Rapid Layout and Development Strategy of Hospital Artificial Intelligence During the COVID-19 Pandemic

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Abstract: This study aims to explore the application of artificial intelligence (AI) in the context of the coronavirus disease 2019 (COVID-19) pandemic, with an aim of promoting the top-level design and rapid layout of hospital-orientated AI applications to provide a new path for the Healthy China Initiative. Since the outbreak of the COVID-19 epidemic, China has conducted epidemic prevention and control using the strength of the whole country while developing global cooperation by donating medical supplies, sending medical teams, and sharing treatment experience and high technologies. In the fight against the epidemic, frontline medical staff have obtained valuable experience in medical AI applications. AI has played an outstanding role in the anti-epidemic front line and indicates the urgent and strategic demands for medical AI. After reviewing the medical AI application status and development direction, we suggest that China should make a comprehensive layout of AI applications in hospitals nationwide and cultivate a prosperous medical AI ecology, thus laying a key foundation for future hospital construction in China. To this end, the government should make an overall top-level design for medical AI applications and shift forward interventions to change the passive situation. It also should scientifically coordinate resources, strengthen hardware construction, improve the databank, and improve the guarantee system for professional teams. Armed with medical AI, hospitals can fight against large-scale acute respiratory infectious diseases with better efficiency.

Keywords: hospital construction; coronavirus disease 2019 (COVID-19); artificial intelligence (AI); application status; development direction

1 Introduction

The basic characteristics of the rapid spread of infectious diseases create high requirements for the comprehensiveness and effectiveness of medical response. Entering the 21st century, the world has encountered three coronavirus outbreaks: SARS in 2003, MERS in 2015, and COVID-19 in 2019. Currently, the COVID-19 pandemic is still spreading in many parts of the world, seriously impacting the political, economic, and social aspects worldwide. The pandemic poses a great challenge to some developing countries with poor medical-response capacity.

Existing data show that China benefits from its national strategy of Internet + Healthcare. This project has played an important role in pandemic control. However, its effectiveness cannot be achieved without the artificial

intelligence of Chinese hospitals. The advanced AI layout and continuous construction began 10 years ago. These efforts are divided into three main phases: (1) system integration and data exchange (2009–2014). After the initial system integration and data exchange, the medical information island was eliminated. (2) Information loop and Internet + construction (2015–2018). Medical data centers were completed. (3) AI application (2019) to apply AI in hospital diagnosis and treatment activities, thus solving the problems of decision-making, clinical, and medical research.

In China and abroad, COVID-19 has caused such a severe situation in which the application of hospital AI has been emphasized more than ever for a healthy China. Meanwhile, the COVID-19 pandemic constitutes a counter-force situation for hospital-capacity development. AI improves the sense of acquisition and participation of hospital staff; thus, they reflect a greater acceptance of AI products. Wide public education is pushing the breakthrough point. Based on the above background, this article reviews hospital AI applications during the COVID-19 pandemic and shares our experience of hospital AI in disease prevention and control.

2 Macro demand

After the outbreak of COVID-19, China impressed the world with its determination, speed, and efficiency. Driven by its mission, China has actively contributed to the global fight against the pandemic, not only by sending medical teams and donating materials, but also by sharing its experience in medical treatment, especially in high-tech AI applications.

The COVID-19 pandemic has directly driven AI technology and products into hospitals. For example, Huoshen Mountain Hospital and Leishen Mountain Hospital in Wuhan, Hubei Province, opened a cloud supervisor. During the isolation period, the local government used the cloud platform to resume work and production observations, thereby improving efficiency and recovery. The First Affiliated Hospital of Zhejiang University and Shulan Hangzhou Hospital adopted a variety of AI devices to solve specific problems. However, it is still necessary to summarize the first-line application experience over time, analyze the technical shortcomings faced in meeting the actual needs, and condense the bottlenecking problem. Hospitals should implement large-scale AI devices and technology. The overall planning and top-level design before construction should consider the intervention gate, changing from a passive coping situation to a positive preventative pose. It is vital to construct the necessary hardware to prevent possible large-scale acute respiratory infectious diseases in the future.

AI is an important direction for speeding up manufacturing power. COVID-19 pandemics push AI+ as a strategic direction for health care. Hospitals at all levels should take on this mission and share their visions. We should focus on refining and combing medical AI applications to construct a new medical platform ecosystem for diseases and patients.

3 AI application in pandemic prevention and control

3.1 AI-aided diagnosis software

AI-based image-reading technology can quickly and quantitatively evaluate a patient's lung condition. During the outbreak, the shortage of medical personnel and the wearing of protective clothing in the isolation ward was inconvenient for radiology staff and slowed down their procedures, whereas AI technology can rapidly evaluate pulmonary medical images of COVID-19 patients. AI provides great value for clinical diagnosis and intervention. During the outbreak, the computerized tomography (CT) films of each designated hospital were overwhelmed. The average daily inspections exceeded 1000 cases; thus, it is far beyond the doctors' ability to read films manually. Many enterprises provided AI hardware and software so that doctors could complete many image-processing tasks in a short time. AI technology can automatically handle image screening and quantitative evaluations. The AI collected key images and characteristic information of COVID-19 patients, such as lesion formation, scope, and density, for quantitative analysis. AI software directly supports doctors in diagnosis and efficacy evaluation, which significantly improves COVID-19 diagnosis and treatment efficiency [1,2].

The AI algorithm can quickly form the initial diagnosis report by evaluating the degree of pulmonary infection in patients to develop an accurate diagnosis and treatment plan. The algorithm can also be prioritized according to the degree of pulmonary abnormality to guide the intelligent diagnosis; AI interpretation of one CT chest film only requires 2–3 min, which is 4–5 times faster than manual interpretation. AI saves valuable energy and considerable time for overwhelming physicians. The AI system can differentiate similar signs by quantitative analysis to evaluate the stage and severity of pneumonia. It generates structured graphical and text reports for COVID-19

diagnosis with intervention recommendations.

3.2 AI algorithms build epidemiological survey models

Patient information forms a basic epidemiological database, which AI algorithms analyze and manage. The AI accurately follows the flow of traces to simulate the epidemic-transmission process. Based on the data collected on virus characteristics, propagation speed, lesion development, and symptoms, several AI research teams in China constructed models, such as the epidemic situation map, real-time dynamics, and data reports. The transmission probability, hospital capacity, transmission speed, spread, and scope of the epidemic were predicted scientifically. The analysis provides public information, such as confirmed cases, suspected cases, and close contacts. AI provides key information support for joint defense and control work at all levels.

Medical experts use the above data information to evaluate the epidemic transmission mode of COVID-19 epidemic, reasonably estimate the spread scale of the epidemic, and provide direct support for the prevention and control decisions of governments at all levels. A domestic digital map model was built using AI technology, to trace the whereabouts of five million people who had left Wuhan before the lockdown in the first place, indicating the direction of epidemic prevention and control and providing data support for the isolated observation and management of people who had returned home from Wuhan. The researchers completed the AI model training research, obtained the epidemic trend prediction results, and drew the epidemic curve by combining the epidemiological data of COVID-19 epidemic with the classical infectious disease prediction models and referring to the historical data of SARS in 2003. Based on the prediction results, the nationwide migration of people during the Spring Festival was blocked in time. The shelter hospitals was constructed to deal with the potential secondary outbreak of the epidemic, providing a scientific basis for the timely and effective control of the pandemic.

3.3 AI algorithms assist in predicting virus hosts

Finding natural and intermediate hosts and determining the route of transmission are the core problems in controlling the source of infection and cutting off the transmission route. Many research teams in the country rely on AI to build mathematical models. The Peking University Research Team uses PathCNN [3]. The Wuhan Virus Institute of the Chinese Academy of Sciences uses genomic sequencing [4]. Similarly, South China Agricultural University [5] and the China Center for Animal Health and Epidemiology examined 4800 samples with AI-empowered mathematical models. The effort pushed the implementation of emergency legislation to prohibit trade and indiscriminate consumption of wildlife. The source of infection was removed by removing the transmission route.

3.4 AI supports drug screening and molecular diagnostic targets

Deep-learning techniques enhance the efficiency of proteomics and sequential relevance, thereby helping drug development. AI provides technical support for new drug-development models so researchers can efficiently model the three-dimensional structure of a variety of known target drugs and their possible relationship with viral action sites. Automatic screening of potentially effective drugs from a wide variety of drug databases enables the rapid development of emergency drugs.

Nucleic acid sequences in the blood of suspected patients were extracted via nucleic acid detection. Comparison with the COVID-19 database can determine whether there is a pathogen infection. This is a diagnostic method for genome-wide sequencing of virus samples from suspected cases. However, this method is time-consuming and laborious. AI can quickly complete screening work and greatly improve detection efficiency. The large-scale implementation of the above detection process, computational power, and algorithm is extremely critical, and is therefore considered a key support for epidemic prevention and control. From 2020, many innovative research institutions in China have offered the Linear Fold algorithm as a free service. It can be used to predict ribonucleic acid (RNA) structures in whole sequences and whole gene groups, and has accelerated structural forecasting. Computational power supports COVID-19 drug-screening research.

3.5 AI enhances telemedicine operations and consultation capacity

A number of provincial and municipal hospitals throughout the country have sent medical teams to help Hubei to replace the overtired local staff. Such a coordination system plays a decisive role in the rapid and accurate control of pandemics. Thousands of miles away from Wuhan, other remote consultation headquarters use mobile

communication networks for convenient data transmission. The combined AI device and technology carry out video consultations and remote guidance. The local isolation ward and radiology exam room are equipped with a camera, microphone, auscultation equipment, and other hardware connected to the information network. This system enabled non-touch diagnoses, thus significantly reducing the potential risk of medical staff infection due to direct contact with patients.

Intelligent equipment, such as isolation ward robots and nucleic-acid swab robots, were used in first-line hospitals on a large scale. The intelligent outpatient pre-examination system can classify high-risk populations to avoid cross-infection in the hospital. This reduces the load of the hospital fever clinic and saves medical protection materials in the outbreak stage. The new self-assessment system of coronavirus infection, installed on smart phones, is used to intelligently analyze the risk of infection and provide medical advice, alleviate social panic, and guide residents to seek medical treatment rationally. The intelligent epidemic prevention and control system in the transportation department reports travel-related information to the community, providing dynamic monitoring of the situation. The COVID-19 rehabilitation AI monitoring system provides comprehensive and accurate follow-up services for the recovered group.

3.6 AI multi-scene temperature screening

Hospital use AI technology for patient temperature measurements and face recognition. Epidemic prevention personnel perform non-contact body temperature detection and personal information identification. AI can quickly detect fevers, identify suspicious patients, and protect medical staff from the risk of contact infection.

AI technology improves traffic efficiency in hospitals, shops, airports, stations, etc. AI supports online investigation and clarifies the flow trajectory of patients through a sanitary touchpad. The mobile dual-light rapid temperature-measurement and intelligent recognition system was developed by domestic institutions. It integrates infrared thermal imaging and facial recognition technology. It can quickly and accurately monitor the body temperature of traffic personnel. The monitors can measure 200 people per minute from a distance of 5 m. Abnormal body temperatures can be detected immediately, thus minimizing the potential risk of viral transmission. By using a facial recognition algorithm and intelligent thermal imaging technology, it can also realize automatic ID recognition and management in real time.

3.7 AI upgrades medical information management with blockchain technology

AI combined with blockchain technology is used in emergency medical supply management, drug tracing, and medical data management. This helps hospital administrators perform accurate management and dynamic monitoring. The medical and engineering departments use radio-frequency identification and two-dimensional code identification to accelerate supply distribution. An AI intelligent warehouse was constructed, in which innovative AI technologies help purchase, trace, and allocate medical materials. In such a publicly sensitive event, the AI release system is especially vital for public supervision. It provides confidence through its transparency and efficiency. Each designated hospital initially realized the intelligent remote management of equipment, such as water, electricity, air, HVAC, and lighting. Through intelligent security fire-control and -monitoring system technology, including face recognition, fingerprint recognition, and sound recognition, a more secure ward environment is provided.

4 Problems of AI Application during the pandemic

4.1 AI-related legal and ethical issues

With the new application of AI in medicine, several issues have emerged. Legislation should improve the awareness and responsibility of medical data security. The necessary laws, regulations, and standardized procedures should fit the big data platform to protect personal privacy and data security. The personal information of patients should be protected in the context of relevant legal ethics. During COVID-19 pandemics, everyday life has become challenging, with questions such as: What information can be collected? Who can publish patient information and how to release information? The government needs to work on regulations to answer these questions. Medical data should not be misused, and big data should not violate privacy. Unauthorized individuals are not allowed to track personal information [6–9].

During the COVID-19 pandemic, authorized officials have collected personal information. AI has been combined with various massive data information, such as travel routes, aviation data, mobile communications data,

and e-commerce consumption data. AI conducts comprehensive modeling and analysis of the population. This helps the government to perform evidence-based decision-making. If not authorized, this information cannot be released to the public. AI-accessible data abuse is a consequence of violating the privacy of citizens. For example, patients in Wuhan, Hubei Province, have the right to undergo medical treatment and resume work. Without a permit, their personal information cannot be released from the public information platform, including their name, home address, phone number, ID number, and train number. In response to such unauthorized release situations, national legislature should enact legislation. The government should clarify the appropriate procedures during the outbreak of infectious diseases. The regulation of the collection, storage, transmission, use, and destruction of personal information should follow operational norms, thus forming a supporting guidance for hospital operation.

4.2 AI effectiveness needs to be improved

During the outbreak, several AI products have been used. Intelligent disinfection and antivirus, drug-distribution, and food-delivery robots, as well as other intelligent technology products, have been employed in hospitals. However, these AI robots can only perform limited services, and medical staff and patients are not widely involved in AI services. Overall, AI technology is still in its initial stage for hospital applications.

Hospitals have zero tolerance for AI diagnosis errors. The threshold for AI technology to enter hospital applications is extremely high. The overall effectiveness of AI in hospitals is not satisfactory. Medical AI is still in the "weak artificial intelligence" stage. R&D enterprises should establish professional AI technical teams and data-mining research teams to carry out interdisciplinary capacity building to empower AI.

4.3 Sharing and mutual trust related to big data urgently need to be improved

To promote the disclosure of information on pandemic prevention and control, AI systems need to enforce mutual trust and information transmission across regions and institutions. Data sharing is the fundamental way to break the phenomenon of the "isolated information island" in the medical system and improve the efficiency of prevention and control cooperation during the pandemic. In the COVID-19 outbreak, despite strong efforts, there remains a large gap between actual needs and available support.

AI applications are based on reliable high-quality big data. Blockchain can perform point-to-point data distribution, storage, and transmission using a reliable consensus mechanism. The combination of blockchain and AI can provide technical support for data sharing and information construction during the prevention and control of new outbreaks of infectious diseases. AI enforcement helps hospitals obtain massive data from different departments with different dimensions. It can also efficiently manage data from patient visits, treatment, prescriptions, and medical insurance, as well as strategic decisions against the epidemic situation through comprehensive modeling and analysis.

5 Objectives and framework

The COVID-19 outbreak is driving medical care in China to accelerate AI technology development. The current focus is on an efficient response to pandemics. The government will build more hospitals with modern AI construction, and public health in the future will be changed by AI to promote the deep integration of medical services and information. The hospital structure is described briefly below.

(1) Data platform construction. Strengthen the construction of hospital information data centers for storing massive information for diagnosis and treatment training. AI should integrate algorithms for deep learning. These measures can continuously incorporate and train new data, and the data center should be maintained routinely. AI should be developed for specific clinical application tasks and scenarios.

(2) Information collection. Information-collection terminals should be installed to meet the needs of intelligent medical care, using information-acquisition hardware and equipment such as cameras, voice assistants, and sensors. The collected data include not only the behavioral data from medical staff and patients, but also the medical process and result data from hospital logistics centers, energy consumption, air quality, and other spatial environmental information.

(3) Fifth-generation mobile communications (5G). 5G facilities should be included in hospital plans to ensure high-speed, high-efficiency, and low-delay transmission of hospital network data. 5G facilities help form a new model of data-driven medical treatment and can continuously pool clinical phenotypic data and scientific research data, supplemented by individual patient behavior data, to form clinical research data resources. With strong and qualified data resources, AI can carry out analysis and decision making. This will optimize hospital procedures.

(4) Software and hardware cooperation. The Hospital Information Support System (HISS) should implement the pathology subsystem, image archiving, and communication system (PACS) to form a functional unit. It should connect wards, operating rooms, pharmacies, laboratories, and imaging departments to ensure the development of daily work in hospitals, such as auxiliary disease diagnosis, health management, medical imaging, clinical decision support, portable equipment, and rehabilitation medical and biomedical research.

(5) Establishment of an interactive relationship. AI should consider its role in connections and relations. AI is applied to meet the specific functional needs of medical services, such as medical activities and scientific research services. AI construction should intelligently carry out recruitment, appointment, examination, treatment, rehabilitation, follow-up, and other medical treatments. This will promote good doctor–patient interactions.

6 Countermeasures and recommendations

During the outbreak of COVID-19, AI technology and products not only support the diagnosis and treatment of diseases in many hospitals, but also provide important support for social life by providing online education services and online medical consultations of COVID-19. Preliminary experience shows increasing acceptance of AI technology and products, which broadens medical AI application scenarios. "Anti-epidemic with AI" is an important driving force in hospital construction, and even grows as a new economic network.

6.1 Layout of new medical AI applications scenario

AI can drive technical development and application in the medical industry. AI-powered hospitals should be established as soon as possible for pilot trials of regulatory and support policies. AI hospitals cultivate AI-related enterprises and form a medically oriented application market. The combination of AI and medical scenarios promotes run-in practices and can also build a demonstration exploration. The AI application scenario can also push standards and usage specifications for applications. Hospitals equipped with 5G will develop new business models for remote operation, consultation, patient health monitoring, and real-time follow-up.

In view of the need for the prevention and control of new infectious diseases, it is suggested that AI technology and products be integrated into the diagnosis and treatment process of highly pathogenic infectious diseases. AI provides diagnosis and medical services for patients with a high risk of infection through a non-contact modes. This measure will effectively reduce the risk of infection among medical staff and the operating costs of hospitals. The government, public health departments, and medical institutions also need to pay attention to other industries closely related to the operation of hospitals. For example, medical supply donations and distribution should work on big data platforms for transparency and efficiency.

6.2 Layout of new scenarios for medical AI robot application

AI technology should be applied in more medical scenarios to speed up unmanned intelligent applications. In an environment where the risk of infection is very high, the use of medical AI robots should be prioritized. They can work in all weather conditions with heavy physical strength and repetitive working loads to reduce the risk to medical staff. Medical AI robots should engage in the first-line duties of the most dangerous isolation wards to reduce the risk of contact between medical staff and patients. Breaking through the reliability bottleneck of medical robot applications makes AI a reliable tool for collecting information on the epidemic situations, conveying and realizing diagnosis and treatment operations, and exploring remote-control rounds of isolation wards. The application of 5G technology, telemedicine, AI hospital sensor warning, and AI robots can reduce the risk of virus infection.

6.3 Strengthening the construction of hospital big data platform

Early control of epidemic situations is critical, and requires close collaboration of administrative and information resources. The main body of patient information collection is scattered, failing to provide a unified and complete database, which directly restricts the intensity and effect of epidemic prevention and control. For the prevention and control of new infectious diseases, time is life. It is suggested to establish early warning and evaluation models of epidemic situation data and data-driven decision-making mechanisms as soon as possible and popularize them in hospitals at all levels. AI support technology enterprises need to develop integrated solutions for new infectious diseases and cooperate with hospital information systems.

6.4 Strengthening ethical and standard for medical AI application

We suggest timely adjustment of AI relevant legal system and ethical provisions during the process of using AI technology. The using scope of AI technology and its data should be strictly defined. When AI technology enterprises apply advanced scientific and technological means to major public health emergencies such as the COVID-19 epidemic, they should maintain a prudent attitude toward the use of big data technology and pay attention to the protection of personal information. The government should timely update AI screening and imaging diagnosis standards of emerging infectious diseases and effectively promote the construction of AI medical imaging diagnosis and control system of emerging infectious diseases. The government also should pay attention to the market-oriented principle in the development process and establish an investment return mechanism for AI medical oriented enterprises.

6.5 Strengthening indiscipline cooperation and personnel training

Institutions, universities, enterprises, and hospitals should be encouraged to carry out joint research through cooperation, and the upstream and downstream AI enterprises should achieve innovative functions, such as image analysis, diagnosis, treatment, and health management. Furthermore, new technology enterprises should be encouraged to develop medical AI products. Medical AI interdisciplinary training of technical personnel lays a solid and forward-looking foundation of talent.

6.6 Establishing a mechanism for sharing medical AI benefits

It is suggested that the administrative department of health should establish a benefit-sharing mechanism. The network organizes and classifies the medical data of various institutions efficiently to form the national medical treatment AI public database. Solutions for commonly complained issues should be answered, such as data ethics, data security, data attribution, data opening, data standard, and data cost. The network explores and creates a system flow that reflects the actual effect orientation, eliminating unnecessary restrictions. It is suggested that the State Drug Administration should open approval channels for medical AI diagnostic algorithms or software. Hospitals, patients, pharmaceutical companies, insurance companies, and government agencies should share responsibility for health care.

Establishing a benefit-sharing mechanism can also promote AI products from hospitals to the normal market. Hospital AI construction has great social and economic value. It is suggested that the government encourage and support medical institutions to innovate payment methods, extend service scenarios, and break through the limitations of traditional settlement methods of project payment to hospital revenue. Through the establishment of a socially recognized benefit distribution mechanism, hospital AI construction can accumulate huge amounts of medical consumption and properly solve the problem of return on investment for related parties to achieve greater economic and social benefits.

6.7 Muti-mode interactive demonstration of medical services

We suggest that AI robot project demonstration should be conducted to establish and improve the multi-mode interaction ability of AI medical services. Based on human–computer cooperation and the gradual improvement of deep learning ability, the R & D and service capability can be notably promoted. In the long term, the unmanned AI robot care service is expected to be realized [10–14], thereby solving the practical problems of shortage of medical professionals, incomplete care, and insufficient humanized service. In the development process, AI should be used for improving the quality of medical services, and the diagnostic efficiency and comprehensive effectiveness should be raised in terms of medical imaging, intelligent diagnosis and recognition, AI-assisted surgery, and long-term health monitoring.

7 Conclusion

The New Generation of Artificial Intelligence Development Plan points out that by the year 2030, AI in China will take the lead in the world on theory, technology, and application [15,16]. Domestic AI and the big data industry are becoming innovation forces. AI can support the government, hospitals, and social institutions to fight against COVID-19 pandemics. Our experience of pandemic prevention and control shows that AI is vital in controlling the spread of respiratory infectious disease. Medical AI is regarded as a key direction in hospital development and will extend beyond medicine.

The COVID-19 pandemic prevention and control highlights AI technology. The benefit originates from the strategic layout of e-commerce, logistics, 5G, big data, community control, etc. [17,18]. During pandemics, the public is aware of the importance of medical AI construction. In the context of upcoming implementation of the new infrastructure construction, it is suggested that the government should make decisions ahead of the layout, vigorously promote the construction of medical robots, intelligent drug vaccine screening, unmanned wards, automatic logistics for hospital infection control, online diagnosis and treatment, and telemedicine. The government should encourage the industry to face the future and develop more practical medical AI products to help combat infectious diseases in order to achieve the mission of building a healthy China.

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