REVIEW

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Artificial intelligence in skin cancer diagnosis: a literature review

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ABSTRACT

Nowadays, artificial intelligence (AI) has been integrated into various sectors including dermatology. AI offers alternative diagnostic tools for skin cancer, especially for dermatologists who are not familiar with dermoscopy and when histopathology examinations are not available. Therefore, this paper provides a review of the role and development of AI, as well as its limitations in assisting the diagnosis of skin cancer. Artificial intelligence (AI) is a computer science aiming to produce a program mimicking human cognition to analyze complex data. AI in dermatology comes in a variety of programs, such as the integration of AI in smartphone applications. From several studies, AI helps to diagnose skin cancer as early as possible resulting in early treatment and offers a more objective examination than dermoscopy which is operator-dependent. AI helps to give dermatologists consideration to perform more invasive examinations such as biopsies as well as treatment recommendations that can be done. However, AI still can not replace the ability of doctors to integrate the patient's medical history with findings obtained from the physical examination. This breakthrough is still at an early stage which requires the support of more research with collaboration between dermatologists and computer experts.

Keywords: artificial intelligence, skin cancer, diagnosis, cancer, skin tumor.
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INTRODUCTION

The incidence of skin cancer, including melanoma and non-melanoma skin cancer (NMSC), has been increasing in the last decades. *World Health Organization* (WHO) states that 2 to 3 million NMSC and 132,000 melanoma skin cancer (MSC) happen globally every year.[1] In 2018, there were 1,042,056 new NMSC cases with 65,155 mortality rates. Most cases were reported from North America (482,722 cases) while 13,353 cases happened in Southeast Asia.[2] In Indonesia, skin cancer incidence ranked in the third position after cervix cancer and breast cancer. From 2018 to 2010, it was reported that 50 of 2,945 new patients in the dermatology clinic in Prof. Dr. R. D. Kandou Academic Hospital in Manado, Indonesia were skin cancer patients.[3] The data from the Skin Surgery Division, Dermatology Clinic in Dr. Soetomo General Academic Hospital from January to December 2018 showed that the incidence of skin cancer was 27 patients out of 3,065 patients (0.88%). This number increased in 2019 when the incidence of skin cancer was 35 patients out of 3,368 new patients (5.15%).

Skin cancer is common in the Caucasian race. However, people of color like Indonesian have a greater mortality rate due to the delay in detection. Skin cancer is often diagnosed in the advanced stage among people of color making the treatment more difficult. The diagnosis of skin cancer includes history taking about the complaint, lesion development, and risk factor followed by a thorough skin examination. The histopathology examination is still the gold standard to confirm a skin cancer diagnosis. Dermoscopy examination is a non-invasive examination, that helps in skin imaging to provide additional information which does not obtain by regular inspection. Dermoscopy helps to differentiate melanocytic skin lesions from non-melanocytic skin lesions and benign from malignant lesions, increasing the diagnostic accuracy. Unfortunately, dermoscopy is an operator-dependent tool and it needs exercise and experience to operate.[4,5]

Artificial intelligence (AI) offers alternative solutions in skin cancer diagnostics. AI is a computer science that involves creating programs that aim to reproduce or imitate human cognition and the processes involved in the analysis of complex data. The use of AI in the field of dermatology, especially in the diagnosis of skin cancer, has continued to grow in the last decade. AI assists dermatologists in screening for benign versus malignant and melanoma from non-melanoma skin lesions. Various studies comparing AI with dermatologists were conducted to determine the performance of AI. Artificial intelligence ability is often assessed using statistics that are familiar to dermatologists such as sensitivity and specificity, but a statistic commonly used to evaluate AI that may be new to some dermatologists is the area under the curve of the receiver operating characteristic (AUROC).[6] Artificial intelligence can be an alternative, non-invasive, and objective method in the diagnosis of skin cancer. Among dermatologists in Indonesia, AI is unpopular and not widely known. But over time, dermatologists need to learn about AI. This literature review was created to discuss the role and development of AI, as well as its limitations in assisting the diagnosis of skin cancer, based on the current literature.

ARTIFICIAL INTELLIGENCE IN SKIN CANCER DIAGNOSIS

Artificial intelligence (AI) is a computer science aiming to produce a program mimicking human cognition to analyze complex data. Commonly, AI can be divided into two sub-categories: strong and weak. Strong AI or artificial general intelligence is the ability of a machine to communicate, think, and operate independently in a similar way to humans, or in other words machines with human-level intelligence. On the other hand, weak AI is the current technology where a machine learns to fulfill a task with a program we made.[5,6]

There are several sub-fields of AI that need to be known. The first is machine learning (ML). Machine learning is a subfield of AI that studies how computers can learn tasks without being explicitly programmed. Machine learning is structured in the form of algorithms or statistical models to complete predetermined tasks (e.g., performing a diagnosis). These algorithms or statistical models study data sets have been labeled with answers (e.g., dermoscopy images) so that the machine can predict answers from pre-entered data sets, optimizing given success (e.g., the accuracy of diagnosis).[5,6] The second one is deep learning (DL). Deep learning is a specific type of ML that uses an artificial neural network (ANN). Deep learning requires a large number of data sets and has the capacity to use an infinite number of layers, where each layer in the neural network can recognize and learn specific features, which are different from the others. In other words, this model can learn and perform more complex tasks than ML. One type of ANN that is often used and reported to be beneficial in recognizing and classifying images is the convolutional neural network (CNN), which has been widely used in dermatology.[6,7]

A CNN is a set of filters that can operate on a particular plane (for example, a filter that calculates the relationship between a group of pixels in each environment) at a time. Convolutional neural network specializes in studying inputs (e.g., images) and classified tasks (e.g., diagnosis) by analyzing local relationships between specific sample environments (e.g., pixels in images). Convolutional neural network works through several layers where the first layer is the input and the last layer is the output, including classification or diagnosis of the picture/lesion. The first and last layers are the two layers that are accessible to the user. However, several layers hid between the two that may be accessed indirectly via input and output. This hidden layer is an internal part of CNN to analyze deeper and more sophisticated dimensions.[5]

In its development, AI in dermatology comes in a variety of programs. The most relevant and close to everyday life is the integration of AI in smartphone applications to take photos of skin lesions, collect relevant clinical information, and provide necessary referrals. Many smartphones already have DL support on devices with Google's TensorFlow Lite (TensorFlow) or Apple's CoreML (Apple Inc.). The AI system (Moleanalyzer Pro®) has been approved for the European market as a medical device and has been shown to work on pair with dermatologists.[8] Research on AI in dermatology may use different programs or algorithms. The study of AI in dermatology should consider the dataset (dermoscopy or non-dermoscopy images), the classification task (binary, i.e., distinguishing between "A" and "B" lesions; or multiclass classification, i.e., distinguishing between various lesions), algorithm performance used, and the performance of the dermatologists being compared.

Artificial intelligence programs are often evaluated using statistical assessments known to dermatologists, such as sensitivity and specificity. However, a common statistical assessment used to evaluate AI programs that may be new to some dermatologists is the area under the curve of the receiver operating characteristic (AUROC). Area under the curve of the receiver operating characteristic quantitatively assesses how accurate the program can classify two situations, usually "disease present" or "without disease". An AUROC value of 1.00 means that it is completely distinguishable between true and false classifications. A score of 0.5 implies that the result is categorized as occurring by chance. The bigger the AUROC, the more accurate the AI program will be.[6]

Cancer diagnosis using AI is divided into three stages, which are pre-processing, image segmentation, and post-processing. In pre-processing, an effort is made to improve image quality by removing components from the image that are not needed. Inaccurate diagnosis often results from poor image quality, such as low contrast between the skin lesion and the surrounding healthy skin, irregular borders, and skin artifacts that may affect it, such as hair, skin scratches, and others. Several things are done in this stage, including adjusting the contrast, correcting the color, removing the sketch effect, removing the hair, smoothing the image, as well as normalizing and localizing the skin lesion. The next step is image segmentation which means separating the region of interest or part of the image that you want to use for further processing, from the image background. Segmentation is divided into four main classes which are threshold-based segmentation, region-based segmentation, pixel-based segmentation, and model-based segmentation. The final stage is post-processing, by merging regions, widening the borders, and smoothing the image.[9]

The use of AI to diagnose skin tumors by dermoscopy images of nevus and melanoma was first reported in 1994 by Binder et al. Researchers compared the accuracy of the use of ANN with human judgment. However, the development has been slow due to a lack of image datasets with which to conduct further research.[10] Han et al. conducted a study, testing the DL algorithm to classify clinical images from 12 diseases. The algorithm is able to diagnose 8 of 12 diseases while the other 4 diseases are diagnosed as differential diagnoses.[10]

The biggest breakthrough regarding the use of AI in the diagnosis of skin cancer so far has been to make predictions for dermoscopy image classification of skin lesions. The emergence of DL and ML algorithms which consist of several layers of simple models, which are then processed to produce an answer, makes the diagnosis of multiple skin lesions automatically possible. The first layer group will construct an object representation in the image from the selected pixel data. Thereafter, each layer, using data from the previous layer, progressively recognized further lesions. For example, in the early stages of detecting the periphery, then mapping the boundaries of the lesion, and ending with the irregularity of the lesion.[5]

Many studies have compared CNN with the performance of dermatologists in diagnosing skin tumors. Haenssle et. al. (2018) conducted a study comparing CNN (Google's Inception v4 architecture) which had been trained and validated using dermoscopy images and appropriate diagnoses, with the judgment of a dermatologist.[11] In the study, 300 images were created in the examination set (set-300), which included 20% of melanoma images (in situ and invasive) and 80% of benign melanocytic nevus lesions. Prior to the CNN examination, two experienced dermatologists selected 100 images (sets of 100) to increase the difficulty of diagnosis, which were then used to compare the CNNs with the dermatologist who read the images. One hundred and seventy-two dermatologists were grouped according to their level of experience in dermoscopy, who are beginners with <2 years of experience, trained with 2-5 years of experience, and experts with 5 years of experience. The image reading is divided into 2 stages, level I where the dermatologist only reads dermoscopy images and is asked to make a dichotomous diagnosis (melanoma or benign nevus), and treatment decisions (excision, follow-up, referral, or no action). After 4 weeks, the same dermatologist had to determine the diagnosis and treatment at level II by viewing the dermoscopy images plus additional clinical information and close-up images of the 100 cases. As a result, at level I readings, the mean sensitivity, and specificity achieved by dermatologists in classifying lesions were 86.6% and 71.3%, respectively. The additional clinical information provided at level II increased the sensitivity and specificity to 88.9% and 75.7%, respectively. However, CNN ROC showed higher specificity compared to dermatologists at the level I (52.5% vs. 71.3%) and level II (82.5% vs. 75.7%). The CNN ROC was greater than the dermatologist's mean ROC area (0.86 vs. 0.79). Although most dermatologists give lower performance than CNN, CNN is still recommended to be used as an aid in image classification, not as a primary diagnostic tool.[11]

Convolutional neural network can also help classify dermoscopy and close-up images of non-pigmented lesions with a degree of accuracy comparable to that of humans. Tschandl et al. conducted a study to compare the accuracy of the CNN-based classifier with doctors with various levels of experience.[12] The CNN model was previously trained using 7,895 dermoscopy images and 5,829 close-up images of excised lesions in a skin cancer clinic. Then, this CNN composite was tested using 2,072 previously unknown cases, compared with results obtained from 95 medical personnel, 62 of whom are dermatologists with different levels of experience with the use of dermoscopy. The results showed that the AUROC of CNN was higher than the human rating (0.742 vs. 0.695).[12]

The use of CNN by dermatologists can reduce disease morbidity because diagnoses can be made more quickly, and unnecessary diagnostic procedures can be avoided, thereby lowering treatment costs. Although all studies that have been conducted have shown that the diagnosis of skin lesions using AI is comparable to dermatologists, the number of clinical images of patients, varying in age and ethnicity, should be increased to increase the accuracy of the CNN system.[5,13]

Despite all the advantages of AI, it can not replace histopathological examination as the gold standard for the examination of skin lesions. Currently the use of DL has developed to diagnose melanoma from histopathological assessment.[14] This tool still can not replace the ability of doctors to integrate the patient's medical history with findings obtained from the physical examination. AI also unable to assess what is happening in other parts of the body, which may be beneficial to determine the differential diagnosis. Furthermore, no machine can replace a doctor's empathy in building a doctor-patient relationship. In the case of chronic skin disease, the relationship between doctor and patient plays a significant role in the patient's recovery. There are studies assessing patients' views on the use of AI for skin cancer screening, with the results showing that patients accept the use of AI when implemented while maintaining the integrity of the doctor-patient relationship.[15]

In the future, a larger, better, and neatly organized image database is essential until a comprehensive and accurate algorithm has established. In addition, it is necessary to clarify how to implement AI in clinical situations, whether it is aimed at patients or doctors, how predictions can be conveyed, and what role AI will play in the diagnosis and management of skin tumors. For example, it is currently unclear how general practitioners or patients should deal with the predicted 2% chance of melanoma. It shows that AI cannot replace the role of doctors, but rather as a tool in clinical practice.

CONCLUSION

Artificial intelligence (AI) is a computer science that aims to produce programs that can analyze complex data with human cognition. Currently, AI in the field of dermatology is experiencing rapid development, especially as a diagnostic method. Research on AI in dermatology evolve nowadays more focused on skin cancer. Artificial intelligence offers a more objective examination than dermoscopy which is operator-dependent. Artificial intelligence helps to give dermatologists consideration to perform more invasive examinations such as biopsies as well as treatment recommendations that can be done. Artificial intelligence can be also operated by general practitioners to screen or assist dermatologists who rarely use dermoscopy. Given the development and benefits of AI, dermatologists should start learning about AI. However, this breakthrough is still at an early stage which requires the support of more research with collaboration between dermatologists and computer experts.

CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Author IC contributed in conception and design of the work, definition of intellectual content, data analysis, manuscript editing, manuscript review, final approval of the version to be published. Author MW contributed conception and design of the work, definition of intellectual content, literature search, data acquisition, data analysis, manuscript preparation, manuscript editing.

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