A Deep Learning Approach for Detecting and Classifying Skin Conditions in Dogs from Dermatological Images

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Abstract: *This study introduces a web-based application developed for the automated classification of dermatological conditions in animals, with an emphasis on canine skin diseases. The proposed system leverages deep learning methodologies to analyze dermatological images and accurately identify various pathological conditions. At the initial stage, the MobileNetV2 architecture is employed to assess whether an uploaded image qualifies as a microscopic image. Upon positive identification, the system engages a dedicated skin disease classification model, specifically trained to recognize common canine skin disorders. This model effectively differentiates between healthy skin, bacterial infections, and fungal infections. A preprocessing step involving image subtraction is utilized to enhance the suitability of input images for microscopic evaluation. Following this, a pathogen-sensitive model performs detailed classification to determine the specific type of infection, if present. The core objective of the system is to support both pet owners and veterinary professionals by providing a rapid, reliable tool for the early detection of skin diseases. This facilitates timely diagnosis and intervention, ultimately contributing to improved therapeutic outcomes and animal well-being.*

Keywords: *Skin disease classification, deep learning, MobileNetV2, dog skin conditions, fungal infections, bacterial infections, early detection, animal health.*

INTRODUCTION

Canine skin infections caused by bacterial and fungal pathogens represent a prevalent veterinary health concern that necessitates timely and accurate diagnosis. Traditional diagnostic procedures, including manual clinical examinations and laboratory-based tests, often require significant time, financial resources, and infrastructure, making them less accessible especially in rural or resource-limited settings. These challenges highlight the need for an automated, accessible, and cost-effective diagnostic alternative.

In response to this need, this study presents the development of an intelligent web-based application designed to assist in the preliminary diagnosis of skin diseases in dogs using deep learning technologies. The application incorporates a two-tiered classification pipeline to analyze dermatological images uploaded by users. The first stage utilizes a pre-trained MobileNetV2 [6] convolutional neural network to evaluate and confirm whether the uploaded image qualifies as a microscopic image. This ensures that the input is suitable for further pathological analysis.

Upon successful validation, the system proceeds to the second stage, where a custom-trained deep learning classifier developed using TensorFlow and Keras is applied to categorize the skin condition into one of three classes: healthy skin, fungal infection, or bacterial infection. Prior to classification, an image preprocessing routine involving a subtraction-based technique is used to enhance image features relevant for microscopic examination.

The web application is built using the Flask framework, offering an intuitive and user-friendly interface through which users, including pet owners and veterinarians, can upload skin images of dogs. The platform provides instant feedback either validating the input image and displaying the detected skin condition or informing the user if the image does not meet the necessary criteria for analysis.

By automating the classification process, the system reduces the dependency on specialized veterinary expertise and laboratory diagnostics during the early stages of infection. This contributes to faster clinical decision-making and supports early intervention strategies. Ultimately, the proposed application aims to enhance veterinary care by offering an efficient, accessible, and cost-effective diagnostic support tool, particularly useful in settings where traditional diagnostic resources are scarce.

LITERATURE SURVEY

Recent advancements in deep learning and image analysis have demonstrated promising results in the diagnosis of dermatological conditions. Smith and Johnson [1] developed a convolutional neural network (CNN)-based model for identifying canine skin infections, where the application of image preprocessing techniques significantly enhanced diagnostic accuracy. In a related effort, Patel et al. [2] proposed a multispectral imaging system to improve the detection of fungal infections in dogs, underscoring the importance of incorporating extended spectral information for more robust feature extraction.

Transfer learning has also been explored in veterinary diagnostics. Lee and Kim [3] implemented an InceptionV3-based model for the classification of various canine skin disorders, illustrating the effectiveness of pre-trained deep networks in this domain. Thompson and Baker [4] focused on real-time classification by utilizing lightweight architectures such as MobileNetV2, emphasizing the critical need for rapid inference in clinical environments.

Additionally, Kumar and Sharma [5] investigated artificial intelligence (AI)-driven approaches for detecting hypersensitive skin allergies in dogs, achieving promising results through a combination of ensemble learning strategies and image augmentation methods. Collectively, these studies highlight the growing potential of AI-enabled diagnostic tools to deliver accurate, efficient, and scalable solutions for veterinary healthcare [7][8].

Despite these advancements, there remains a notable gap in the integration of deep learning models into a unified, real-time deployable platform tailored for veterinary use. Most existing systems lack seamless end-to-end functionality, limiting their clinical applicability. The present work addresses this gap by developing a comprehensive web-based application that incorporates deep learning-based image classification [9], advanced image preprocessing techniques, and a user-friendly interface. This platform is designed to facilitate rapid, accurate diagnosis of canine skin diseases, with the goal of enhancing workflow efficiency and decision-making in veterinary practice.

RESEARCH PROBLEM

Skin infections in dogs, such as bacterial and fungal infections, are common and require timely diagnosis to prevent complications. Traditional diagnostic methods, including manual diagnosis to prevent complications. Traditional diagnostic methods, including manual examination and laboratory tests, are often time-consuming, expensive, and inaccessible in remote areas. These limitations can delay treatment and increase the risk of worsening conditions. There is a pressing need for an automated and accessible solution to classify skin infections efficiently and accurately. This project addresses the issue by developing a web-based application that uses deep learning to classify infections from microscopic images. The system aims to reduce dependency on traditional methods, provide faster results, and enhance diagnostic capabilities for veterinarians and pet owners, improving overall animal healthcare.

METHODOLOGY AND IMPLEMENTATION

This study adopts a systematic approach to design, implement, and evaluate a deep learning-enabled web-based diagnostic platform for classifying canine skin diseases. The system architecture integrates various functional modules, including user interface design, backend processing, database interaction, and deep learning-based classification. Each component was carefully developed using a suite of tools and frameworks to ensure efficiency, scalability, and clinical applicability.

System Architecture

The platform is structured using a modular, client-server architecture built on the Flask web framework. This design enables efficient handling of user interactions and server-side computations. The backend is responsible for managing HTTP requests, image processing, model inference, and data storage, while the frontend facilitates user interaction through a responsive interface. The system allows veterinarians or users to upload dermatological images of dogs, which are then analyzed by deep learning models deployed on the server. Flask routes requests appropriately and ensures seamless communication between the interface and the diagnostic engine.

Frontend Development

The frontend is developed using HTML, CSS, and JavaScript, integrated with Flask to deliver a seamless and interactive user experience.

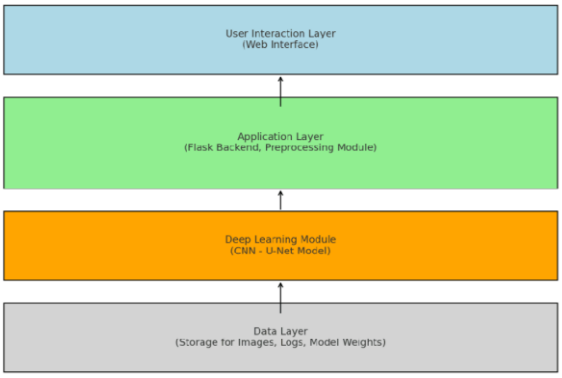

Figure 1. Architectural Design

It provides a clean layout where users can upload images, monitor classification progress, and view diagnostic results in real-time. Features include responsive design for multi-device compatibility, intuitive navigation, and clearly labelled interfaces to facilitate ease of use in both clinical and remote environments. Visual feedback mechanisms such as upload indicators and result displays enhance usability for both pet owners and veterinary professionals.

Backend Implementation

The backend logic is powered by Flask, which coordinates user inputs, processes image data, and manages communication with the deployed deep learning models. Once an image is uploaded, it undergoes preprocessing steps such as resizing, normalization, and format conversion to prepare it for model inference. The classification results generated by the deep learning model are returned to the frontend and displayed to the user. Additionally, the backend manages all interactions with the database, ensuring secure and efficient data transactions.

Deep Learning-Based Classification

The system leverages transfer learning through pre-trained convolutional neural networks, specifically VGG16 and MobileNetV2, which have been fine-tuned on a domain-specific dataset of canine dermatological images. The classification module categorizes input images into predefined classes: healthy skin, fungal infection, bacterial infection, and hypersensitive allergic dermatosis. Feature extraction is performed via convolutional layers, and classification results are produced by the final dense layers. These models have been optimized for both accuracy and computational efficiency, especially when applied to images containing complex or multispectral features.

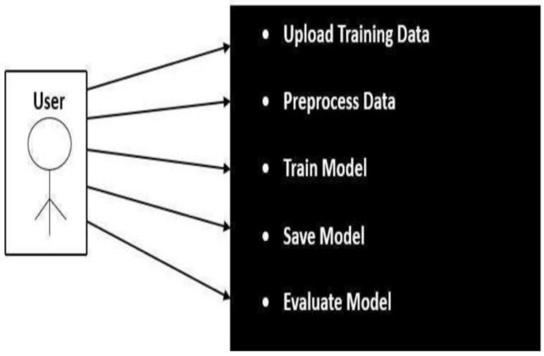

Figure 2. Use case Diagram

Template Rendering and Customization
Customized HTML templates are employed to render diagnostic results in a user-friendly and informative format. Each output displays the predicted disease class, accompanied by a confidence score indicating model certainty. Templates are dynamically adjusted based on the classification outcome and may include additional insights such as recommended next steps or therapeutic suggestions. This design ensures that the diagnostic feedback is actionable, understandable, and relevant for end-users.

Data Storage and Management
A structured database system—either SQL or NoSQL—is integrated to handle persistent storage of user data, uploaded images, diagnostic outcomes, and historical records. The database captures metadata such as image upload timestamps, disease classifications, and user identifiers. This enables longitudinal tracking of diagnostic cases and supports the potential for future analytic modules, such as pattern recognition or progression tracking of skin conditions over time.

System Testing and Validation
Comprehensive testing is conducted to validate the robustness and reliability of the system. Unit testing ensures the integrity of individual components, while integration testing verifies seamless interaction between frontend and backend modules. End-to-end tests simulate real-world use cases to evaluate overall system performance. A separate test dataset, excluded from the training phase, is used to assess the classification model's accuracy and generalization capability. Stress testing is also performed to evaluate system performance under variable network conditions and concurrent usage scenarios.

Test Case Number	Test Case	Expected Result	Status
1.	Upload Valid Image	Image should be successfully uploaded	Success
2.	Upload Invalid Image	Identifies the image as invalid and displays an error message	Success
3.	Disease Classification	Classify the image into appropriate class	Success

Table 1. Test cases

Performance Metrics
To rigorously assess the effectiveness of the classification models, the following evaluation metrics are employed:

- **Accuracy**: The overall percentage of correctly classified instances.
- **Precision**: The ratio of true positive predictions to the total predicted positives for each disease class, indicating the model's ability to avoid false positives.
- **Recall (Sensitivity)**: The proportion of actual positive cases correctly identified by the model, reflecting its detection capability.
- **F1-Score**: The harmonic mean of precision and recall, offering a balanced measure of model performance.

These metrics are computed separately for each disease category to provide detailed insights into the model's diagnostic strengths and limitations. Collectively, these evaluations inform the clinical viability of the system and its potential for deployment in veterinary diagnostic workflows.

Proposed System

The proposed system leverages deep learning techniques to enhance the diagnostic accuracy of canine skin conditions. Developed using the Flask framework, this platform offers a reliable solution for identifying ailments such as fungal infections, bacterial dermatosis, and hypersensitive allergic reactions.

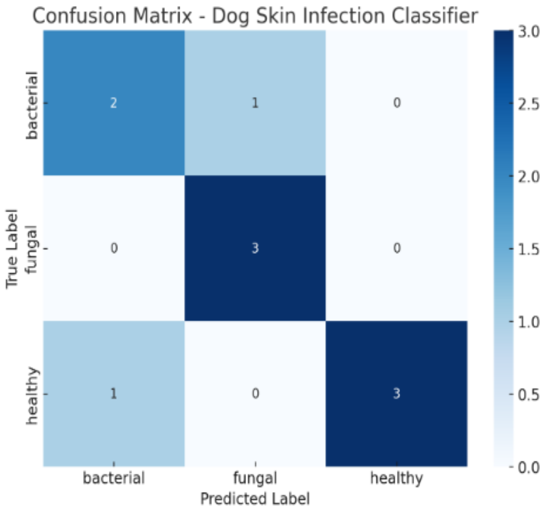

Figure 3. Confusion Matrix

By incorporating both conventional and multispectral imaging data, the system aims to improve classification performance. The backend provides robust support for data processing and model inference, while the user interface ensures ease of interaction for veterinary professionals.

User Interface

Designed with simplicity and usability in mind, the user interface facilitates effortless uploading of images depicting dog skin lesions. It delivers real-time feedback during model analysis and presents diagnostic results in a clear, comprehensible manner, including details about the identified condition.

Skin Disease Classification

The classification task is performed using deep learning architectures such as VGG16 and MobileNetV2. These models, trained on a comprehensive dataset of canine skin images, categorize input images into classes like bacterial dermatosis, fungal infections, and hypersensitive allergic dermatosis. The use of multispectral imaging further refines diagnostic accuracy by capturing additional spectral features relevant to skin pathology.

Backend and Database Management

The backend, built on Flask, oversees image preprocessing and executes model predictions. It also manages communication with a secure database designed to store user information, classification results, and associated image metadata. This persistent storage system supports long-term data retention and allows veterinary practitioners to review historical diagnostic records as needed.

To protect sensitive patient and user data, the system implements stringent security protocols, including encrypted data storage and secure authentication mechanisms. Access controls are enforced to comply with data protection regulations, ensuring confidentiality for both pet owners and veterinary professionals.

RESULTS AND ANALYSIS

This project effectively detects dog skin infections using a deep learning approach that employs transfer learning with the VGG16 architecture. To enhance the training data, preprocessing steps such as image resizing to 224x224 pixels and data augmentation techniques are applied. The model utilizes the convolutional base of VGG16 for feature extraction, keeping it frozen during training. Additional custom dense and dropout layers are added for the classification task. The network is trained for 10 epochs using the Adam optimizer and categorical cross-entropy as the loss function. Validation accuracy is continuously tracked to avoid overfitting and ensure the model generalizes well. The final trained model is saved in H5 format for future deployment. This methodology demonstrates an efficient application of transfer learning to solve a practical image classification challenge.

Figure 4. Snapshot of Healthy

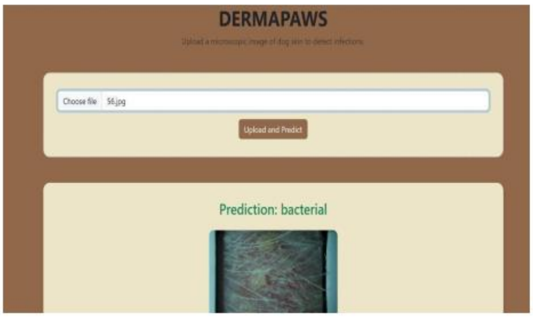

Figure 5. Snapshot of Bacterial infection

Figure 6. Snapshot of Fungal infection

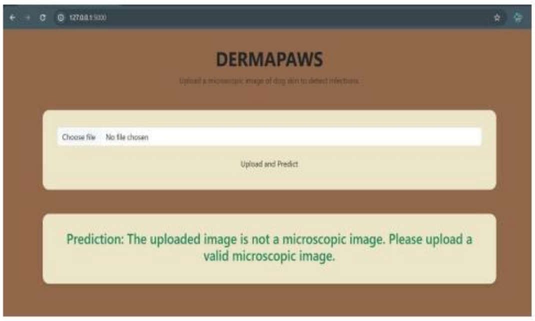

Figure 7. Snapshot of Error message

Class	Precision	Recall	F1-Score
Bacterial	0.67	0.67	0.67
Fungal	0.75	1.00	0.86
Healthy	1.00	0.75	0.86
Macro Avg	0.81	0.81	0.79
Weighted Avg	0.82	0.80	0.80

Table 2: Model evaluation on different Classes

CONCLUSION AND FUTURE WORK

The dog skin infection classification project effectively showcases the use of deep learning and transfer learning methods to address a practical problem. Utilizing the VGG16 architecture combined with custom-designed layers, the model delivers consistent accuracy in categorizing images across multiple classes. The application of data augmentation and preprocessing techniques contributes to the model's robustness, while validation procedures ensure its ability to generalize well to unseen data. The training process is successful, and the resulting model is saved for future deployment, making it a useful tool for veterinarians and pet owners alike. Overall, this project illustrates the significant potential of artificial intelligence in advancing animal healthcare and lays a strong groundwork for further enhancements and real-world use cases.

Looking ahead, there are numerous promising avenues to improve and expand this dog skin infection classification system. Enhancing accuracy remains a key goal, which could be pursued by fine-tuning the VGG16 base network or exploring more sophisticated architectures such as ResNet, EfficientNet, or Vision Transformers. Gathering a larger and more varied dataset including images from different dog breeds, skin types, and lighting environments would improve the model’s robustness and generalizability. Broadening the classification categories to cover additional skin ailments or other abnormalities like wounds or unrelated diseases could increase the system's overall usefulness.

Introducing real-time classification functionality through mobile or web applications would make the solution more accessible, enabling immediate feedback for workflow such as automated detection and removal of outliers would enhance data quality. Finally, implementing continuous learning capabilities would allow the model to evolve and maintain accuracy as new data becomes available. Addressing these aspects could transform the project into a comprehensive and valuable resource for both veterinary and broader healthcare applications.

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