

# Artificial intelligence in dermatology: past, present, and future

Cheng-Xu Li<sup>1,2</sup>, Chang-Bing Shen<sup>1,2</sup>, Ke Xue<sup>1,2</sup>, Xue Shen<sup>3</sup>, Yan Jing<sup>3</sup>, Zi-Yi Wang<sup>1,2</sup>, Feng Xu<sup>4</sup>, Ru-Song Meng<sup>5</sup>, Jian-Bin Yu<sup>6</sup>, Yong Cui<sup>1,2</sup>

<sup>1</sup>Department of Dermatology, China-Japan Friendship Hospital, Beijing 100029, China;

<sup>2</sup>Graduate School, Peking Union Medical College and Chinese Academy of Medical Sciences, Beijing 100730, China;

<sup>3</sup>Department of Dermatology, The First Affiliated Hospital, Anhui Medical University, Hefei, Anhui 230032, China;

<sup>4</sup>Shanghai Wheat Color Intelligent Technology Company, LTD, Shanghai 200051, China;

<sup>5</sup>Department of Dermatology, Air Force General Hospital of People's Liberation Army, Beijing 100142, China;

<sup>6</sup>Department of Dermatology, The First Affiliated Hospital of Zhengzhou University, Zhengzhou, Henan 450052, China.

Artificial intelligence (AI) had been first coined at a famous Dartmouth College conference in 1956. AI is gradually interrelated with all disciplines, and also permeates all aspects of the medical field. In the early 1970s, medical researchers discovered the applicability of AI in life sciences.<sup>[1]</sup> AI can play a role in many aspects, such as medical image recognition and auxiliary diagnosis,<sup>[2]</sup> biotechnology,<sup>[3]</sup> drug research and development,<sup>[4]</sup> etc. Currently, medical image recognition is the most widely used.

Dermatology is a subject that relies on morphological features, and the majority of diagnoses are based on visual pattern recognition. Dermatology is exceedingly suitable for applying AI image recognition capabilities for assisted diagnosis. At present, skin imaging technology represented by dermoscopy, very high-frequency (VHF) ultrasound, and reflectance confocal microscopy (RCM). Each method of skin imaging equipment has its own advantages and limitations. Dermatologists need to choose different imaging methods according to different conditions of skin lesions. Skin imaging technology has become a vitally important tool for clinical diagnosis of skin diseases, and widely accepted and applied in the world.

## The past of AI in dermatology

In the early days, AI in medicine has not received much attention and application for various reasons. Due to the problem of data acquisition, there is a lack of large amounts of labeled data, and there are not enough samples to fit the parameters of the complex network model. Local extremum problems, gradient dispersion problems, insufficient hardware conditions have limited the development of AI in medicine.<sup>[5]</sup> At first blush, artificial neural

networks (ANNs) have been developed in the last few decades for many different applications in medical science. However, their use in the field of dermatology remains relatively limited. The main use of ANNs in dermatology is the *in vivo* differentiation of benign *vs.* malignant pigmented lesions.<sup>[6]</sup> Until 2006, Hinton *et al*<sup>[7]</sup> proposed the concept of “deep learning” and the training method of deep learning. Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. It has turned out to be very good at discovering intricate structures in high-dimensional data and defeating other machine learning techniques in image recognition and speech recognition.<sup>[8]</sup> After more than 10 years of development, deep learning with the convolutional neural network (CNN) as the core has been widely applied in image processing, speech recognition, text processing, and other fields. Even in the game of go, deep neural networks are trained by a novel combination of supervised learning from human expert games, and reinforcement learning from games of self-play. AlphaGo eventually defeated the human European Go champion by 5 games to 0.<sup>[9]</sup>

The beginning of dermatological AI lags far behind the radiological AI. Radiological AI is leading in small pulmonary nodules<sup>[2]</sup> and lung cancer.<sup>[10]</sup> From the very beginning, the location of suspected nodules, including the description of its shape and the nodules detection, benign and malignant judgments, AI can now follow up and judge nodule changes at different times. These tiny changes are difficult to distinguish accurately, but AI can do it. The application of AI in the field of radiology will greatly shorten the gap between doctors at different levels and doctors at different levels of hospitals, and improve the accuracy of diagnosis. The application of AI in the field of radiology has played an exemplary role in dermatology,

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**Correspondence to:** Prof. Yong Cui, Department of Dermatology, China-Japan Friendship Hospital, Beijing 100029, China  
E-Mail: wuhucuiyong@vip.163.com

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and its benefits have greatly promoted the development of dermatological AI.

### The current status of AI in dermatology

In 2017, Stanford University published a study on deep learning of skin tumor machines in *Nature*. They trained a CNN using a dataset of 129,450 clinical images consisting of 2032 different diseases. The CNN was used to perform pixel and disease labeling of fine-grained objects, and a training model was constructed, which was used in subsequent model validation. In subsequent model validation, machine recognition was performed for “keratinocyte carcinomas *vs.* benign seborrheic keratosis” and “malignant melanomas *vs.* benign nevi.” The results were compared with the diagnostic results of 21 board-certified dermatologists. The CNN achieves performance on par with all tested experts across both tasks, demonstrating an AI capable of classifying skin cancer with a level of competence comparable to dermatologists.<sup>[11]</sup> The recent research compared the performance of a convolutional neuronal network trained with dermoscopy images exclusively for identifying melanoma in clinical photographs with the manual grading of the same images by dermatologists. This study used an enhanced deep learning approach to train a CNN with 12,378 open-source dermoscopy images and used 100 melanoma clinical images to compare the performance of the CNN with 145 dermatologists. The result demonstrated higher robustness of computer vision compared with dermatologists assessment for dermatologic image classification tasks.<sup>[12]</sup> In addition, Tschandl *et al*<sup>[13]</sup> reported the diagnostic accuracy of the state-of-the-art machine-learning algorithms and human readers in all clinically relevant types of benign and malignant pigmented skin lesions. State-of-the-art machine-learning classifiers are superior to human experts in the diagnosis of pigmented skin lesions and should play a more important role in clinical practice.

Chinese dermatological AI started later than some developed countries. Chinese dermatology currently faces quite a few problems: the total number of dermatologists in China is less than 30,000. There are long-standing problems in Chinese medical industry, such as the uneven distribution of high-quality doctors' resources, basic level hospital doctors prone to misdiagnosis, and missed diagnosis and insufficient knowledge of rare diseases. Experienced clinicians need standardized training. The traditional medical service model is difficult to provide high-quality medical services for a large number of people.<sup>[14]</sup> There is a large gap between supply and demand of doctor resources and the high cost of medical expenses, medical AI technology relies on the highly efficient computing ability and imitates through deep learning to provide high-quality medical services and solve the problem of the uneven distribution of medical resources.<sup>[1,15]</sup> Therefore, in the face of the above problems, vigorously develop dermatology AI is imminent.

### Chinese Skin Image Database: a new way to integrate skin image resources

The massive skin image resources are extremely valuable, which provides the possibility for the application of AI in

dermatology and is a crucial basic data for AI. However, the skin image data of various hospitals in China have not shared resources, so they form an “information island,” which directly hinders the formation of “big data” required by AI.<sup>[16]</sup> How to integrate different imaging technologies to complement each other's advantages, how to use massive skin imaging data to provide basic resources for the AI of dermatology, and how to make the auxiliary diagnosis of diseases through AI are important topics for the development of skin imaging.

For the above reasons and needs, the Chinese Skin Image Database (CSID) was established in May 2017, which can be used to assist the development of AI, by combining the expert team of dermatology and venereal diseases with the Internet and AI technology team.<sup>[17]</sup> The establishment of a CSID is undoubtedly an ice-breaking move. Skin image data is “flowed” through the Internet, dermatological diagnosis and treatment are “wisdom” through AI.<sup>[16]</sup>

Expected results of the CSID project are as follows: focus on domestic superiority in the field of skin imaging, building a skin imaging collaboration network, developing a quality management system for skin disease assisted diagnosis, and a “cloud” platform for user-oriented image services based on the Internet technology team, constructing a “multi-dimensional skin image resource library.” CSID applies data collection mode and data information mining technology to develop auxiliary diagnostic application software for various skin diseases, providing better clinical decision support for doctors.

### Dermatological AI products of China

In 2018, Chinese dermatological AI has made great achievements, with a number of AI products released. Based on the high-quality and huge data of the CSID project, the first AI-assisted decision-making system for the Chinese human skin tumors – Youzhi Skin AI has been developed. The test results of the Youzhi Skin AI manifest that the coincidence rate of benign and malignant classification by identifying dermoscopy images can reach 85.2%, and up to 66.7% in the mixed classification of diseases and major categories.<sup>[18]</sup> Subsequently, the Youzhi Skin-Melanonychia AI was launched, which was mainly used for the auxiliary diagnosis and differential diagnosis of pigmented damage on deck. The Psoriasis Chronic Disease Management AI, which can assist decision-making on psoriasis, differential diagnosis of similar diseases, remote disease assistance and treatment activities, and management of patient information: history, previous medication, Dermatology Life Quality Index score, Classification Criteria for Psoriatic Arthritis score, skin image, severity of psoriatic lesions, joint damage, laboratory indexes, etc.

Based on the dermoscopy image data of CSID and the underlying technical framework, there is an AI remote diagnosis and treatment tool for skin tumors in the elderly has released. This AI tool uses a combination of “handheld dermoscopy + mobile application,” which has a portable advantage and enables mobile wisdom treatment.

AIDERMA is the first comprehensive platform for AI assisted diagnosis and treatment of skin patients in China. AIDERMA mainly includes three functional sections: assisted diagnosis and treatment, continuing education, and doctor consultation. In the assisted diagnosis and treatment, it can support more than 90 kinds of common skin diseases. The operation is extremely simple, just takes pictures and upload the skin lesions, the system immediately provides the clinician's diagnosis and treatment ideas, and also has the Pad version.

### Foreign dermatological AI products

Many foreign AI teams and research institutes have participated in the research and development of dermatological AI products, and have achieved remarkable results. A joint research team at Stanford University used a single CNN trained on general skin lesion classification to develop an AI system that is comparable to human physicians in the diagnosis of skin cancer.<sup>[12]</sup> A team of German, American, and French researchers trained an AI system to identify dangerous skin lesions and benign lesions.<sup>[19]</sup>

At the same time, some companies focus on AI research and development. For example, DeepMind, which was established in 2010, has conducted a series of researches in the field of medical AI, including AI eye disease detection, AI recognition of breast cancer, and prediction of kidney damage. SkinVision was founded in 2011 by researchers and dermatologists. It serves as a health-prevention medium to help every subject understand their own skin health. SkinVision makes early detection of skin cancer possible, treating it as early as possible and reducing treatment costs. The subjects take a picture of the skin lesion through the mobile phone. After about 30 s, they will receive a low-risk or high-risk indication, and the next step to take the relevant advice, and set the next time to check.

### Dermatological AI organization in China

The rapid development of AI in dermatology is inseparable from the unremitting efforts of dermatologists, Internet companies, and scientific research institutions. With the wide application of dermatological AI, in addition to CSID, a number of AI organizations have been established in the field of dermatology in China, including: National Telemedicine and Connected Health Center Dermatology Committee, Chinese Medical Equipment Artificial Intelligence Alliance Dermatology Committee, Huaxia Skin Image and Artificial Intelligence Cooperation, and Dermatology Artificial Intelligence Development Alliance of China.

### The future of dermatology AI: opportunities and challenges

In recent years, many developed countries in the world have actively formulated strategic plans for the development of AI and promoted the development of AI to a new strategic era. The United States has released the *National AI Research and Development Strategic Plan*. The United Kingdom has released *Growing the AI Industry in the UK*.

The EU has issued *The Age of AI: Towards a European Strategy for Human-Centric Machines*.

In order to seize the AI development of crucial strategic opportunities, to build Chinese first mover advantage in the development of AI, speed up the construction of an innovation-oriented country and a strong country in science and technology, China has issued the *Made in China 2025 plan*, *The State Council on Promoting Action Guidance for "Internet +," A New Generation of AI Development Plan*. China promotes the development of AI from the perspective of national policy.

Although dermatological AI has developed rapidly in recent years, it has encountered bottlenecks in the clinic, and there are many problems that need to be solved urgently: First, the current scale of skin disease image data is still insufficient, the degree of information sharing between hospitals is low, and the standard and quality of skin images are not uniform. It is difficult to obtain high-quality image data, which will lead to the unreliability of research results. Second, the combination of medical and AI complex talents is extremely scarce. It is indispensable to cooperate closely with multi-disciplinary personnel in computer science, biomedical and medical. Third, there are many kinds of diseases in dermatology. Dermatological AI can only recognize one or a group of specific skin diseases. How to make AI recognize more skin diseases is one of the bottlenecks in AI diagnosis of skin diseases. Fourth, the current AI diagnosis also involves legal issues, ethical issues, and data privacy issues that have not yet been fully resolved. Fifth, due to database sources, approval processes, and the specificity of AI products. At present, there is no medical AI product of a company in China that has obtained a medical device registration certificate, and no dermatological AI product has been approved for market entry. It has certain restrictions on the development of medical AI commercialization. Sixth, the diagnosis of skin diseases requires not only clinical images and skin images but also comprehensive consideration of patient history, gender, age, and other information to obtain an accurate diagnosis. Therefore, skin image data and patient information need to be integrated, and AI is used to comprehensively analyze these data, thereby playing a greater role in disease diagnosis, treatment decision-making, and prognosis judgment in the future.<sup>[19]</sup> In addition, AI is not a substitute for communication between doctors and patients, nor can it provide patient care and humanistic care. In the face of these thorny problems, dermatologists and related field experts are trying to solve various problems.

In the scientific research of AI aspect, the National Natural Science Foundation of China has increased funding for basic theories, basic methods, and key technology research projects in the field of AI and related interdisciplinary fields. Theoretical and methodological research in the fields of AI, machine learning, machine perception and pattern recognition, natural language processing, knowledge representation and processing, intelligent systems and applications, cognitive and neuroscience-inspired AI are encouraged. In order to encourage dermatologists to conduct research on skin imaging, the CSID has

established an open research fund program that focuses on scientific issues, application problems, and solutions in the fields of skin photography, dermoscopy, VHF ultrasound, and RCM.

Since 2010, more than 40 universities and colleges in China have set up AI related majors, speeding up the cultivation of AI talents and basic theoretical research, and promoting the transformation of the AI technology industry. In 2018, a number of universities set up AI research institutes. Many hospitals, universities, and scientific research institutions in China have invested in the field of AI in dermatology. Major technology companies have laid out the medical AI field. The market scale and capital investment have increased year by year, large-scale financing has occurred frequently, and the total amount of medical AI financing has reached a new high. Internet medical companies in the dermatology field have also received tens of millions of RMB Yuan in a new round of financing.

In general, dermatology AI has received unprecedented attention from all aspects of the national level, personnel training, scientific research support, technology development, and market capital. There are still numerous potentials for AI in the dermatology field. In the future, with the promotion and innovation of AI theory and technology, the expansion and quality improvement of database resources, and multi-disciplinary and cross-disciplinary cooperation, AI will bring more professional, accurate and personalized auxiliary diagnosis and treatment to dermatologists. The ultimate goal is to make AI better serve doctors and patients.

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### Conflicts of interest

None.

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