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Artificial intelligence applications in medical sciences—Illustrations in pharmaceutical and medical imaging areas

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ABSTRACT

Artificial intelligence (AI) technologies have been used to develop and advance healthcare industry. Typical application scenarios in medical sciences include diagnosing patients, end-to-end drug discovery and development, improving communication between physician and patient, transcribing medical records, and remotely treating patients. This paper aims at introducing AI applications in the field of medical sciences, especially the areas of pharmaceutical and medical imaging. It first introduces the current AI technologies used in medical science in general, and then showcases these applications in pharmaceutical and medical imaging areas. Insilico Medicine (Hong Kong) and Pfizer (US) are the illustration cases from pharmaceutical industry; and Deepwise (China) and GE healthcare (US) are selected cases from medical imaging industry. The comparison within each industry and between two countries (China and US) are summarized at the end.

Keywords: AI, medical sciences, pharmaceutical, medical imaging

1. INTRODUCTION

The concept of artificial intelligence (AI) was initially proposed at the Dartmouth Conference in 1956. It is affiliated with computer science and is commonly applied to expert systems, speech recognition, machine vision, and natural language processing[1]. AI in the medical field combines various application scenarios. Medical scientists use natural language processing, computer vision and other AI-related technologies to improve the efficiency of patient diagnosis and service quality, reduce costs, and promote performance of medical products[2].

Stanford University's AI 2021 study panel report divided AI applications in healthcare into five broad sections: (1) clinical settings: AI optimizes automated consultation processes, (2) medical analytics: managing patient data and interpreting images, (3) medical robots: assisting doctors in implementing treatments, (4) digital health: providing personalized advice to patients, and (5) elder care: facilitating services for the elderly[3]. The most significant benefits of AI technology in healthcare are improving treatment outcomes and reducing healthcare costs. AI is expected to enable accurate diagnosis through massive machine learning. Besides, the well-known IBM Watson technology in healthcare assists patients to understand medical procedures by understanding natural language[4]. In addition, AI technology is also applicable to predict and solve epidemic diseases. This paper aims to introduce AI's application in two branches of medical sciences: pharmaceuticals and medical imaging. Moreover, through a comparative analysis of companies in both fields, we expect to gain insights in the similarities and differences between medical AI applications in China and US. As AI-based medical applications are beneficial to improve the health status and quality of life, as well as to promote better communication between healthcare workers and patients, the present study is of vital importance to medical science practitioners.

2. AI TECHNOLOGIES IN MEDICAL SCIENCES

2.1 Machine learning

Machine learning (ML) optimizes its performance in processing data by analyzing enough training data sets. In the medical field, the use of supervised machine learning to predict various health events has been proven to be efficient[5]. For instance, in

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diagnostic sessions, machine learning is beneficial in assisting physicians in identifying subtle pathologies and non-routine diseases. Diagnostic errors are not uncommon. Conditions such as cardiogenic chest pain and childbirth complications are difficult to diagnose even with precise therapeutic instruments and experienced physicians[6]. Machine learning has the ability to process data beyond the limits of the human brain, facilitating fewer medical decision errors[7].

2.2 Deep learning

Deep learning (DL) simulates human neural networks and models complex relationships in large datasets[8]. Convolutional Neural Network (CNN) in deep learning algorithms are typically used to recognize image, video and audio pairs and are now widely implemented in medical imaging and radiation oncology[9]. A research group from Google adopted deep learning algorithms to automate the diagnosis of diabetic retinopathy images to assist physicians in treating the disease in the clinic[10]. CNN is utilized in biological-image analysis for classification, feature detection, extraction, and pattern recognition[11]. Complex data can also be processed to diagnose patient diseases accurately.

2.3 Computer vision

Computer vision (CV) has excellent efficacy in understanding images and videos, which involves target detection, image classification and other tasks that can significantly benefit medical image analysis[12]. CV can assist in medical imaging applications at three levels: (1) image post-processing: AI systems process the original image to improve image quality, (2) automatic image detection and classification: assist in identifying disease categories, benign and malignant, and (3) medical decision-making: provide rational decisions for clinical improvement through data analysis[13]. Moreover, CV can be leveraged as a scalable form of workforce and resource measurement to improve resource allocation for hospital operations[12].

2.4 Natural language processing

Natural Language Processing (NLP) is the analysis of human language performed by computer systems, primarily for handling text and speech. In the medical field, NLP technology can improve the utilization of electronic health record (EHR) and enable patient-to-AI consultation in the form of questions and answers[14]. NLP is mainly integrated with medical research, patient diagnosis and care, clinical coding and other events. Since most current medical records contain free-text elements, NLP can efficiently manage these elements and facilitate clinicians to evaluate the effectiveness of treatments and interventions[15].

3. ILLUSTRATIONS IN PHARMACEUTICAL INDUSTRY

3.1 Insilico medicine (Hong Kong)

Founded in 2014, Insilico Medicine is renowned for its utilization of AI technology as an alternative to animal testing in research and development projects in the pharmaceutical industry. The company innovatively combines genomics, big data analytics and deep learning to advance computerized drug discovery[16]. In addition to developing drugs independently, Insilico Medicine's Pharama.AI division also provides machine learning services to other pharmaceuticals, biotech and nursing companies. Insilico was named one of the top five AI companies with the most social impact potential by NVIDIA in 2017. Its multiple collaborations in the AI field with companies and research institutions have cemented its leadership position in the pharmaceutical industry[17].

3.1.1 PandaOmics. Insilico PandaOmics is designed to allow medical researchers to access all Omics data generated by the scientific community and eliminates the need to convert the data into an interpretable format. In addition, the AI algorithms provided by PandaOmics suggest viable hypotheses for new drug targets for researchers with no bioinformatics experience, reducing the time consumption required for research[18]. In Insilico's project to develop a drug for idiopathic pulmonary fibrosis (IPF), PandaOmics provided a system to identify targets through deep feature selection, causal inference and de novo pathway reconstruction, significantly reducing the time and cost required for drug development[19].

3.1.2 InClinco. InClinco is a data-driven, multi-modal platform for predicting the probability of success (PoS) of a single clinical trial, implementing an AI system to predict clinical trial success rate and identify experimental design weaknesses. In the implementation of therapeutic pipeline due diligence conducted by inClinco, the advanced AI platform supported by

multimodal data has ML algorithms for extracting information and coordinating data and NLP systems for processing public data. Furthermore, the system also enables the prediction of industry-wide success rate analysis for clinical trial enrolment[20].

3.2 Pfizer (USA)

Pfizer is a biopharmaceutical company designed to discover and develop treatments or prevent diseases. It was established in the United States 1849. Pfizer's AI technology is adopted primarily to predict the connection between biological systems and disease symptoms to identify and develop appropriate drugs. With the help of supervised ML, Pfizer believes AI can handle large amount of data as fast as possible, significantly reduce costs, and achieve a more efficient allocation of human resources. Moreover, by using DL, the AI system can be informed of drug efficacy and side effects in advance to enhance the company's decision-making efficiency[21].

During Covid-19 pandemic, Pfizer used AI algorithms to develop oral drugs and vaccines (e.g., Comirnaty) against the virus. AI ML technology was involved in every aspect of vaccine development, clinical trials, supply chain management, and retail. AI enabled the development and implementation of pandemic-fighting drugs at record speed. Among other things, ML models have tremendous potential to find new molecules with the desired properties, which assists scientists quickly understand how viruses work. At the same time, the ML algorithm helped Pfizer predict the yield of the manufacturing phase and analyze the participants' symptoms when testing the vaccine. When developing the oral drug Paxlovid, Pfizer also used ML models to assist scientists in identifying candidate molecules to ameliorate allergy problems caused by the vaccine[22]. In addition, AI technology enables the rapid creation of new drug labels and the timely updating of available information. It eliminates the need for manual information entry and confirmation, which significantly improved efficiency and avoided errors caused by human oversight[22].

3.3 Comparison between Insilico Medicine and Pfizer

The above sections discussed the application of AI in the pharmaceutical industry. In this section, the two companies are compared and analyzed in Table 1.

Table 1. Comparison of AI applications in Insilico Medicine and Pfizer.

	Insilico medicine	Pfizer
Application areas	Data processing, drug target hypothesis, clinical trial success rate prediction	Vaccine development, clinical trials, supply chain management, retail
The scale of AI application	All drug development projects based on AI technology	Collaboration with other companies on AI applications for specific drug development projects
AI service provider	Providing AI machine learning service to other companies	No AI services provided to other companies
Benefits	Replace animal experiments, simplify data processing, and reduce time and cost of drug development	Improve drug development efficiency, predict drug efficacy and side effects, and reduce manual errors

4. ILLUSTRATIONS IN MEDICAL IMAGING INDUSTRY

4.1 Deepwise (China)

Deepwise is a Chinese company focused on developing AI technologies in radiology images for accurate cancer diagnosis. Based on cloud computing, DL is used to assist in medical image analysis, which aids in clinical decision-making and research[23]. Deepwise has a computer science team of up to 100 engineers dedicated to developing AI healthcare solutions. Data show that

the company offers AI diagnostic imaging technology that is more accurate than the average physician in diagnosing lung nodules, but still lags compared to elite physicians[24].

4.1.1 Dr. Wise AI Medical Assist Diagnostic System. Deepwise's AI assisted diagnostic system implements cutting-edge technologies to screen early lung cancer, early breast cancer and help with children growth and development assessments. It also provides physicians with further treatment recommendations. During Covid-19 pandemic, the AI Medical Assisted Diagnosis System has examined up to 2,000 cases per day, releasing the pressure of image analysis[25].

4.1.2 Dr. Wise Smart Cloud Imaging System. This is an online diagnostic center based on application virtualization that assists physicians in conducting diagnostic tasks in different scenarios by combining with AI medical-assisted diagnostic systems. At the same time, it enables the interoperability of different medical data within a particular region. In pandemic, this smart imaging cloud system connected major hospitals across the country for data transmission to solve the shortage problem of primary care resources[26].

4.2 GE Healthcare (US)

GE Healthcare is a leading global provider of drug diagnostics and AI digital solutions for patient screening, diagnosis, treatment planning guidance and testing. The company improves the efficiency of health systems and provides personalized services to patients through smart devices and intelligent platforms[27].

4.2.1 Edison Digital Health Platform. Edison digital health platform is designed to integrate data from vendors and feature an integrated AI engine. The platform provides data transformation services for healthcare providers and uses aggregated data to train AI models. Healthcare professionals can easily access care workflows and clinical applications during treatment, which helps them provide better services to patients and drive growth in hospital operations and revenue[28].

4.2.2 Allia Platform. Allia Platform aims to integrate advanced image guidance into various medical scenarios and to increase the adoption of advanced image guidance in daily practice. The platform's core technologies are AutoRight (an AI-based advanced interventional image chain) and Liver ASSIST Virtual Parenchyma (a 3D visualization software solution). Allia's AI technology generates virtual parenchymal imaging to assist physicians in simulating injection procedures and performing liver embolization procedures[27].

4.3 Comparison between Deepwise and GE healthcare

Deepwise and GE Healthcare are pioneers in the medical imaging industry, and their innovations have led to advancements in the industry. Table 2 presents a comparison between the two companies regarding their AI applications.

Table 2. Comparison of AI applications in Deepwise and GE healthcare.

	Deepwise	GE healthcare
Application areas	Cancer diagnosis, medical image analysis, treatment recommendation provision	Medical data integration and conversion, patient screening and diagnosis, treatment plan guidance and testing
AI products	Developing intelligent systems through AI deep learning technology	Developing software systems and medical hardware devices through AI technology
Benefits	Improve the accuracy of medical image diagnosis, relieve the pressure of medical system image analysis, and solve the lack of medical resources	Assist clinical decision making, simplify medical imaging operations and optimize the patient examination process

5. COMPARISON OF AI APPLICATIONS IN MEDICAL SCIENCES BETWEEN CHINA AND THE US

While China and US are pioneers in AI development, their research focus are distinctive. In terms of AI development purpose, China is committed to solve problems of insufficient medical resources, while the US is more inclined to provide personalized treatment solutions for patients[29]. Regarding the AI development environment, China has a large population base, sufficient medical data, high penetration of electronic medical records, and government policy support. US has more stringent medical data protection. Currently, China still faces the problem of lack of high quality technological talents compared with US.

6. CONCLUSION

This paper discussed the applications of AI in the pharmaceutical and medical imaging fields. It uses companies from these two industries as case studies to illustrate the differences within industry and across cultures. In pharmaceutical industry, Insilico medicine focuses more on AI R&D whereas Pfizer focuses on a wider areas of AI, which include vaccine development, clinical trials and more. In terms of medical imaging area, Deepwise is still at a beginning or experimental stage of AI development and application, whereas GE healthcare has been well developed in this area, and began to provide mature clinical services to the patients. For the comparison between the two countries, China in general lacks high quality of technological talents, and is still at the stage to test the AI technologies. US, on the contrary, is able to provide personalized treatment solutions for patients on a larger scale. Due to the page limitation, we are not able to provide more detailed information for these interesting comparisons. Further research should investigate on more differences between countries (China and US) in not only pharmaceutical and medical image fields, but also other medical sciences areas (e.g., medical robots, remote treatment and diagnosis). As a conclusion, AI has brought fundamental changes in the way medical services are conducted. It has a far-reaching impact on the future development of medical science.

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