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PAWPAL:AI-Based Pet Health Assistance System Using Image-based Disease Detection and NLP Symptom Analysis

Aishwarya AP[1], Ananya Rao R[2], Shubha C[3], Varsha V[4], Malathi P[5]
Dept. of Information Science and Engineering Dr. Ambedkar Institute of Technology Bengaluru, 560056

Abstract: ***Early identification of health problems in pets is generally hindered by the unavailability of immediate veterinary services and a low level of awareness among pet owners. Presenting here is PAWPAL, a pet health support system powered by AI, which combines image-based disease classification and a natural language-based symptom analyzer. The system makes use of Convolutional Neural Networks (CNN) to diagnose common skin diseases in dogs and cats from the images provided by the users. Moreover, the text-based symptom checker figures out the condition's severity and suggests care instructions. The frontend was built with React (Next.js), and the backend was developed in Flask, the integration of TensorFlow models and an AI reasoning module were done.The test performance results showed that the model for diagnosing dog skin diseases was 93% accurate, while the model for diagnosing cat skin diseases 80% accurate. The system offers help to users in real-time, thus the delays in diagnosis are lessened and the accessibility to the first veterinary guidance is improved.***
Keywords: Convolutional Neural Network, Image Classification, AI Symptom Checker, Veterinary Health, Pet Care, NLP.

I. INTRODUCTION

The global increase in pet ownership has led to a corresponding rise in the demand for intelligent medical devices that can provide veterinary support. Early diagnosis of diseases in animals is the most effective way of reducing health risks, however, access to veterinary clinics is still a problem, especially in the countryside.

PawPal is not letting that be a problem anymore by building a dual AI system that can understand visual symptoms (skin diseases) and also read the textual description of the symptoms and thus generate the health insights.The system developed is intended to identify dermatological diseases in pets by means of CNN models trained on suitable data, analyse pet owners' symptom description through NLP to provide the most likely diagnosis, produce real-life recommendations such as severity and drug prescription advice and offer an easy and convenient platform for technical non-users..

Through the combination of image recognition and language-based reasoning, PawPal is narrowing the gap in diagnostics that exist between professional veterinary systems and home-based pet monitoring.

II. LITERATURE REVIEW

Pet healthcare diagnosis has increasingly been facilitated with the help of AI to enable early detection of diseases and support medical decision-making. AI diagnostics for pet healthcare have been increasingly facilitating early detection of diseases and supporting medical decision-making. Normally the vet performs the physical check and the specialist gives the interpretation, but the cost of the latter is quite high especially in a remote or less developed area where pet owners cannot make use of it. The improvement in computer vision and natural language processing (NLP) have made it possible to build intelligent systems that understand symptoms and predict diseases.

Image-based disease detection with CNN: CNNs are the main method for the classification of medical images as they can automatically derive intricacies both spatial and structural. The research of Zhang et al. (2021) [1] on the use of CNNs for the classification of images of skin diseases showed the effectiveness of the method, which resulted in a very high accuracy of identification of skin lesions. By analogy, Kim et al. (2020) [2] have done the same experiments with CNN models for the identification of canine dermatophytosis and allergic dermatitis, thereby proving that deep learning models in the area of pattern-recognition are of higher efficiency than the traditional techniques.There are very few publications based on animal dermatology datasets. Rodriguez (2022) [5] are of the opinion that most veterinary models are built on small data sets which in turn have a bad effect on their generalization capabilities.

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On the other hand, transfer learningmethods employingImageNet-pretrained architectures such as VGG16, ResNet50, and MobileNethave been very successful in overcoming the problem of a lack of datasets. Actually, these models are searching for the most prominent veterinary dermatology texture patterns, e.g. redness, scaling, and hair loss, which are not only the common animal hairs but the decisive features.This article goes further to explain a CNN-based classifier that can identify skin disorders in dogs (Dermatitis, Fungal Infection, Hypersensitivity, Demodicosis, Ringworm) and cats (Dermatitis, Flea Allergy, Scabies, Ringworm). The model is being trained on curated datasets and tested through classification reports and confusion matrices to show its real-world implementation beyond the laboratory.

Symptom-Based Diagnosis Through NLP: Among the clinical assistance systems, the most important one by far is Natural Language Processing (NLP). Williams et al. (2022) [7], while conducting their research, found that transformer-based language models can comprehend a user's story and associate it with the most likely clinical diagnoses even if the user doesn't employ any medical terms. This feature is particularly helpful to pet owners who may present an unorganized account of the symptoms (e.g. "scratching a lot", "hair loss", "red patches").In the field of veterinary informatics, Laranjo et al. (2022) [4] built a rule-based pet triage chatbot and identified its inflexibility and lack of logical reasoning as the disadvantages. Contemporary methods depend on context-aware text models which change their answers depending on the seriousness, medical patterns, and past cases.

PAWPAL is one of the AI Symptom Checkers that delivers the main points of the pet owner's story in a simplified manner, estimates the severity (low, medium, or high), and offers doable assistance. The model takes care of the fact that medical knowledge should not become a barrier, especially for those who might be the first pet owners.

III. METHODOLOGY

A. Disease Prediction System (Image-Based Diagnosis):

This project features the disease prediction system as the main actor to detect only the skin-related diseases in pets, i.e. Dogs and Cats, that are visible to the human eye. The user has to upload the photo of the area of the pet's skin, fur, or body that is most affected. Therefore, this picture is the input of the disease prediction model. To be able to classify the image has to go through various steps - it is resized, normalized, and transformed into pixel arrays. The prepared image is the output of a trained Convolutional Neural Network (CNN) model that is MobileNetV2.

In this paper to breed, the model is separate for dogs and cats and trained on a dermatology dataset for veterinary skin diseases. Each data set comprises the diseases such as Ringworm, Dermatitis, Hypersensitivity, Scabies, and so on. All the photos in the dataset were augmented and divided into train, validation, and test sets to make sure the models are robust and thus not overfitting. The CNN picks up the patterns of the lesion surface, redness, fur loss, or fungal surface appearance, etc.

Once the image is fed to the model, the output will be a vector of probabilities over the different disease classes. The model picks up the disease category with the maximum confidence score and sends back the prediction to the backend. The backend then changes this disease tag into predetermined Veterinary Care Instructions and shows them to the user. TheDisease Prediction System output comprises:

- Severity Level (Low / Moderate / High)
- Possible Conditions (e.g., Allergies, Parasitic Infection)
- Immediate Care Instructions
- Whether Emergency Vet Attention is Needed

Title Of Dataset: Feline Skin Condition and Parasite Infection Image Dataset

Source: AWD Veterinary Dermatology Reference Archive & Annotated CSV-Based Label Map (Manually Curated)

Description:

This is the collection of labeled images showing the various dermatological disorders of cats, with each picture being linked to the respective disease via an externally stored label mapping CSV file. The dataset is comprised of four major categories of diseases: Dermatitis, Flea Allergy, Ringworm, andScabies.In the case of the dog dataset, images are kept in class-wise folders, while this dataset has pictures collected in one folder, and the .csv file is used for specifying: FileName, DiseaseClass, LabelOther metadata (e.g. lesion presence,hairlossarea)While training, the model obtains the labels on the fly from the CSV file, thus it always has the correctimage-to-labelcorrespondence.There are different severities of infections shown in the pictures of the dataset, consequently, the model will be able to gradually distinguish the pet cats with parasitic skin diseases from those with fungal infections. This diversity strengthens the model's robustness and lowers the number of incorrect disease predictions.

Title Of Dataset: Dog Skin Disease Classification Dataset

Source: Compiled from Kaggle Open Veterinary Dermatology Image Collections & Veterinary Dermatology Case Repositories (Open Source)

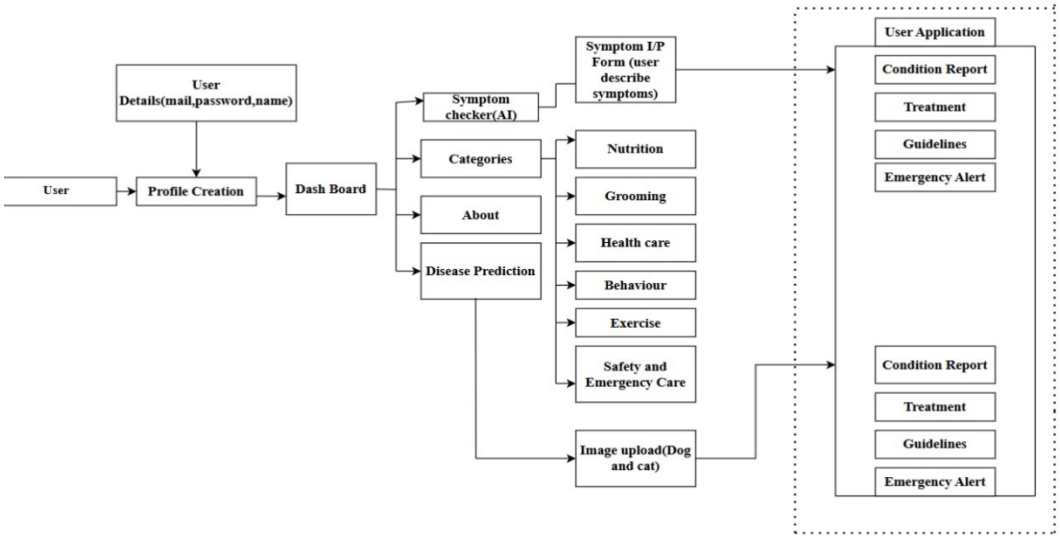


Figure 1: System Architecture of Pawpal

Description:

This data collection comprises the dermatological images of skin diseases of dogs, divided into six categories, namely Dermatitis, Fungal Infections, Healthy Skin, Hypersensitivity, Demodicosis, and Ringworm. The data set is split into train, test, and validation folders to facilitate supervised learning." Each category has a number of annotated pictures taken in real-world situations, and these images vary in lighting, zoom level, angle, and skin texture. These differences help the model to generalize over different breeds, fur patterns, and coatcolors.The data collection is instrumental in the creation of the Convolutional Neural Network (CNN) model (MobileNetV2) used in PAWPAL that makes it possible for the system to automatically distinguish between skin conditions that are visually similar with a very high degree of accuracy. In this way, the data set acts as a medium through which the model can be able to detect the first signs of skin abnormalities, thus enabling a pet owner to get timely treatment guidance.

B. Symptom Checker System:

The Symptom Checker module enables users to express the pet's symptoms in common terms, e.g., "My dog is scratching continuously and has red patches". A Natural Language Processing (NLP) model that is either newly trained or fine-tuned specifically for understanding aspects of symptoms in pets is applied to process this input.

The system identifies terms like "itching", "redness", "hair loss", "vomiting", "lethargy", etc. from the text. Basically, the model first determines the severity level of the symptoms described and then, with the help of a veterinary knowledge base and the possible disease categories it maps the symptoms to. The symptom checker output comprises:

Severity Level (Low / Moderate / High)

Possible Conditions (e.g., Allergies, Parasitic Infection)

Immediate Care Instructions

Whether Emergency Vet Attention is Needed

The technology minimizes the risk of error and is also instrumental in the assessment of the urgency of the situation when the symptoms cannot be seen, or the disease has not yet developed. Besides, it works as the first-level triage system that facilitates prompt medical interventions.

MobileNetV2:

MobileNetV2 is a small Convolutional Neural Network (CNN) that was created with the main goal of performing efficient image classification. Definitely, it is a very good choice for your task of embedding PAWPAL as a mobile,web,or anembeddedsystemapp.

Why We Chose MobileNetV2?:

- Lightweight architecture: Remains efficient in systems with low hardware and mobile devices.
- Depth wise Separable Convolutions: Computational cost is reduced without compromising accuracy.
- Pre-trained on ImageNet: The model learns general features of the objects very fast.
- Transfer Learning Friendly: Enables training using fewerpetdiseaseimages.
- High Accuracy on Medical Image Classification: Supports that subtle skin diseases can be differentiated effectively.

What we did in your work (Architecture Workflow)?:

- Base_Model:_MobileNetV2(weights='imagenet', include_top=False).
- Feature Extraction: At first, the layers were kept frozen in order to not alter the general features of the images.
- CustomLayers:
  GlobalAveragePooling.
  DenseLayer(ReLUactivation).
  Dropout.

Output: SoftmaxLayer.

IV. OBSERVATION AND RESULTS

A. Disease Prediction System (Image-Based Diagnosis):

The Convolutional Neural Network (CNN) model for Dog Skin Disease Detection has shown remarkable performance in terms of predictive power. The model was trained with a dataset that comprises six different dermatological conditions, namely Dermatitis, Fungal Infections, Ringworm, Hypersensitivity, Demodicosis, and Healthy Skin. When the model was tested, it was able to recognize the skin conditions that had the same pattern of characters with an accuracy ranging from 87.94% to 89% of the test accuracy.

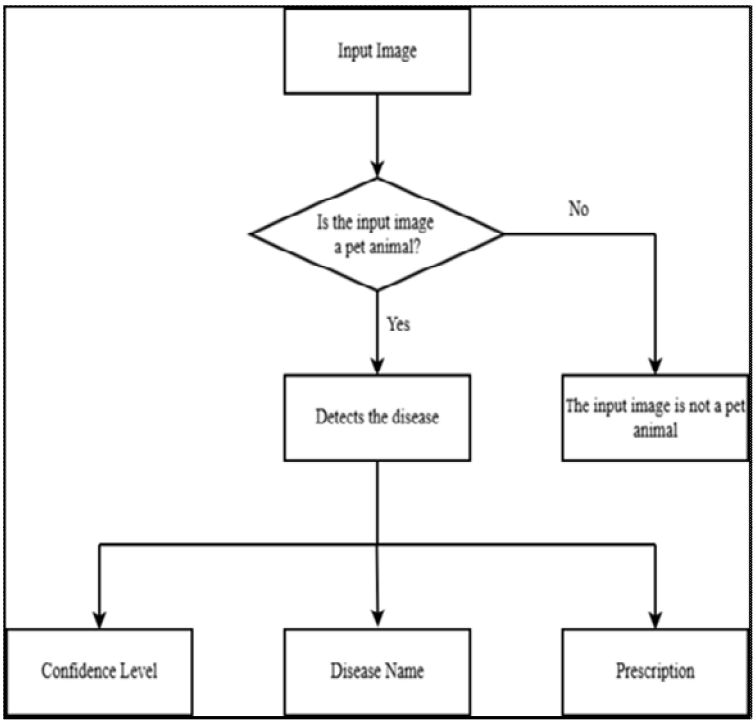


Figure 2: Disease Prediction Model workflow

The Cat Skin Disease Model was built from a differently annotated dataset that was aligned via an external label sheet. The dataset had four classes: Dermatitis, Flea Allergy, Ringworm, and Scabies. The lower performance of the cat model is due to the smaller dataset. The model reached about 77% of the training accuracy, 67% of the validation accuracy, and 65% of the test accuracy, which is a level that can be raised further by increasing and augmenting the dataset.

The below table is the classification report of Dog Skin Disease Prediction Model.

Class	Precision	Recall	F1-Score	Support
Dermatitis	0.93	0.82	0.87	66
Fungal infections	0.83	0.54	0.65	54
Healthy	0.82	0.93	0.87	69
Hypersensitivity	0.82	0.79	0.81	29
Demodicosis	0.88	1.00	0.94	100
Ringworm	0.91	0.96	0.93	115
Accuracy			0.88	433
Macro Avg	0.87	0.84	0.85	433
Weighted Avg	0.88	0.88	0.87	433

The below table is the classification report of Cat Skin Disease Prediction Model.

Class	Precision	Recall	F1-Score	Support
Dermatitis	0.75	0.75	0.75	20
Flea Allergy	0.71	0.63	0.67	19
Ringworm	0.67	0.46	0.55	13
Scabies	0.52	0.68	0.59	19
Accuracy			0.65	71
Macro Avg	0.66	0.63	0.64	71
Weighted Avg	0.66	0.65	0.65	71

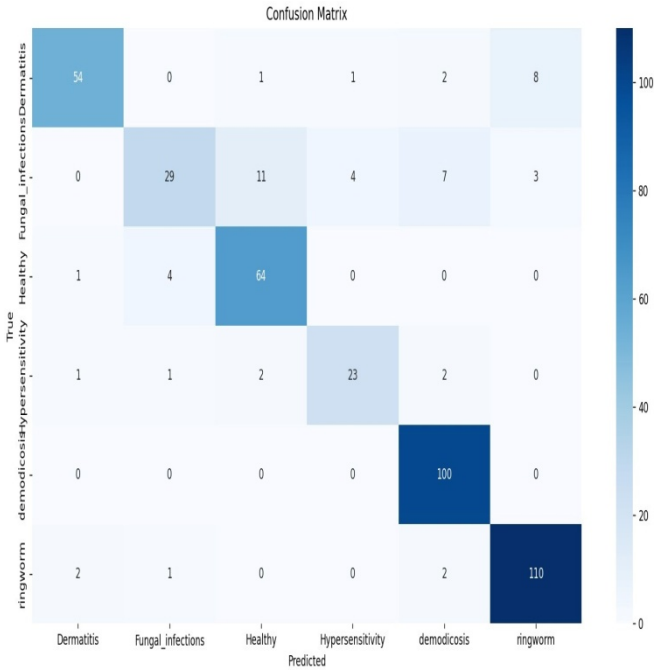


Figure 3: Confusion Matrix of Dog Disease Prediction model

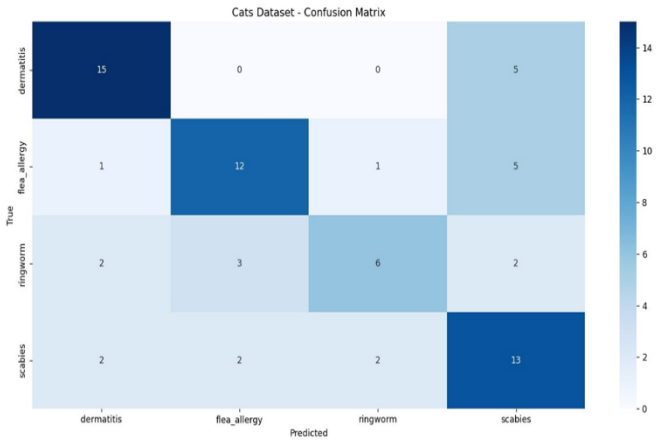


Figure 4: Confusion Matrix of Cat Disease Prediction model

B. Symptom Checker System:

The Symptom Checker, which relies on an NLP-based inference model, was given a range of user-described symptoms to evaluate its operation. The checker was able to performa:

- Severity Assessment (Low, Medium, High / Emergency)
- Most Probable Diseases or Conditions
- Home-CareRecommendations
- Time for Veterinary Visit

The system achieved a high level of explainability and agreement when it came to making results that were logical, especially in cases where the symptoms were explicitly mentioned. However, the system sometimes indicated that it was unsure about the severity of a situation when a short or incomplete description of symptoms was provided by a user. Such an answer is a confirmation of the hypothesis that people's descriptions of health problems in natural language may vary significantly from one user to another.

Pawpal results:

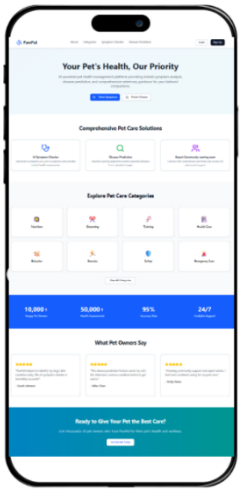


Figure 5: Dashboard

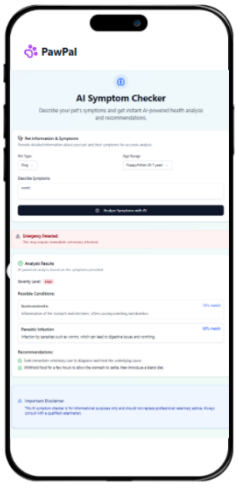


Figure 6:Symptom Checker page

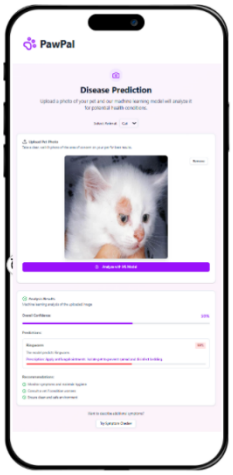


Figure 7: Disease prediction Page (Cat)

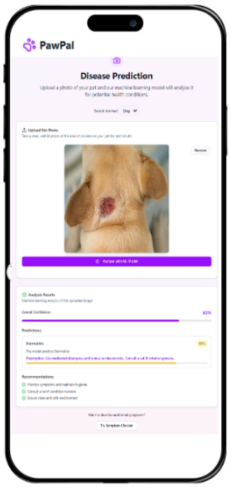


Figure 8: Disease prediction Page (Dog)

V. FUTURE ENHANCEMENT

PAWPAL, as a tool, has the ability to indicate the presence of diseases efficiently and can also be used in diagnosis by showing the symptoms in dogs and cats. However, through the clinical use of the instrument, there is still a lot of room for growth in the expansion of its use and the possibility of making it work more efficiently. One of the concerns that will be very important for the company in the future to address is the variety of datasets which should be changed drastically especially by the inclusion of more breeds, different skin colors, age groups, and environmental conditions.An increase in not only the size but also the diversity of the dataset will significantly enhance both model generalization and diagnostic robustness, especially, for rare diseases, that may have a few samples in the training data.Another area where the money could be spent is onboard real-time tele-veterinary consultations directly within the platform. A pet lover would be facilitated by this jewel to get in immediate contact with a certified vet at the very moment the device detects the most severe symptoms or a case of urgent medical help. This will make PAWPAL be more than just a diagnostic tool, instead, it will become a hybrid AI-assisted veterinary decision support system. Just so you know, by locally training domain-specific language models on veterinary case histories, the Symptom Checker can be improved in many other ways as well such as not only severity classification but also language ambiguity reduction due to variations in user input. In addition, to extend the range of the system and make it more user-friendly, the plan of implementing it as a mobile application capable of making offline inferences and being appropriate for remote areas with a weak internet connection can also be considered. This can be done by performing optimizations for TensorFlow Lite or ONNX-based CNN models to enable lightweight on-device inference.Furthermore, the developers may integrate an activity and behavior monitoring feature that can obtain the data from the wearable sensors or the user, regarding behavior, and then utilize the data for health-related conclusions, thus, leading to the early recognition of systemic disorders beyond dermatology.

In other words, expanding the features of the application to cover animals such as birds, rabbits, cattle, and horses will be a fantastic idea. It involves model training and data extension gradually and in a well-organized way, but it is in line with the larger concept of PAWPAL as an AI-driven universal pet and livestock wellness platform. All these changes will make the system more dependable, have a substantially wider impact, and be able to deliver the concept of more proactive, accessible veterinary care to more people.

VI. CONCLUSION

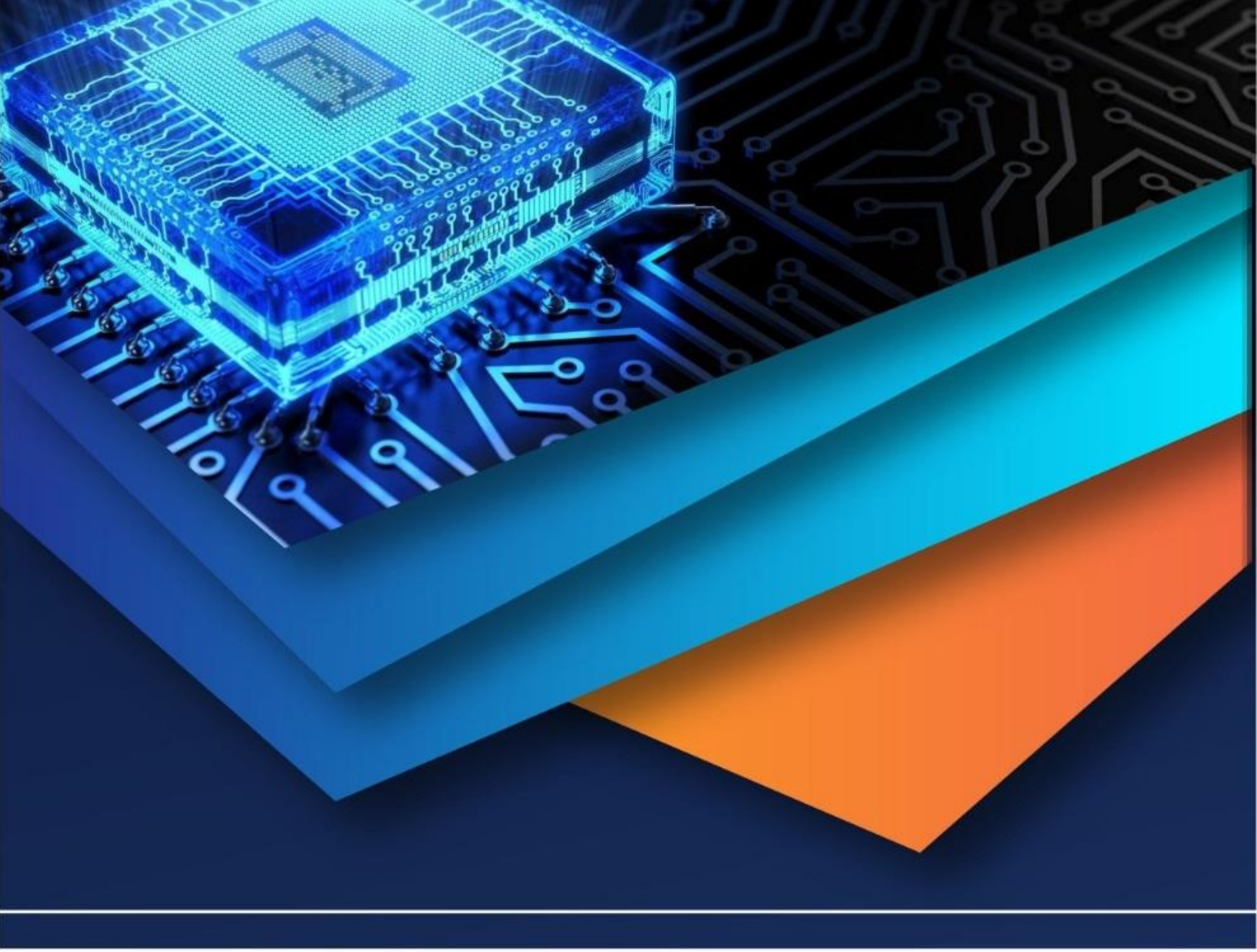
The PAWPAL system is a fine example of how AI integration can effectively elevate the early detection of diseases and the making of health-related decisions for pets to a large extent. By design the system merges CNNs for image-based skin disease classification with the NLP-based Symptom Checker, which, by definition, addresses two major issues that pet owners encounter - misinterpretation of the visual symptoms and lack of vet consultation. Besides classification reports and confusion matrices, the paper also presents the experimental results to demonstrate that the proposed disease prediction model has attained high diagnostic accuracy for dogs and good performance for cats. Moreover, the symptom analysis unit is instrumental in further system enhancement by determining symptoms' severity, suggesting condition indicators, and recommending first-aid measures.

The whole system is mostly aimed at pet owners, is quite affordable, and has a huge potential for further development, thus, it helps pet owners by providing them with simple and clear directions and giving them the opportunity to carry out interventions at an early stage, which, therefore, can considerably reduce the risk of disease progression. It is important to mention that PAWPAL is not a replacement for a professional veterinary consultation; nevertheless, to a large extent, it serves as a means of instant support, thus, facilitating the identification of the necessity of medical care. Later, the updates will entail broadening the datasets, enhancing diagnostic accuracy for various breeds, allowing live veterinary consultation, and adding more species of pets. As a result, PAWPAL is one of the essential digitally connected components of the veterinary health care system and a vivid illustration of how AI can bring real-life conveniences to animal welfare.

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