Collaborations of Industry, Academia, Research and Application Improve the Healthy Development of Medical Imaging Artificial Intelligence Industry in China

Yi Xiao, Shiyuan Liu*

Department of Radiology, Changzheng Hospital, Naval Medical University
(Second Military Medical University), Shanghai 200003, China

Key words: medical imaging; artificial intelligence; white paper; innovative alliance

Abstract In recent years, artificial intelligence (AI) has developed rapidly in the field of medical imaging. However, the collaborations among hospitals, research institutes and enterprises are insufficient at the present, and there are various issues in technological transformation and value landing of products in this area. To solve the core problems in the developmental path of medical imaging AI, the Chinese Innovative Alliance of Industry, Education, Research and Application of Artificial Intelligence for Medical Imaging compiled the *White Paper on Medical Image AI in China*. This article introduces the current status of collaboration, the clinical demands for medical imaging AI technique, and the key points in AI technology transformation: robustness, usability and security. We are facing challenges of lacking industry standards, data desensitization standard, assessment system, as well as corresponding regulations and policies to realize the application values of AI products in medical imaging. Further development of AI in medical imaging requires breakthroughs of the core algorithm, deep involvement of doctors, input from capitals, patience from societies, and most importantly, the resolutions from government for multiple difficulties in links of landing the technology.

IN recent years, with the rapid development of computer hardware and software, the computing power has been greatly improved, which makes artificial intelligence (AI) come to the stage once again after years of silence.^{1,2} According

to the "New Generation of Artificial Intelligence Development Plan", released in July 2017 by the State Council of China, intelligent medical care has been put forward as one of the key tasks of the nation. In this governmental document, the guiding ideology, strategic objectives, key tasks and supporting measures for developing the new generation AI in 2030 are proposed officially. The technological innovation and the favorable policy of the nation have rendered rapid development of AI in the field of biomedicine. AI has also become one of the strategic directions of traditional medical giants as well as emerging internet technology companies.

The application domain of AI in medical care can include hospital management, personal health man-

Received June 5, 2019; accepted June 10, 2019; published online June 14, 2019.

* Corresponding author E-mail: cjr.liushiyuan@vip.163.com

Supported by the National Key Research & Development Program of China (2018YFC0116404); Shanghai Health and Family Planning Commission Intelligence Medical Research Program (2018ZHYL0101); Shanghai Science and Technology Commission's Major Innovation Action Project (17411952400).

agement, clinical case analysis, virtual assistant for physician, intelligent machinery, new drug research and development, medical imaging, disease diagnosis, etc.^{3,4} The AI enterprises in United State have covered variant fields of medical care system, while in China, AI enterprises have been mostly working on medical imaging due to the rapid growth of clinical demands, the imbalanced distribution of high-quality healthcare resources and the lack of medical imaging doctors around the country. Although AI products of medical imaging have covered the whole process of disease diagnosis and treatment, e.g. computer-aided diagnosis, decision-making for treatment, quantitative follow-up, precise treatment, some core problems have emerged on the way forward to its in-depth development and application. For example, "information island" exists regarding data storage and image interworking; multi-terminal communication is still underdeveloped. Large volume of data in medical image database need to be labeled in standardized formats. Issues in data application and sharing have gradually become the bottleneck for further development of medical AI. In addition, technology research is poorly docked with medical demand, application of AI in health care are limited to a few scenarios, and consequently there exist homogenization in medical AI products currently.⁵

EFFICIENT COLLABORATION OF INDUSTRY, ACADEMIA, RESEARCH AND APPLICATION IS NEEDED FOR HEALTHY DEVELOPMENT OF AI IN MEDICAL IMAGING

In view of the problems on the road of development, the Chinese Innovative Alliance of Industry, Education, Research and Application of Artificial Intelligence for Medical Imaging (CAIERA), the first Chinese organization sponsored by the demand-apply end, was set up on April 12, 2018. The original members of the Alliance include 120 well-known large-scale Tertiary hospitals in China, 55 enterprises of medical imaging artificial intelligence and 35 scientific research institutions. The CAIERA commits itself to effectively integrating various resources from the industry, education, research and application field to give full plays to their respective advantages. The mission of the alliance is to promote the technological innovation and rapid development of medical imaging AI in China. Cooperating with some Chinese associations of medical imaging, leading experts from the alliance advice on clinical de-

mands, make top-level design, promote standardization and performance assessment for AI products from both the medical academia and AI technology perspectives. The alliance has issued a certain number of consensus on relevant topics in AI.^{6,7} Meanwhile, to solve the present pain points and key points for the technological innovation and development in medical imaging AI, the alliance has compiled the *White Paper of Medical Image AI in China*(full text available in supplementary material),⁸ where the up-to-date AI algorithms, applications, policies, and so on, were analyzed, aiming at improving hospital-university-enterprise cooperation and jointly exploring the developmental path of medical imaging AI in China.

CURRENT STATUS OF MULTI-LATERAL COLLABORATION IN MEDICAL IMAGING AI IN CHINA

With the popularity of digital medical equipment, high-resolution thin-section scanning and the rapid expansion of storage power of multi-model imaging modalities, the data volume of medical images increases by over 30% each a year, which also account for 90% of digital data volume for a hospital. In contrast, the number of radiologists increases by only about 4% a year. The overwork has affected the image interpreting quality and the diagnostic accuracy of radiologists in China. Under this circumstance, AI technology can help to improve the diagnostic accuracy while shortening the image reading time greatly for its theoretical features of semi-supervised, self-learning and self-evolution, which greatly solves the clinical pain point.

The first national survey on medical AI in doctors and researchers, initiated by the CAIERA, found that young or middle-aged physicians, senior physicians and radiologists who also take administrative responsibility were generally more interested in AI technology; for AI technologic researchers and developers, young students took the great proportion. The majority of professionals in this emerging area are relatively young indicates a broad and promising future of the AI industry. Furthermore, the survey found that the demands of physicians and the researchers are consistent with each other. Physicians pertain active attitudes to sharing resources they have, e.g. the image data, the clinical data, image annotation data, and they apt to give suggestions on clinical demands, provide feedbacks information of the products as the initial users.

This is invaluable to AI technological researchers who engage themselves in investigating novel technology and meanwhile concern about the transformation of the technology to product, which they believe is very challengeable to them.⁹

The collaborations among hospitals, research institutes and enterprises are insufficient at the present. There are some barriers for this issue. Firstly, in the field of medical imaging AI, the fundamental researches are relatively weak in both hospitals and science & technology research institutions. Secondly, many healthcare facilities are not likely to open and share their medical data in concern about information security, while only a few researchers or enterprises possess the key technology to maintain data security and have practical experience in this process. Thirdly, most imaging physicians lack AI-related knowledge. They also concern about the reliability of AI products and the differentiation of legal liability between physicians and AI when applied clinically. They believe that no standard to follow is the most important problems.

CLINICAL DEMANDS FOR MEDICAL IMAGING AI PRODUCTS IN CHINA

Distinctive from other AI products, medical imaging AI products should meet the practical needs in health care practice and be seamlessly integrated to the clinical workflow of a healthcare facility. From this point of view, a close cooperation of supply end with the demand end is particularly important. The white paper summarizes the opinions and suggestions on clinical demands from experts in subspecialties of medical imaging. Regarding the pain point problems in a variety of medical imaging subspecialties where AI has been applied, the white paper analyzes the current situation of research, clinical application, the goals and challenges, and points out the direction of research and development for AI product in future. For example, it is suggested that improving the efficiency and accuracy of an AI product should be the major task of product design in its early stage, in another word, to focus on optimizing a "dot", an AI application in a single scenario for a certain disease in a certain department firstly. Multi-task learning based on anatomic sites, as well as multi-disciplinary data intelligentization based on clinical medical record, radiographic information, pathological and genomic information, can effectively facilitate

clinical decision-making and scientific research. It is only through integrating the respective advantages of hospitals, AI enterprises, research institutions, and medical equipment manufacturers in aspects of diagnosis, treatment, research and data management that we can realize the real breakthrough in AI algorithm, and thus help to fulfill the values of medical AI.

RAPID DEVELOPMENT OF MEDICAL IMAGING AI TECHNIQUE AND TECHNICAL TRANSFORMATION

Artificial intelligent technique has made substantial breakthrough in medical image segmentation, registration, recognition and mapping, which has promoted its application and development in various aspects of medical imaging.¹⁰⁻¹³ At present, AI technology has been used in speeding data acquisition, optimizing image with lowered radiation dose, chest film intelligent reporting, intelligent imaging of coronary CTA, breast cancer screening, lung nodules screening, accurate delineation of radiation targeted area, bone age interpretation, diagnosis of brain white matter diseases, joint disease, prostate cancer, bladder cancer, colorectal cancer, etc. Besides, great progresses have been also achieved beyond radiological field, such as intelligent diagnosis of pathology, fundus diseases, skin diseases, as well as surgical robots.

In these areas, the current status of researches, demand, dilemma and future direction has been systematically combed and presented in the white paper. In particular, three problems were emphasized as the keys solutions for AI in medical imaging to truly move from lab forward to technology transformation and clinical landing.

Robustness

Models with a small training database are not adaptable well enough for the highly complex clinical environment. The data quality and quantity used in developing AI products directly affect its performance in real clinical setting. To ensure the robustness of AI product, efforts are needed to improve quantity of structured data, quality of image marking, representation of data distribution, and feasible approaches of training.

Usability

The server of an AI product needs to be seamlessly connected with the existing hospital information system,

and to make sure it does not affect the stability of the existing information system, does not interfere with the on-going diagnosis and treatment workflow, and does not complicate physicians' operations. Ease of use is crucial for an AI product being accepted and recognized by its user, the clinicians. It is not only the premise of sustainable existence, but also a huge challenge.

Security

To protect patient privacy and ensure biomedical data safety should be the premier in developing medical imaging AI products.

CHALLENGES TO FULFILL THE VALUE OF MEDICAL IMAGING AI PRODUCTS

To land the medical artificial intelligence, which is driven by the technological development, inevitably there are problems in merging into the traditional medical infrastructure and supervision system. At present, policies and regulations regarding artificial intelligent products are in lack in term of registration approval, market licensing, etc. The industry standards for medical AI application are almost vacant. Neither the desensitization standard for medical data used in AI, nor the assessment index system and ethics principle for medical AI products have been established yet.

The white paper calls on people from all stakeholders pay active attention to the development of medical imaging AI and participate in the integration with each other. It is suggested to set AI technological innovation as priority, reformulate corresponding policies based on research and investigation, through which to promote reformation of traditional healthcare model and drive the development of the industry.

The clinical demands for medical imaging AI exist objectively; deep fusion of new technology, new business performance, and new business model is paramount for the promotion of the whole industry. Application of AI in medical imaging has initially shown its prospect, playing assistant role successfully for doctor in some scenarios. However, there is still a long way to go for a truly clinical application, which requires breakthroughs of the core algorithm, deep involvement of doctors, input from capitals, patience from societies, and most importantly, the resolutions from government for multiple difficulties in links of landing the technology.¹⁴

Conflict of interest disclosure

The authors declared no conflict of interests.

Supplementary material

The white Paper on Medical Imaging AI in China (English Version): available electronically on journal's website.

REFERENCE

1. Esteva A, Kuprel B, Novoa RA, et al. Dermatologist-level classification of skin cancer with deep neural networks. *Nature* 2017; 542(7639):115-8. doi: 10.1038/nature21056.
2. Syed AB, Zoga AC. Artificial intelligence in radiology: current technology and future directions. *Semin Musculoskelet Radiol* 2018; 22(5):540-5. doi: 10.1055/s-0038-1673383.
3. Tonutti M, Gras G, Yang GZ. A machine learning approach for real-time modelling of tissue deformation in image-guided neurosurgery. *Artif Intell Med* 2017; 80:39-47. doi: 10.1016/j.artmed.2017.07.004.
4. Krittanawong C, Zhang H, Wang Z, et al. Artificial intelligence in precision cardiovascular medicine. *J Am Coll Cardiol* 2017; 69(21):2657-64. doi: 10.1016/j.jacc.2017.03.571.
5. Liu SY, Xiao Y. Challenges and opportunities of deep learning artificial intelligence in medical imaging. *Chin J Radiol* 2017; 51(12):899-901. Chinese. doi: 10.3760/cma.j.issn.1005-1201.2017.12.002.
6. National Institutes for Food and Drug Control; Chinese Society of Radiology Cardio-thoracic working group. Expert consensus on the rule and quality control of pulmonary nodule annotation based on thoracic CT. *Chin J Radiol* 2019; 53(1):9-15. Chinese. doi: 10.3760/cma.j.issn.1005-1201.2019.01.004.
7. Chinese Society of Radiology Cardio-thoracic working group. Expert consensus on the imaging management of pulmonary subsolid nodule. *Chin J Radiol* 2015; 49 (4):254-8. Chinese. doi: 10.3760/cma.j.issn.1005-1201.2015.04.005.
8. Liu SY, Qian DH, Shen DG, et al. editor. Chinese Innovative Alliance of Industry, Education, Research and Application of Artificial Intelligence for Medical Imaging, CAIERA. The White Paper on Medical Imaging AI in China. <https://vcbeat.top/Report/getReportFile/key/Nzgw>. Released March 26, 2019; accessed June 3, 2019.
9. Zhang HM, Xiao Y, Hong N, et al. The report of status and needs in medical imaging artificial intelligence

- industry. Chin J Radiol 2019; 53(6):507-11. Chinese. doi: 10.3760/cma.j.issn.1005-1201.2019.06.013.
10. Buda M, Saha A, Mazurowski MA. Association of genomic subtypes of lower-grade gliomas with shape features automatically extracted by a deep learning algorithm. Comput Biol Med 2019; 109:218-25. doi: 10.1016/j.compbiomed.2019.05.002. Epub: 2019 May 3.
11. Ehteshami Bejnordi B, Veta M, Johannes van Diest P, et al. Diagnostic assessment of deep learning algorithms for detection of lymph node metastases in women with breast cancer. JAMA 2017; 318(22): 2199-210. doi: 10.1001/jama.2017.14585.
12. Sitek A, Wolfe JM. Assessing cancer risk from mammograms: deep learning is superior to conventional risk models. Radiology 2019; 190791. doi: 10.1148/radiol.2019190791. Epub: 2019 May 7.
13. Liu K, Li Q, Ma J, et al. Evaluating a fully automated pulmonary nodule detection approach and its impact on radiologist performance. Radiol Artif Intell 2019; 1(3). doi: 10.1148/ryai.2019180084. Epub: 2019 May 29.
14. Xiao Y, Liu SY. The state-of-the-art medical imaging artificial intelligence: challenges and strategies. Chin J Radiol 2019; 53(1):2-5. Chinese. doi: 10.3760/cma.j.issn.1005-1201.2019.01.002.