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Image dermoscopy skin lesion classification using deep learning method: systematic literature review

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ABSTRACT

Classifying skin lesions poses a significant challenge due to the distinctive characteristics and diverse shapes they can exhibit, particularly in identifying early-stage melanoma. To address the shortcomings of the prior method, a neural network-driven strategy was introduced to differentiate between two types of skin lesions based on dermoscopic images. This new approach comprises four key stages: i) initial image processing, ii) skin lesion segmentation, iii) feature extraction, and iv) classification using deep neural networks (DNNs). Computers can also provide more accurate diagnosis results. In the review process, the articles are analyzed and summarized to contribute to developing methods or application development in skin lesion diagnosis. The stages include defining the relevant theory, input data, methods used (architecture and modules), training process, and model evaluation. This review also explores information based on trends and users, emphasizing the skin lesion segmentation process, skin lesion classification process, and minimal datasets as recommendations for future research.

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1. INTRODUCTION

Dermatology is a specialized field focused on thoroughly understanding and treating skin, hair, and nail conditions. Dermatologists are responsible for diagnosing both dermatological and cosmetic skin disorders. Detecting these conditions is critical due to the increasing prevalence of skin diseases, causing significant challenges for individuals worldwide. An automated and comprehensive symptomatic system is necessary, particularly in developed countries, to streamline the workload for dermatologists and save time for medical professionals and patients [1].

Skin infections are common occurrences, often triggered by fungi, bacteria, allergies, and other factors. They can lead to changes in skin color and texture. These conditions are typically chronic, often with a viral nature and a potential to develop into skin cancer. Early detection of skin disorders is crucial to minimize their progression and impact. Detecting and treating skin diseases can be time-consuming and financially burdensome for patients. Unfortunately, many people lack awareness about various forms and

stages of skin conditions. Sometimes, it takes several months for signs of an infection to become visible on the skin, and this delay allows the infection to spread rapidly. This lack of medical knowledge within the general public is often held accountable [2].

Sometimes, dermatologists face challenges in accurately identifying a skin ailment and may resort to expensive testing facilities for a precise diagnosis. Recent advancements in medical technologies, particularly in lasers and photonics, have significantly improved the accuracy and ease of diagnosing skin diseases. However, these diagnostic methods come with a high cost. Therefore, we propose an alternative image-processing approach for identifying skin diseases. This method utilizes digital images of affected skin areas to employ image recognition for disease classification, offering a more accessible and cost-effective means of diagnosis [2].

Computer aided diagnosis (CAD) is a device or tool used by doctors or dermatologists for the decision-making process in the medical field in patients with specific symptoms. The diagnosis process carried out by dermatologists requires a short time so that patients with symptoms can immediately know the disease suffered. The computational stages used in CAD are the acquisition process, preprocessing of the acquired image, segmenting the foreground and background images, extracting features on the segmented image, and the classification process. Classification results are used to detect or diagnose diseases in skin lesion images [3]. Human skin is an organ that can be damaged by external factors such as radiation, lifestyle, and daily activities. This review paper will present the results of a review on Melanoma and Psoriasis. Melanoma is a form of skin cancer resulting from uncontrolled melanin growth within melanocyte cells. It is the fastest-growing and most prevalent type of cancer. Benign and malignant melanoma are the two main classifications [4], [5].

The development of computational methods is growing very fast, especially in medicine. Classification methods are used to help doctors diagnose diseases based on the symptoms entered into the computer. Many researchers in computer science have recently carried out deep classification methods, thus providing a reference for the author to review and use deep learning methods for research in the medical field, especially in skin lesions. Evaluation of area structures, such as lesion boundaries, pigment networks, dots/blobs, and stripes. These evaluation methods are complicated and require more time in the detection process. Therefore, accurate and efficient methods should be considered detection process of these structures that can help the skin lesion classification process. Previous researchers have carried out several methods to classify diseases in skin lesions. The deep learning method is the most popular in computational methods for skin lesion classification [1], [2].

2. METHOD

Numerous researchers have investigated skin images, the categorisation of skin lesions constitutes a new and innovative topic of research. We examine the current trend of using deep neural networks to detect skin lesions. Our systematic approach reviews machine learning optimization for medical image classification within the context of skin lesion images. We follow the steps outlined in Figure 1 to create a paper showcasing this new trend.

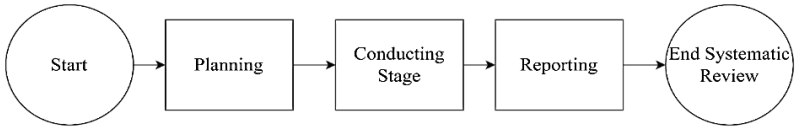

Figure 1. Systematic review steps

The explanation of the process of reviewing journals that we do is the planning process. Journal search planning is carried out by identifying journals to be reviewed. The identification results are then evaluated for the relevance of the journals reviewed. After the planning process, we conduct conducting by selecting journals relevant to the development of science by selecting journals from several digital libraries, accessing and making a system from the conducting results. The last process is disseminating the results of the conducting to be used as a final reference in the review process. The details of the peer review process for journals are shown in Figure 2. The most relevant articles on the latest trending aspects in the recent period related to skin lesion images with preprocessing, segmentation, feature extraction, and classification.

2.1. Research question

The research questions (RQs) were established to maintain focus in the review. Utilizing the population (P), intervention (I), comparison (C), outcome (0), and context (C) criteria [6]. The structure of

the research questions based on PICOC is illustrated in Table 1. Table 2 presents the research inquiries and the rationale driving the literature review process.

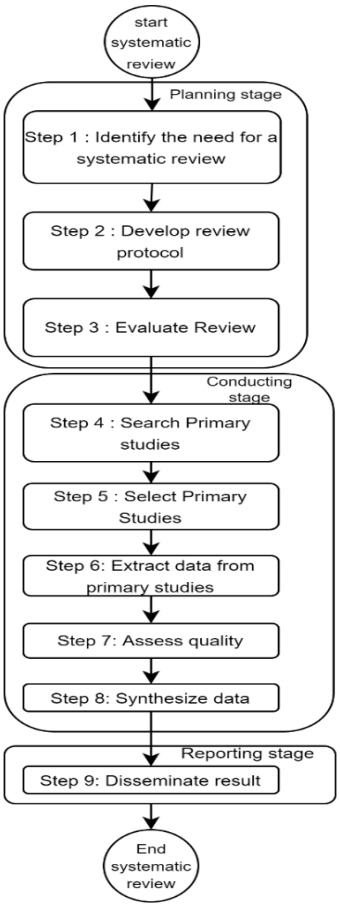

Figure 2. Detail process systematic review

Table 1. PICOC criteria

Criteria	Description
P	Image, image processing, segmentation, feature extraction, detection, and classification
I	Fault prediction, fault-prone, detection, classification, estimation, model, method, technique, and dataset
C	n/a
O	Prediction accuracy, prediction method, successful classification
C	Research conducted in healthcare and academia involves investigations utilizing both small and large data sets

Table 2. Research questions in the literature review

No	Research questions	Motivation
RQ1	Journals that are considered the most important?	Identify the most relevant journals in the field of image processing.
RQ2	The most productive and influential researcher in the field of image analysis with a special emphasis on skin imaging?	Identify researchers who have conducted many studies on skin lesions.
RQ3	What kind of research topics do researchers in machine learning choose?	Identify research topics and trends in skin lesion images.
RQ4	Which type of data set is most widely used for skin lesions?	Identify commonly used data sets.
RQ5	What kind of method is used to classify the tweet image?	Classification method.
RQ6	What methods are most commonly used for image segmentation?	Identify the most widely used method for skin image segmentation.
RQ7	Which method performs best when used for feature extraction in skin lesions?	Identification of the best method for skin image extraction
RQ8	What kind of method improvements are proposed for Skin lesion segmentation and extraction?	Identify the proposed improved method for classifying images.
RQ9	What type of framework is used for image processing of skin lesions?	Identify the most widely used frameworks in image processing of skin lesions.

The main objective of this systematic review was to identify the use of machine learning models in categorizing images depicting skin lesions. This was in response to RQ1, as documented in Table 2. We conducted a literature search for peer-reviewed publications that empirically tested classification processes using neural networks. Subsequently, we extracted relevant information from the identified primary studies to address research question 1 (RQ1). We analyzed the journals most suitable to new trends in classification research and those not relevant to the research question (RQ2, RQ3, RQ4, RQ5, RQ6, RQ7, RQ8, and RQ9 in Table 2).

2.2. Search strategy

A systematic literature review (SLR) is valuable for obtaining the most recent research findings. The purpose of conducting an SLR is to identify pertinent subject matters, extract necessary data, and analyze and synthesize reviewed papers' results to gain a comprehensive understanding of the issue [7]. This paper examines and evaluates some research conducted on skin lesions and the machine learning-based classification process. Identification of suitable literature about the research questions stated in Table 3 was undertaken. The library search phase entailed defining the search term, optimizing it, and evaluating articles corresponding to the inputted term. The selection of databases was based on the experience of conducting systematic reviews and recommendations by experienced SLR researchers in collaboration with university bibliographers. The most important and relevant databases were selected. Process of searching journal review publications using databases;

- IEEE Explore (http://www.ieeexplore.ieee.org)
- ScienceDirect (http://www.sciencedirect.com)
- Springer (http://www.springerlink.com)
- Scopus (http://www.scopus.com)

Table 3. Research question mapping

Search attributes	Research question
Researchers and publications	RQ1 and RQ2
Topic dan Trends	RQ3
Method	RQ5, RQ6, RQ7, RQ8, and RQ9
Dataset	RQ4

The list of journals obtained from several databases was discussed and modified using SLR. The availability of the database had a significant impact on the results of the review. The SLR process began with accessing and selecting from the databases that provided the journals reviewed. Keyword search results entered into the digital library database yielded 325 relevant primary studies. The process to obtain the number of journals selected the most recent journals and journals that were not related to the topic. However, we decided to try changing some of the search strings to get closer results and impact on future research. The search string was performed with the following steps: i) identify relevant and recent research questions, ii) identify the title of the article with relevant keywords, iii) identifying keywords and synonyms of related words, and iv) constructing search strings using Boolean operators (AND and OR) 4.

2.3. Data extraction

Data extraction in the literature review also provides a foundation for a more in-depth synthesis of the literature. This process assists the researcher in mapping common patterns, differences and convergences between findings from different literature sources. By detailing each source in a structured way, data extraction forms a strong framework for constructing a narrative about the development of knowledge in the research field. Therefore, data extraction in literature review is not only a technical step, but also makes an essential contribution in guiding researchers in understanding and interpreting the existing knowledge base.

3. RESULTS AND DISCUSSION

As a result of reading some literature, we made important points to be presented in this paper, including the method used for the classification process, the image acquisition stage, the preprocessing stage, the segmentation process of skin lesions, and the dataset used in the classification process. The description of the results is as follows:

3.1. Image acquisition

From various studies that researchers have conducted, the skin lesion analysis (SLA) acquisition process can be done using photography, dermoscopy. Many previous researchers used dermoscopy images

for skin image analysis in the image acquisition process. Datasets commonly utilized in SLA comprise publicly available data from the International Skin Imaging Collaboration (ISIC). The dataset table of ISIC is provided in Table 4.

Table 4. Summary description of the ISIC dataset

No	Dataset	Description
1.	ISIC-16	The dataset comprises a balanced assortment of images representing malignant and benign skin lesions. It was segregated into discrete training and testing sets containing 900 and 350 images, respectively.
2.	ISIC-17	The dataset comprises 2000 images, with 150 images reserved for validation and 600 images designated for testing.
3.	ISIC-18	The images provided are 2594 for training data and 1000 for testing data.
4.	ISIC-19	25331 images for training data and 8,238 images for testing data.
5.	ISIC-20	Total images 33126 for training data and 10982 for test data

3.2. Preprocessing skin lesion image

From the review, we obtained information on image preprocessing using how to remove artifacts in skin lesions using the DullRazor application. Some researchers also consider color intensity with saturation and improve image quality by filtering and stretching. As a result of the searches, we conducted on the four digital libraries, we got some results shown in Table 5.

Table 5. Summary of research on skin lesi image preprocessing

No	Methods	Ref.
1.	Artifact removal uses the bottom-hat filter, while dark corner removal is achieved through thresholding. Color enhancement is then implemented utilizing the Intensity with saturation characteristics of the HSV color model. DullRazor is applied to remove any remaining artifacts.	[8]
2.	Artifact removal using DullRazor	[9]
3.	Image enhancement was achieved via top-bottom filtering, contrast stretching, and log transformation techniques. Additionally, artifact removal was performed with the upgraded DullRazor tool. Contrast enhancement and artifact removal were also carried out using an average filter.	[10]
4.	Multiscale decomposition is used to remove artifacts.	[11]
5.	Image enhancement using contrast enhancement method.	[12]
6.	Image improvement using gamma correction and artifact removal using a short line detector.	[13]
7.	Image improvement with unsharp filtering and artifact removal with morphological processes.	[14]
8.	Artifact removal using DullRazor.	[15]
9.	Image improvement and artifact removal utilizing color constancy and shades of gray.	[16]
10.	Histogram-based preprocessing for artifact removal and picture enhancement.	[17]
11.	Artifact removal using a deep learning method.	[18]
12.	Image improvement using global-local contrast stretching and artifact removal with DullRazor.	[19]
13.	Artifact removal using DullRazor with a median filter.	[20]
14.	Image enhancement using CLAHE	[21]
15.	Image enhancement using Z-score transformation.	[22]
16.	Contrast adjustment using CLAHE and hair removed	[23]

3.3. Skin lesion image segmentation process

The results of our research, which was carried out by deriving data sources from four digital libraries, show that the classification of skin images has been addressed by previous researchers who have used deep learning and thresholding approaches. Table 6 highlights the systematic review results of the segmentation process.

3.4. Skin image classification process

The results of the review of articles that discuss skin lesions (SL) mostly use neural network (NN) methods, convolutional neural network (CNN), and deep convolutional neural networks (DCNN). From the observation of several articles, researchers use networks with many hidden layers (convolutional or fully connected) to diagnose diseases in skin lesions. The goal is to get better accuracy results. Table 7 presents the neural networks used to diagnose normal and disease-detected lesions.

3.5. Evaluation

The most widely used performance evaluation metrics in the detection process are true positive (TP), true negative (TN), false positive (FP), and false negative (FN). The emphasis is on accuracy, precision, failure rate (FR), recall, F1 score. The formulas are listed in Table 8.

Table 6. Research related to skin lesion image segmentation

No.	Ref.	Input image	Object segmentation and background	Description
1	[4]	Acne, Psoriasis, Melanoma, Benign, Eczema, and healthy skin	Otsu's	The system is established on preprocessing, segmentation, feature extraction, and classification stages. A total of 1800 images were evaluated, and an accuracy of 83% was reached for classification into six groups deploying support vector machine (SVM) with the quadratic Kernel.
2	[2]	Psoriasis, Melanoma, Eczema, and healthy skin	SVM	Process a colored image by resizing it to extract features via a pre-trained convolutional neural network. Subsequently, deploy a multiclass SVM to classify the characteristics. The system accurately recognizes three distinct categories of skin conditions with a 100% precision level.
3	[2]	Psoriasis, Melanoma, Eczema, and healthy skin	SVM	This method involves taking digital images of affected skin areas and using image analysis to determine the category of the condition.
4	[24]	Acne, Psoriasis, Melanoma, and Rosacea.	Otsu's	The methodology presented in this study aims to identify skin diseases through analysis of input images. This process includes filtering the input to remove noise, converting the image to grayscale, and segmenting. Classification of skin diseases is done using SVM. The accuracy of the identified skin patterns was 89%.
5	[25]	Melanoma	Region of interest (ROI)	Image segmentation is needed so the system can focus on skin lesions only. To do this, an active contour algorithm can be used to isolate the lesion area from the rest of the image. The PH2 dataset has many features, but we'll concentrate on extracting colour features with the fuzzy colour histogram (FCH) technique. SVM, K-nearest neighbor (K-NN), ANN, and FFNN classifiers gave promising results with 100% accuracy, 100% sensitivity, and 100% specificity rate.
6	[1]	Acne, Psoriasis, Melanoma, Benign, and Eczema	Otsu's	An approach to differentiate between abnormal skin growth and healthy skin is through image segmentation. To do this, the Otsu multilevel thresholding technique is applied. Firstly, IM quantize is utilised to perform a two-stage image segmentation process employing a 2-level threshold.
7	[26]	Acne, Cherry angioma, Melanoma, and Psoriasis	Otsu's	The plan includes five stages: taking pictures, preparing the images, dividing the images, selecting important information, and grouping data. We also utilised machine learning to evaluate the plan, with SVM, random forest (RF), and K-NN classifiers reaching 90.7%, 84.2%, and 67.1% respectively.

Table 7. Summary of neural network type search results on digital library

No.	Method	Representatives
1	GAN	GAN, SPGGAN, DCGAN, DDGAN, LAPGAN, PGAN
2	DenseNet	DenseNet 121, DenseNet 161, DenseNet 169, DenseNet 201
3	Inception/GoogLeNet	GoogLeNet (Awal v2), InceptionResNet-v2, Inception v3, Inception v4
4	U-Net	U-Net
5	ResNet	ResNet 34, ResNet 50, SEResNet 50, ResNet 101, ResNet 152, FCRN
6	Xception	Xception
7	AlexNet	AlexNet
8	EfisienNet	EfficientNet, EfficientNetB5, EfficientNetB6
9	VGG	VGG 16, VGG 19
10	NASNet	NASNet, NASNet-Besar

Table 8. The performance indicators used in the review

No	Indicator	Equation
1	Accuracy	$\frac{TP + TN}{TP + TN + FN + FN}$
2	Precision	$\frac{TP}{FP + TP} = 1 - FDR$
3	Failure rate	$\frac{\text{Total No: of tested images} - \text{No: of classified images}}{\text{Total number of test images}} \text{x } 100\%$
4	Recall	$TPR = \frac{TP}{TP + FN} = \frac{TP}{P}$; $TNR = \frac{TN}{FP + TN} = \frac{TN}{N}$
5	F1 score	$2x\frac{\text{Precision x Recall}}{\text{Precision} + \text{Recall}}$

4. CONCLUSION

Machine learning is a powerful algorithm that classifies images based on the features included in the machine learning model. Over the years of its development, researchers have used neural networks to support decision-making. In medical images, especially skin or skin lesion images, deep neural networks have been widely used to diagnose lesions and classify skin lesion images. By using the deep learning method, many researchers have attempted to improve the accuracy and traceability of classification results using the method. Using deep learning as a support for decision-making can be used to integrate the field of computer science with the field of medical science. Given that there is still research that has gaps that can be developed to be even better for further research, among them are the methods used during classification.

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