Review article

Application of Artificial Intelligence-Based Computation in the Health Sciences to Ward off the COVID-19 Pandemic

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Abstract:

COVID-19 pandemic is not slowing down, while the government from various countries is currently designing the 'new normal' to restart back their economy. Up to now, there is a significant mortality rate in the health care professionals that act as the frontliners in the hospitals and clinics in battling the COVID-19 menace. Based on computational sciences studied since the 1960s, artificial intelligence (AI) could assist healthcare professionals to protect themselves from the SARS-CoV-2 virus and treat the patients in an efficient and secure manner. AI, starting from the diagnosis, treatment, medication, until the prediction of the next pandemic, could assist in various areas. The objective of this review is to highlight AI in the health sciences in order to assist healthcare professionals in facing the COVID-19 pandemic, and the threat of the future pandemics.

Keywords: Artificial Intelligence, COVID-19, SARS-CoV-2, health sciences, health care professional

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Introduction

The COVID-19 pandemic has infected more than 30 million people, and caused mortality of more than 950.000 people worldwide (as of 20th of September, 2020).^{1,2} Healthcare professionals, who encompass medical doctors, nurses, pharmacist, paramedics, midwife, dentist, physiotherapist and others related profession, are now facing the threat of COVID-19 infection in hospitals and clinics. Reports of healthcare professional's mortality based on published reports by Indonesian Medical Association (IDI) and Indonesian Nurses Association (PPNI) is a wake-up call that something should be done right now to prevent such tragedy.³ Strategic and appropriate instruments are urgently required to deter such high mortality rates. In this regard, artificial intelligence (AI) could be one of the strategic solutions to face the COVID-19 pandemic, or any other pandemic in the future. AI in medicine aims to imitate the human cognitive ability in order to

provide assistance in prevention, diagnostics, and therapy of patients.⁴ AI -based studies tend to involve large scale studies that encompass robotics to human-machine interaction studies, as well as the behavioral studies. As part of AI, machine learning has provided a technical framework and detailed indicators on how to undertake action in resolving daily tasks. Computers and its program can assist humans in determining decisions.⁵ Various artificial intelligent techniques such as artificial neural network (ANN), Bayesian network (BN), fuzzy expert system (FES) and hybrid intelligent system (HIS) have been used in many clinical settings in medicine and health care.⁶ ANN is a computer system that is built based on a system working in human's brain.⁷ BN is the probabilistic graphical model that leverages graph theory to represent complex distribution corresponding to variables in the data.⁸ FES is a decision-making information exposure based on fuzzy inference compositional rule.⁹ HIS is

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a composite framework for the hybridization of various methods from AI studies.¹⁰ Those Machine learning-based methods will provide data structure, data characteristics, algorithmic, and programming development frameworks to optimize AI. In healthcare applications, those methods can assist healthcare professionals to solve problems in niche areas and to accelerate the development of public health. The methods may contribute to accomplishing problems that couldn't directly be accessed by humans.

Medical schools in many developed countries have begun employing AI in their research since the 1960s with the development of computer aided diagnostics, and are still considered as a revolutionary idea up to now.^{11,12} Furthermore, AI has the ability to achieve near-human level performance in some cognition related jobs.¹³ However, as a particularly communicable disease such as COVID-19 is becoming a serious threat to humanity, AI is getting more important in the field of health sciences. Even though, in the advanced level, AI could be classified into two different sublevels which are virtual or simulation and physical, AI has only been used for visual observation. In fact, the physical levels can provide bigger advantages to help healthcare professionals working in a more comprehensive manner.¹⁴ While AI won't replace visual observation of medical imaging and other kinds of data, it will definitely help the healthcare providers to provide a more confirmative diagnostics result. The non-human nature of the AI-agent is making them invincible to any pathogenic agents. Moreover, AI-based robots will be a perfect proxy for healthcare professionals, provided the robots will be in humanoid form (human-like).^{15,16} Once again, what is proposed here is to place robots as only a proxy, not as a replacement for the healthcare professionals.

Artificial Intelligence for Contact Tracing and Telemedicine Application

Worldometer and John Hopkins University have developed real-time tracking maps for tracing COVID-19 cases in the whole world by collecting data from the WHO and other health agencies.¹⁷ Healthcare companies such as Halodoc have installed an online medical AI-based chatbot in order to assist patients in diagnosing the symptoms of COVID-19, and referring them for a further medical examination.¹⁸ The development of the AI-based chatbot has been supported with solid computer science research that employs Natural-

Language-Processing(NLP)-based methods.¹⁹ The gathered data from the tracking maps has enabled the data scientist to fill in the important infection-related measurement. As a measure of the real-time infection numbers, R_0 should be lowered from 1 to indicate the decline of the pandemic as it means that the R_0 of 1 imply that one COVID-19 positive person will only infect an average to 1 (one) other person only. R_0 , as the main parameter, as well the general mathematical formula that represents the infectivity of SARS-CoV-2, should be an integral part of any digital contact tracing application.²⁰

AI-based pipelines have shown great promise to cut down the time needed to significantly establish the diagnosis and treatment for COVID-19.²¹ Efficient paperless and streamlined administration business processes have enabled hospitals to allocate their human resource for more urgent tasks. Moreover, some companies are trying to leverage AI-based agents in predicting the next SARS-CoV-2 outbreak, as well as other coronavirus infections in their neighborhoods.²² The predictive abilities of the machine learning methods has provided a strong pandemic forecasting capability, such as the one that Bill and Melinda Gates foundation had predicted a few years ago.²³ Unfortunately, this far-sighted prediction had fallen into the unscientific claim of conspiracy theory that is now causing harmful infodemic. The good news is that nowadays, there are mechanisms to deter the spread of infodemic in social media. There are significant initiatives that use NLP-based database annotation which are able to verify the validity of information in the social media.^{24,25}

Challenges faced by modern medicine in acquiring, analyzing and applying the large amount of knowledge leads professionals utilizing AI based in their projects. AI using evolutionary-based computation that imitates the mechanism of natural selection and Darwinian survival of the fittest may also solve complex medical-setting based problems. They are a class of stochastic search and optimisation algorithms based on natural biological evolution. This technique can help to forecast a survival probability of a patient or check the likelihood of a treatment curing a disease.²⁶

Artificial Intelligence and Imaging Informatics for COVID-19 Diagnosis

Employing AI in imaging informatics has been applied successfully in the non-communicable disease such as in the various types of cancers.^{27,28} Nowadays, as COVID-19 pandemic has

forced the hospital-owned medical information system to generate a massive amount of imaging data, mainly on chest and lungs imaging, this system is also employed in helping of COVID-19 diagnosis as a supplement to the molecular-based testing of RT-PCR.²⁹ Moreover, findings of bilateral and peripheral ground glass images as a general pattern in the chest CT-scan examination can be confirmed.³⁰ In this regard, the AI-based technology could be leveraged to optimize the respective patterns as a basis to enhance diagnosis in this modern age.

AI-based image acquisition system that annotates CT-scan and X-ray images could assist radiologists and internists to make clinical decisions for COVID-19 patients.³¹ Although visual validation from the medical doctor is still necessary for summing up the final diagnosis, the AI agents have streamlined the whole process to be much less time consuming, and making the diagnostics to be more accurate to supplement the RT-PCR based diagnostics.

Moreover, as the most popular AI technique in medicine, Artificial Neural Networks (ANNs) that consist of highly parallelized cluster computers and are inspired by biological nervous systems have been used in clinical diagnostics to conduct image patterns to assist in the recognition and analysis of large datasets. This can be a very useful AI technique that can assist professionals work with a large bulk of COVID-19 data and information.²⁶

Artificial Intelligence for Drug and Vaccine Design of COVID-19

The standard operating procedure (SOP) for drug design of COVID-19 is to employ molecular simulation methods.^{32,33} However, this SOP is only doable for a very limited data set. Providing virtual screening for up to millions of lead compounds will require AI or machine learning-based agent intervention.³⁴ This kind of initiative will require at least a High Performance Computing (HPC) system to do the work.³⁵ One of the institutes in Indonesia that currently own the HPC is the informatics research center of the Indonesian Institute of Sciences (LIPI). With employing a machine-learning based MTI Openscreen Large Scale virtual screening web server, the main protease of SARS-CoV-2 was screened against a database of almost 8000 purchasable drug compounds, and had determined that the drug candidates from the virtual screening results could potentially inhibit the virus.³⁶⁻³⁸ The MTI

Openscreen database is updated regularly, and also includes natural product compounds. In this regard, more and more leading compounds could be screened in a quick and efficient manner.

On the other hand, the standard SOP for vaccine design of COVID-19 is to employ an immunoinformatics approach that was enriched with AI agents. Immunoinformatics approaches usually employ Hidden Markov Model (HMM) and Artificial Neural Network (ANN) agents that are part of the machine learning methods. This approach is simulating the immune system expression in human's body, especially on the activity of the B and T cells against the pathogens, or the antigens to be exact.³⁹ In regard to the COVID-19 pandemic, early initiatives have already shown that the development of the epitope-based vaccine design employ pattern-matching and molecular simulation methods, both of them can target the SARS-CoV-2 spike protein.^{40,41} However, another research group is also using immunoinformatics approach to develop epitope-based vaccines by targeting SARS-CoV-2 hydrolase protein.⁴²

Artificial Intelligence with Robotic Agent to assist Health Care Providers

COVID-19 pandemics have pushed the healthcare industry to employ robotics accordingly.⁴³ Point-of-care testing that has been applied in South Korea and has become one of the viable solutions as long as the infrastructure is provided accordingly.⁴⁴ Such speed and accuracy in diagnostics could be viable with robotics-based technology. A number of facial-recognition companies in China, such as Sensetime and Sunell, have enabled their pattern-matching methods to be leveraged with temperature detection features, and therefore sensors have been placed in the various locations in that country.¹⁷

In order to detect the compliance to the mask-wearing protocol, the Detecting Mask-wearer AI-based method must be employed. In China, the facial recognition system has been installed in the country-wide CCTV monitoring system to detect compliance to the mask wearing policy.⁴⁵ The camera employs a high-resolution lens and sensor to scan up to 200 persons per minute.⁴⁶ Provided that there is a standard CCTV system, information system and swift internet bandwidth, developing a mask-wearing system could be easily installed with a simple programming effort in the Google colab.⁴⁷

AI-based robotics has been shown to be

indispensable in the current pandemic. Mobile hospital robots could help in delivering food, prescription and lab samples.⁴⁸ Moreover, such robots have successfully assisted hospitals in providing fast and efficient logistics transportation.⁴⁹ In order to deter criticism that robots are emotionless agents, interactive robots with animal and human-like features have been developed to provide social integration to the patients.⁵⁰ While employing high-level fuzzy linguistic features of the facial components and deriving significant input from the discipline of psychology, the expression of the human's emotion could be predicted accordingly.^{51,52} The whole process of monitoring and evaluating the robotics system is still within the authority of the healthcare professionals. The optimal deployment of the mobile hospital robots will eventually provide security to the healthcare provider in this time of the COVID-19 pandemic due to the restricted physical interaction with the patients, but still be able to maintain social interaction with the interactive robots. A lot of AI applications have been utilized in vast areas of healthcare and medical settings. It ranges from online scheduling of appointments to digitalization of medical records that are centered on the database annotation.¹³ AI can offer a powerful tool to fight against the COVID-19 by developing a Deep Learning (DL) model to rapidly identify existing and commercial drugs. Moreover, health-based big data can potentially support patients' health analysis, diagnostic assistance and drug manufacturing.⁶

Artificial Intelligence and Bioethical Issues in Dealing with COVID-19

Artificial Intelligence and Learning Machines have become important parts of human life, and the COVID-19 pandemic has pushed for more roles of the AI-based agents. The application of AI stands out in four main areas that are affected by the pandemic, namely: automatic vehicles, cybersecurity, criminal justice, medical, and financial services. In the field of automatic vehicles, motorists get guaranteed driving safety and gain mobility. The possibility of leveraging automatic vehicles will provide a total safety protocol for the drivers and the passengers in the pandemic.⁵³ Frequently asked questions are: what are the fundamental rules for guaranteeing automatic vehicle security and what are the roles of government in adapting infrastructure and regulations concerning enforcement and

responsibility? This situation also directly relates to the bioethics-based issues because it overlaps with the safety regulations.⁵⁴

Artificial Intelligence applications are vulnerable to cybersecurity attacks, and it poses risk to the genomics database that belongs to the hospital and the insurance companies. During the pandemic, reports of AI-based cyberattack are increasing world-wide.⁵⁵ However, AI can also be utilized as a detector and a bulwark against cyber-attacks. In the field of criminal justice, especially In the time of COVID-19 pandemic, AI has the potential to reduce the level of felony and crime with the utilization of modern forensic medicine, but is also vulnerable to abuse of privacy and violations of citizens' rights.⁵⁶ The question which is often asked is what are the options for assessing accuracy and potential bias in AI algorithms and data? What is the solution for safeguarding privacy for personal information through the AI systems?. Financial services usually use AI to increase customer satisfaction and strengthen surveillance monitoring systems, maintenance of softwares and hardwares. The question that often arises is how can regulatory sandboxes be used to test business models and a variety of the latest AI products and services? This is an important area to be considered because the COVID-19 pandemic has increased our dependence to the AI-based agents.⁵⁷

AI raises many real-life ethical problems, and especially during this current pandemic. Discourses and discussion of ethics are called machine ethics or roboethics. Those are the codes of conduct that need to be implemented in the robots' AI system, and they should operate in 'zero tolerance' manner during the pandemic. Through these artificial ethics, roboticists and scientists ensure that autonomous systems exhibit ethically acceptable behavior, especially when interacting with humans in this dark times of the pandemic.⁵⁸ In COVID19-based policy and research, Artificial Intelligence (AI) has many implications. Incentivizing data sharing, improving security and safety, updating regulatory approach, assessing acceptable risks and ethical decision-making are some of the implications of AI in policy areas in relation to utilizing the big data of the COVID-19. Meanwhile, AI also has a powerful impact in research areas, such as: expounding AI's impacts and effects on training and jobs, establishing regulatory sandboxes, developing high-quality labelled data, and exploring computational ethics and explainable AI.⁵⁹

Artificial Intelligence for Deterring Future Pandemic

SARS-CoV-2 is known to infect humans through released air-borne droplets. In the past, even up to now, the world has faced numerous aerosol-based pathogens such as tuberculosis, influenza, and Ebola.⁶⁰ The possibility that in the future, the existence of pathogens that are more infectious and more hazardous than SARS-CoV-2 could not be overruled and high alert should always be put in place.⁶¹ This constant menace is pushing the application of AI in medicine, especially as robotic instrumentation to assist the healthcare professionals. It becomes essential and inseparable from handling communicable diseases. In Indonesia, demands from the nursery profession to incorporate robotic-based AI as a partner to assist their workload in handling COVID-19 patients has been suggested, and this manifesto is an excellent breakthrough to encourage AI-based instrument utilizations among healthcare professionals.⁶²

However, ethics should always be upheld when employing AI in the hospital and clinic setting. The informed consent form of the patient should be carefully secured if any medical -based procedures involving robots will take place.⁶³ Patients must be fully aware from the beginning that any medical procedures to be conducted upon them will be assisted with AI-based agents, especially the robotics ones. In order to familiarize the public that robotics-based AI could indeed play an important role in healthcare, every stakeholder in healthcare sectors should promote this new area of therapeutics, remembering that AI-based

agents will not replace healthcare professionals at all.⁶⁴ As an expert system, they will assist them for catering the finer-grained decision for the well being of the patients. Moreover, AI-based agents will not replace conventional human interaction with cold and emotionless robots.⁶⁵ It will, more and less, provide smart partnership to supplement the conventional healthcare professionals-patients interactions at the time of post COVID-19 world.

Conclusion

As COVID-19 pandemic is still ravaging the world to this day, solutions to reduce the workload of the healthcare professionals should be devised. AI-based tools could be plotted as partners for healthcare professionals, provided that they are given sufficient training to operate these tools accordingly. AI agents are suitable for that job because they have been applied extensively for various domains that are necessary for dealing with COVID-19 pandemic such as contact tracing, telemedicine, imaging informatics, drug design, immunoinformatics, and robotics. However, bioethical principle should always be held as it can serve as a humanizing principle for the application of AI for assisting the health sector.

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