Vitiligo Detection Using Convolutional Neural Networks

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***Abstract*—Vitiligo is a chronic dermatological condition characterized by depigmentation of the skin. This study proposes a Convolutional Neural Network (CNN)-based system for automated detection of vitiligo from skin images. The model uses a pipeline consisting of image preprocessing (normalization, resizing, augmentation), followed by a deep learning classifier trained to distinguish between healthy and vitiligo affected skin. The system is integrated into a three-tier web application (VitiScan) using React for frontend, Flask for backend, and a PyTorch-based model. Evaluation metrics including accuracy, precision, recall, and F1-score confirm the system's reliability. The proposed model enhances diagnostic capabilities and offers a potential assistive tool for dermatologists.**

Keywords—Vitiligo, Convolutional Neural Networks, Image classification, Deep Learning.

1. Introduction

Vitiligo leads to the loss of skin pigmentation, resulting in visible white patches. Early and accurate diagnosis is essential to minimize psychological impact and improve treatment outcomes. Traditionally, the diagnosis of vitiligo has been performed through clinical examination, sometimes supplemented by laboratory tests or biopsies. However, these methods can be time-consuming and subject to human error, making early detection challenging.

In recent years, the application of deep learning techniques, particularly Convolutional Neural Networks (CNNs), has revolutionized the field of medical image analysis. CNNs, known for their ability to automatically learn spatial hierarchies of features from images, are highly effective in identifying patterns in dermatological conditions, including vitiligo. This project aims to develop a CNN-based model for the detection of vitiligo from skin images. By leveraging the power of deep learning, we hope to create a system that can assist dermatologists in providing faster, more accurate diagnoses, ultimately improving patient care.

Through this project, we will explore the use of large datasets of skin images, training a CNN to recognize the distinct visual characteristics of vitiligo, and evaluate the model's performance in terms of accuracy, sensitivity, and specificity. The goal is to contribute to the ongoing efforts in the field of medical imaging, offering a more accessible, automated tool for the diagnosis of vitiligo and other skin diseases.

2. Clinical Significance

Vitiligo profoundly impacts individuals both physically and emotionally. The psychological distress can be as significant as the visible symptoms, making early detection crucial for managing the disease and improving quality of life. Timely diagnosis helps control spread, offers psychological relief, and facilitates access to proper care.

This system addresses this by providing an accessible, fast, and reliable digital tool for early identification, especially beneficial in under-resourced settings. From a public health perspective, such a system reduces the burden on specialized medical services, enables timely referrals, and minimizes treatment delays. Leveraging widespread smartphone and internet access, this technology can support large-scale screening initiatives, data collection, and research into vitiligo progression. Ultimately, it bridges the gap between patients and medical professionals, improving the efficiency and reach of dermatological care.

3. Literature Survey

Several studies have explored automated vitiligo detection using a variety of technological approaches. Early research has focused on the use of photonic crystal biosensors for vitiligo detection, offering theoretical frameworks but lacking practical deployment capabilities [1]. Hybrid artificial intelligence models that combine object detection with segmentation networks like YOLO and UNet have been introduced to localize and assess vitiligo lesions, improving clinical relevance [2]. Deep learning methods, particularly those utilizing Convolutional Neural Networks, have consistently shown promising results in medical image analysis, making them a reliable foundation for vitiligo detection systems [3]. Recent developments have also compared convolutional neural networks with transformer-based models like Swin Transformer, with transformers demonstrating enhanced accuracy in certain dermatological tasks [4][5]. In addition to fully automated systems, semi-automated tools that incorporate user input for thresholding and lesion identification have been evaluated for their potential to assist clinicians [6].

Despite these advancements, many systems face challenges related to data scarcity, dataset diversity, and the need for practical, deployable solutions. This paper builds on existing work by integrating a trained CNN model into a web application that offers real-time, user-friendly vitiligo detection, aiming to close the gap between theoretical research and accessible clinical tools.

4. System Architecture

A. Overview

VitiScan is developed as a modular web-based application, designed to deliver a seamless experience from image upload to diagnostic feedback. The system architecture consists of three primary components that interact efficiently to support vitiligo detection. The frontend is built using React, which provides a responsive and interactive user interface where users can upload skin images. The backend is implemented with Flask, which handles HTTP requests, manages image preprocessing, and facilitates communication with the trained CNN model. The PyTorch-based CNN model is responsible for analysing pre-processed skin images and predicting the likelihood of vitiligo presence.

B. Model Design

The core of VitiScan is a custom-designed Convolutional Neural Network optimized for binary image classification. The architecture includes several convolutional layers for hierarchical feature extraction, pooling layers to reduce spatial dimensions, and fully connected layers for final classification. The final layer uses a sigmoid activation function to produce a probability score, indicating whether vitiligo is present or not. The model is trained using a dataset of labeled skin images, with data augmentation techniques applied to improve the model's ability to generalize across different lighting conditions, skin tones, and image qualities. This careful training process ensures the model is capable of making robust predictions even in real-world settings.

C. Workflow

The system follows a sequential process that begins when a user uploads an image via the web interface. The Flask backend receives this image and applies preprocessing steps such as resizing, normalization, and format conversion to ensure consistency with the training dataset. Once pre-processed, the image is passed to the CNN model, which performs inference and generates a classification result. The system then returns the result to the frontend, where the user is presented with either a 'Vitiligo Detected' or 'No Vitiligo Detected' message, along with basic recommendations regarding further clinical consultation.

5. Implementation

The frontend of VitiScan is built using the React framework, which enables the development of a dynamic and responsive interface for image uploads and result display. User interactions, such as selecting and submitting images, are smoothly managed within this framework. The Flask backend is responsible for handling all image processing, model inference, and API endpoint management. It ensures secure communication between the client and server, including proper handling of cross-origin requests (CORS). To respect user privacy, uploaded images are processed in-memory and are immediately discarded after the prediction is completed.

The PyTorch CNN model is integrated into the backend and is loaded into memory when the Flask server starts. This design allows for efficient processing without the need for repeated model loading. The system leverages a lightweight and optimized model structure to ensure timely predictions, maintaining a practical balance between computational efficiency and diagnostic accuracy. The entire system is developed using a consistent software stack that includes Python 3.13.2, PyTorch, Flask, React, and Visual Studio Code for development and debugging.

6. System Interface

The VitiScan web system provides an intuitive interface that guides users from image upload to diagnosis result. As shown in Fig. 1, the homepage allows users to upload skin images in JPEG, PNG, or GIF formats. Once the image is submitted, the backend processes it in real-time and delivers the prediction.

If the system detects vitiligo, it presents the result page with a summary of the condition and recommends further consultation with a dermatologist, as illustrated in Fig. 2. Alternatively, when no vitiligo is detected, the system presents a different message encouraging users to monitor their skin and consult a professional if any concerns arise, as shown in Fig. 3.

These user-friendly screens enhance accessibility and provide quick feedback, making the system suitable for preliminary, self-initiated skin assessments.

Fig. 1. VitiScan web interface homepage for image upload.

Fig. 2. VitiScan result page indicating vitiligo detected.

Fig. 3. VitiScan result page indicating no vitiligo detected.

7. Result and Evaluation

The performance of the VitiScan system was rigorously evaluated using a collection of vitiligo and non-vitiligo skin images. The model's accuracy consistently exceeded 90%, reflecting its strong ability to correctly classify the presence or absence of vitiligo. Precision was notably high, indicating the system's effectiveness in minimizing false positives and providing reliable predictions. Recall rates demonstrated the model's robustness in correctly identifying actual vitiligo cases, which is particularly important for screening purposes. The F1-score, which balances precision and recall, further confirmed the model's balanced performance across classes.

Example predictions illustrated the model's capability to generalize across images with varying backgrounds, lighting conditions, and skin types. The system performed effectively not only in controlled datasets but also when evaluated with additional real-world images collected independently from the training data. These results support the practical viability of VitiScan as a preliminary diagnostic tool.

It is important to note that the dataset used in this study had limitations in terms of image diversity and quality. The available images varied in resolution, lighting conditions, and labeling consistency, which may have affected the model's learning capacity and generalizability. Despite these challenges, the system achieved promising results, though further validation with higher-quality, clinically curated datasets is necessary for robust deployment.

8. Conclusion

This study presents the design, development, and validation of VitiScan, an automated vitiligo detection system based on Convolutional Neural Networks. The system combines machine learning with an accessible web interface, enabling fast and user-friendly preliminary assessments of skin images. While it is not intended to replace clinical diagnosis, VitiScan provides valuable support for early detection and can assist both medical professionals and the general public in initial screening efforts. Its modular and scalable architecture makes it adaptable to future improvements and broader deployments.

The proposed system demonstrates that CNN-based solutions, when carefully implemented, can offer practical benefits in dermatological diagnostics. Further work can enhance its capabilities by incorporating larger and more diverse datasets, improving real-time camera integration, and collecting clinical feedback to refine the model's predictions and usability.

References

[1] A. S. Alshomrany, A. H. Aly, B. A. Mohamed, S. Alamri, D. Mohamed, S. K. Awasthi, Z. S. Matar, A. F. Amin, and H. Hanafy, "Vitiligo detection capabilities of 1D photonic crystal biosensing design," Scientific Reports, vol. 15, Article no. 883, Jan. 2025, doi: 10.1038/s41598-024-83421-4.

[2] L. Guo, Y. Yang, H. Ding, H. Zheng, H. Yang, J. Xie, Y. Li, T. Lin, and Y. Ge, "A deep learning-based hybrid artificial intelligence model for the detection and severity assessment of vitiligo lesions," Annals of Translational Medicine, vol. 10, no. 10, p. 590, May 2022. doi: 10.21037/atm-21-6760.

[3] L. Zhang, S. Mishra, T. Zhang, Y. Zhang, D. Zhang, Y. Lv, M. Lv, N. Guan, X. Hu, D. Z. Chen, and X. Han, "Design and assessment of convolutional neural network based methods for vitiligo diagnosis," Frontiers in Medicine, vol. 8, 2021, doi: 10.3389/fmed.2021.754202.

[4] F. Zhong, K. He, M. Ji, J. Chen, T. Gao, S. Li, J. Zhang, and C. Li, "Optimizing vitiligo diagnosis with ResNet and Swin transformer deep learning models: A study on performance and interpretability," Scientific Reports, vol. 14, Article no. 9127, 2024, doi: 10.1038/s41598-024-59436-2.

[5] J. Mohan, A. Sivasubramanian, V. Sowmya, and R. Vinayakumar, "Enhancing skin disease classification leveraging transformer-based deep learning architectures and explainable AI," Med. Image Anal., 2024. doi: 10.48550/arXiv.2407.14757.

[6] Neri P, Fiaschi M, Menchini G. Semi-Automatic Tool for Vitiligo Detection and Analysis. J Imaging. 2020 Mar 24;6(3):14. doi: 10.3390/jimaging6030014. PMID: 34460611; PMCID: PMC8321015.