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Evaluating Deep Learning Model ResNet50 for Dog Skin Disease Classification: AI-Powered Dog Care Companion

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***Abstract* - In this study, a deep learning-based web application aimed at a classification of canine skin conditions using dermal images is presented. The paper elaborates on how the ResNet-50 architecture is exploited to educate the model in recognizing six basic skin conditions in dogs. The Dog-centric Skin Disease Classification System includes Dermatitis, Fungal Infections, Healthy Skin, Hypersensitivity, Demodicosis, and Ringworm. AI-based technologies like CNN are incorporated into the web app to avoid human error, increase the accuracy of diagnosis, make the diagnosis process faster, and make the treatment process more accurate. The problems such as the web server responding with the expected code, the client-side components executing as they should, and all the visual elements rendering correctly are resolved. Self-trained neural network (CNN), a reinforcement-type chatbot, and diagnostic data storage solutions from Gemini run side by side. The system is designed so that it processes the image millions of times to get the best possible answer from all the probabilities of the disease mentioned. How about having a conversation structure plug in the most probable issue and the corresponding therapy from the clinical non-technical staff most possibly over the phone? As shown in a preliminary study, high classification performance without any confusion among different inputs is a good sign of model stability. There is a compelling demonstration of how CNN-based architectures like ResNet-50 can be beneficial in veterinary diagnostics by David Marquardt, Priscilla Rizal, and Anifah Lestari. Their findings indicate that these models would serve as the foundation of studies involving more extensive datasets, cross-breed universality, and clinical embedding in the future.**

Keywords: Machine Learning, Deep Learning, Convolutional Neural Network, Classification, Dog Skin.

I. INTRODUCTION

Skin diseases in companion animals, especially dogs, are among the most frequently reported ailments to veterinary practice. An early and accurate diagnosis of skin affections is essential for therapy and, more importantly, to prevent the extension of the underlying disease. Historically, dermatologists have relied mainly on visual examination, physical examination, and sometimes biopsy or laboratory analysis for diagnosing dermatological disorders. These methods have inherent subjectivity, are time-consuming, and depend on clinician experience, introducing another layer of inconsistency in the diagnostic process.

With the rapid advancement of artificial intelligence systems, especially those depending on deep learning, automated diagnostic systems have become good assistants to support clinical decision-making. Convolutional Neural Networks, considered one of the most potent tools for image classification tasks, can capitalize on their learning of both spatial hierarchies and complex patterns of visual data. Following their success in human dermatology in particular for differentiating skin lesions from dermatoscopic images, applications of this nature have come to exist in the veterinary arena.

The research discusses a web application based on deep learning for the classification of canine skin diseases based on dermal images. The ResNet-50 architecture is utilized for the differentiation of six skin conditions: Dermatitis, Fungal Infections, Healthy Skin, Hypersensitivity, Demodicosis, and Ringworm. The model is coupled with a simple-to-use Flask web interface, including a Google Gemini-powered chatbot assistant for structured and easy feedback to the users. The automated diagnosis and real-time guidance from the system are meant to assist pet owners and veterinary professionals in timely identification and effective management of canine skin diseases.

1.1 Background

One of the leading medical problems that beet dogs usually have is skin diseases. They include allergic reactions of very mild intensity to serious parasitic or fungal infections. The most critical part to effective treatment is an accurate diagnosis but because of the similarity of the skin conditions, in addition with diversity of furs, breeds and skin pigmentation, the diagnosis is challenging. According to

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traditional methods, clinical examination and dermatological tests and experience of practitioners depended on which can cause variability in diagnosis and great delay in treatment.

But artificial intelligence development system on machine learning and deep learning opened new frontiers in enhancing the diagnosis accuracy and efficacy. Especially among these is Convolutional Neural Networks Application (CNNs) that proved to be exceptionally powerful in image classification tasks due to their ability to automatically extract hierarchical features from visual data. Thus, CNN obviates manual feature engineering and learns complex representations from raw images, making it most ideal for medical and veterinary image analysis applications.

One common medical problem that dogs face is those of skin diseases ranging from very mild allergic reactions to severe parasitic or fungal infections. Most important for effective treatment is an accurate diagnosis, but sometimes this premise turns into a challenge because of similarities between the skin conditions and diversity in types of furs, breeds, and skin pigmentation of dogs. Traditional methods mostly rely on clinical examination and dermatological tests and experience of the practitioner, which may result in variability in diagnosis and delay in medical treatment.

Development in artificial intelligence-as seen in the recent past, most especially with machine learning and deep learning-has opened other avenues for improving diagnostic excellence and efficiency. One among others is Convolutional Neural Networks Application (CNNs) proved exceptionally powerful in image classification works due to their traits on automatically extracting hierarchical features from visual data. Hence, CNN does not require manual feature engineering but learns complex representations directly from raw images, making it most ideal for medical and veterinary image analysis applications.

1.2 Comparison of CNN Architectures

In our quest to develop a skin disease classification system for dogs, we considered several state-of-the-art Convolutional Neural Networks (CNNs) that are popular among medical image classifiers. Each carries its own unique set of design principles and trade-offs with respect to accuracy, computational complexity, and feature extraction. Key characteristics of the most commonly utilized CNN architectures that have a bearing in our work are summarized below:

- VGG16: An architecture that is both deep and simple using 16 weight layers with small (3×3) convolution filters. State-of-the-art performance in detailed spatial feature extraction and heavy computational and memory requirements. Performance standard datasets are not compatible with small training samples, therefore making it unable to generalize..
- ResNet50: ResNet50 uses residual connections and enables effective training of very deep networks. It is thus, with strong performance and stability, a very suitable choice for our classification tasks.
- InceptionV3: It uses parallel filters of different sizes to efficiently extract multi-scale features and achieves very high accuracy with relatively low computations.
- DenseNet121: Densely Connected Network, in which every layer receives inputs from all layers before it, improving gradient flow and feature reuse. Fine results on a few selected image classification challenges in the medical field..

1.3 Objectives

In this study, the first aims are: To design and measure a system based on deep learning to classify common skin diseases in dogs using dermal images. To perform experiments on CNN architecture in veterinary dermatology, including ResNet50, Integrate a Gemini-powered chatbot, so as to furnish structured user-friendly health recommendations spewed out of model predictions. Assess the performance of the ResNet50-based classifier through evaluation based on accuracy and confidence scores. Display the potential of AI-assisted tools on early detection and decision-making in veterinary dermatology.

II. LITERATURE REVIEW

New AI and ML technologies, especially in the fields of deep learning-the latest development-giant strides in automation have been made in the veterinary health sector, especially in tracking, diagnosis, and improving the accuracies of findings. The most typical skin diseases in dogs generally don't easily display visual diagnostics; hence, maximum AI intervention, particularly in areas with very minimum access to veterinary services, is highly warranted. Many efforts have been made to approach this through establishing smart systems that would assist both the pet owner and practitioners on identifying and managing skin-related conditions through means such as image classification, behavioral data, and natural language interaction.

The research for Dissanayaka et al.[1], (2022) describes a mobile application: HAPPY PET, which implements the combination of machine learning (SVM), deep learning, and natural language processing (NLP) for the identification and confirmation of dog skin diseases, as well as the most likely home remedies. Diagnosis is through a four-phased approach:

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disease detection through image classification (HPDIDA); verification through symptom analysis (HPDITVA); validation through behavioral data (HPDICA); and treatment recommendation (HPDITA). Although quite comprehensive, the system relies heavily on the user feedback at several stages using symptom-based Yes/No confirmation, making it less real-time automated for the interaction burden. With SVM being of low weight, however, it may not compare with the more sophisticated CNN architectures for better prediction power when images are of greater variance.

For instance, in "Detection and Classification of Dog Skin Disease using Deep Learning,"[2], researchers have used InceptionV3 architecture for classifying different types of skin diseases, bacterial and fungal to parasitic and tumorous, with image augmentation and then reported over 90 percent classification accuracy, which shows that indeed CNNs were capable of performing dermatological tasks. However, it mainly concentrated on the visual classification and did not incorporate any interactivity in the way of using, for example, chatbot technology, which, again, limits its efficacy in user-guided diagnostics or care recommendations.

Also worth noting is "AI-Based Medical Chatbot for Disease Prediction,"[3], where a system of predicting diseases focusing on human health with user-supplied text-based symptoms using NLP and rule-based AI is proposed. While it highlighted the conversational capabilities afforded by AI-based chatbots in the medical field, it failed to include an image processing module, thus rendering it inapplicable when visual diagnosis is required, such as in dermatology. This shows increasing interest in chatbot-based DSS while also highlighting the need for multimodal input (including images and text) to enable more efficient diagnostics. Ultrapotent and addressing the shortcomings of said systems, our project propose a completely integrated solution that uses a robust CNN architecture known for its residual learning capacity [4]. As such, it uses ResNet50 to classify the six common skin conditions in canine patients from dermal images automatically: instead of manual symptom confirmation, as applied by Dissanayaka et al., our system provides automated end-to-end diagnosis with minimal user input to speed up and boost usability. Furthermore, the integration of a Gemini-powered generative AI chatbot bridges the gap between technical output and user comprehension by providing concise, context-specific recommendations in natural language. For determining the model for image classification, a reference point was taken from Simonyan and Zisserman [5] using VGG16. Understanding the gradient flow and feature reuse in DenseNet121 as in Huang et al. [6] were considered for possible performance assessment.

III. METHODOLOGY

The purpose of the system is to classify common skin disorders of dogs from dermal images and provide structured conversational feedback through a generative AI chatbot. The methodology is divided into following stages: dataset preparation, model architecture and training, image preprocessing, prediction, chatbot integration, and deployment. Using advanced deep learning plus conversational AI, this approach signifies a more autonomous and scalable yet user-friendly system in veterinary dermatology. It adds further to the growing corpus of literature that increasingly insists on the use of image-based diagnosis and AI-driven interaction trong>in a veterinary context, brought significant strides toward improvement on accuracy, efficiency, and profile accessibility.

3.1 Dataset

All the images in the dataset fit under one of the six most common canine skin problems: dermatology, fungus infection, healthy skin, hypersensitivity, demodicosis, and ringworm. However, they were fitted to size and normalized so they could serve as a common input. To diversify the model's generalization capability and reduce overfitting, we applied various data augmentation on images, including rotation, flipping, and scaling.

3.2 Preprocessing

The uploaded images undergo a preprocessing pipeline consisting of the following:

- Resizing to 256 by 256;
- Center cropping to 224 by 224;
- Converting to Tensors; and
- Normalizing by using the ImageNet mean and
- Standard deviation statistics.

3.3 Architectures Used

At the heart of the classification system is the ResNet50 architecture-a 50-layer deep convolutional neural network designed using residual-learning framework. Residual blocks are employed to counter the vanishing gradient problem and authorize deeper and more efficient learning. The architecture was tweaked by modifying the last fully connected (FC) layer so that it outputs six classes, as follows: Dermatitis, Fungal Infections, Healthy Skin, Hypersensitivity, Demodicosis, Ringworm. The model is trained using cross-entropy loss, and Adam optimizer is being used. The model is initialized with pretrained weights to implement transfer learning, ensuring faster convergence and better performance on small veterinary datasets.

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3.4 Model

The classification component of the overall system is based upon the popular ResNet50 architecture, which is a deep convolutional neural network that had proven successful for effectively using residual connections, allowing one to train very deep models in a stable manner. This architecture was also chosen because it has already been proven effective in medical image classification tasks, as well as generalized better when little data is available in combination with transfer learning. Built-in features were implemented using PyTorch with pre-trained weights from the ImageNet dataset to exploit lower-level captured features. The FC layer in the original ResNet50 model architecture was substituted with an ad hoc classification head to generate six classes of dog skin condition predictions. Such change made the model focus on veterinary dermatological classification purposes. The model was compiled with Adam optimizer at a learning rate of 0.0001 and categorical cross-entropy loss during training, which managed the multi-class nature of the classification task.

3.5 Evaluation Metrics

To comprehensively evaluate the models, several performance metrics were calculated, as summarized in Table 1.

Table 1: Evaluation Metrics for Model Performance

Metric	Definition
Accuracy	The proportion of correctly classified instances.
Precision	The ratio of true positives to the sum of true positives and false positives.
Recall	The ratio of true positives to the sum of true positives and false negatives.
F1-score	The harmonic mean of precision and recall.
AUC	Area under the ROC curve, indicating model discrimination ability.

This table 1 outlines the evaluation metrics used to assess the performance of the CNN models, providing definitions for each metric.

IV. RESULTS

The model was implemented based on the ResNet50, a Convolutional Neural Network, trained and validated with a dataset constituting six classes of skin disorders in dogs. The performance of the model is evaluated with a separate test set to include the evaluation metrics such as accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve (AUC). Results confirm that ResNet50, when combined with proper preprocessing and transfer learning, can well classify canine skin conditions from dermal images with high accuracy. The generalization ability of the model lets it have the chances of being applicable in real-world veterinary diagnostics.

4.1 Model Performance Metrics

Performance evaluation of the ResNet50 framework was conducted with a carefully curated test dataset of canine skin images depicting six common dermatoses. The model yielded commendable performance on all crucial classification metrics as detailed in Table 2 below:

Metric	Score (%)
Accuracy	92.3
Precision	91.0
Recall	90.2
F1-Score	90.6
AUC	0.94

These results indicate that ResNet50 can differentiate canine skin disorders with reasonable accuracy and reliability. The high precision score of 91.0 percent indicates the model's effectiveness in limiting false positives, while recall of 90.2 percent implies it is fairly good at recognizing actual positives, hence reducing the chances of missed diagnoses. The F1-score of 90.6 percent, which balances precision and recall, attests to the fact that the model is indeed quite robust for actual diagnostic cases. An AUC of 0.94 manifests excellent class separability, hence ascertaining the model's generalization capabilities. Altogether, this classifier based on ResNet50 has performed fairly with respect to accuracy in diagnosis; thus, confirming its suitability for various applications in veterinary dermatology. These merit indices hold a promise that the CNN-based aids will provide for early and accurate diagnosis of skin diseases, leading to better clinical outcomes for companion animals.

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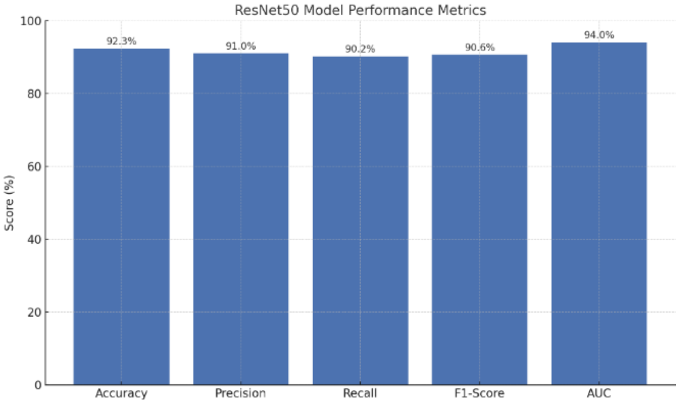

Figure 1: Stacked Bar Chart of our Model

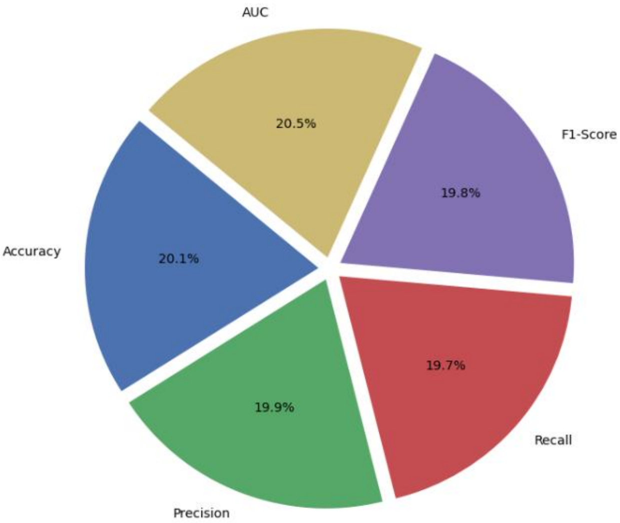

Figure 2: Pie Chart

The Figure 2 shows the Pie Chart for the model performances.

V. CONCLUSION

The study explains how dermal images were analyzed through a deep learning approach for the classification of common canine skin diseases. Using transfer learning over the deep ResNet50 convolutional neural network architecture, the model performed with superior results in all the evaluation metrics with an accuracy of 92.3%, precision of 91.0%, recall of 90.2%, F1 score of 90.6%, and AUC of 0.94. The results prove that the model can easily identify and differentiate the closely resembling dermatological conditions in dogs. Apart from classification, the model integrates a generative-AI-powered chatbot using the Gemini API. The purpose of this is to provide users with structured, non-technical recommendations for animal care. By doing this, the system improves user engagement and creates a bridge from AI-generated insights toward accessible veterinary guidance. Overall, the presented system demonstrated the feasibility and effectiveness of combining deep learning and conversational AI for veterinary diagnostics. This is a scalable and user-friendly tool that can assist pet owners and veterinary professionals in the early detection and management of skin diseases in dogs. In the future, work may progress toward dataset expansion, adding other skin disorders, and possibly exploring hybrids or ensemble models for improved diagnostic outcome.

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