfusion imaging	82.3 %	[32]
Breast cancer	Convolutional neural network	Breast cancer image	78.4 %	[4]
COVID-19	Transfer learning	X-ray image	96.7 % accuracy and 98.66 % sensitivity	[33]
COVID-19	CNN	X-ray image	–	[34]
COVID-19	Transfer learning and capsule network	X-ray image	98.3 % accuracy and 98.6 % specificity	[35]

AI, IoT and big data, which could prove to be beneficial if implemented. AI could be one of the most essential tools in the fight against COVID-19 through the modern advancements of DL and ML, along with algorithm-mediated enhancements, which could bring even greater benefits. Different biological data related to the current COVID virus (SARS-CoV-2) mutations might be incorporated into analysis-based AI systems, which would enable us to clearly pin-point the current problems and the future issues that may arise. Apart from that, the continuous addition of

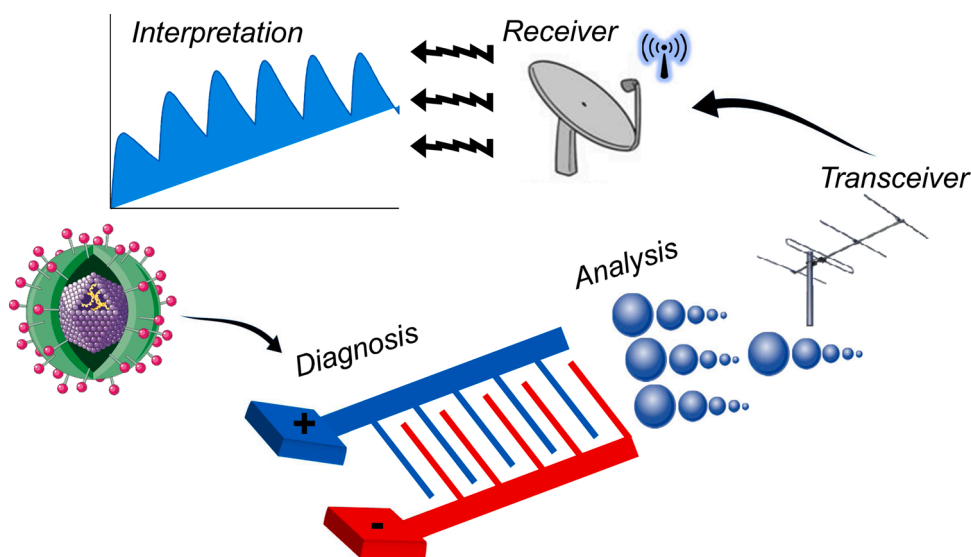


Fig. 5. Schematics behind remote digital monitoring. Remote digital monitoring’ and ‘Tele-medicine’. These involve a self-diagnosing system in which one end is with the patient and another end is with a medical practitioner connected through IoT.

new information to the database is mandatory in order to avoid the re-emergence of more infectious strains. SARS-CoV-2 had been proposed to have originated from a non-human host, so an analysis on host-specificity, or 'receptor analysis' could be seen as another key-point to be kept in the mind for future studies.

8. Conclusion

Artificial Intelligence (AI) being a computer-based technology, simulating the human brain in order to complete tasks in a more effective manner, could be efficiently used in modern health care systems and disease management. AI uses the rapidly available healthcare data and with its excellent data analysis techniques, helps in assisting various medical sectors. By utilizing machine learning (ML) and deep learning (DL) mechanisms, drug discovery, disease control, screening and data management could be done with greater efficiency compared to manpower. AI applications improve the diagnosis of diseases with more efficiency and accuracy allows researchers to effectively use AI tools against the sudden emerging of infectious diseases. AI significantly improves the processes with diagnosing, screening, medication, contact tracing, prediction, and drug development. By observing symptoms, age groups, locations and various other data, ML and natural language processing techniques could help improve the situations revolving around COVID-19. In the near future, AI will be an unavoidable tool in various sectors especially within the healthcare system.

Declaration of Competing Interest

The authors report no declarations of interest.

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