IoT and Deep Learning Based Dog Dermatitis Monitoring System

M.V.D.P.D. Malawana, M.S. Suhail Razeeth, K.K.Y.M. Alawathugoda, and R.K.A.R. Kariapper

Abstract The future of pet care in the changing environment involves the need to incorporate the latest technologies to keep track of pet health and other related issues. The paper presents a new solution to the management of the dermatitis disease through the help of IoT technologies, cloud computing, and intelligent sensor network. The system uses an ESP32 microcontroller to coordinate such sensors as the MPU6050 accelerator, DHT22 temperature and humidity sensor, the MAX30100 heart rate sensor, and Nova Fitness SDS011 dust sensor. The arrangement allows constant and distant observation of the well-being and surroundings of a dog so that the symptoms of dermatitis can be recognized and treated in the initial stages. The MPU6050 measures the movement patterns, the DHT22 evaluates the environmental conditions, the MAX30100 measures the physiological status, and the SDS011 measures the air particulates. Strong firmware will make sure of precise data capture and healthcare analysis, giving a detailed picture of health. Also, a set of 1,000 dog images, which are divided into dermatitis and goods, is utilized to train the model to identify the dermatitis symptoms. The train the images have been trained using the own CNN as well as the transfer learning models. The own CNN model achieved 92 percent accuracy, 0.9 precision, 0.91 recall and 90.5 percent of F1-score. An app named "Smart Pet Owner" was created in Flutter and Firebase and allows access to information about the health of a pet in real-time, which will guarantee that the intervention can be provided in a timely manner. This system improves the quality of care of pets by monitoring them constantly and remotely.

***Index Terms*— Dermatitis, Petcare, Smart System, IoT, Mobile Application**

I. Introduction

THE pets care industry has undergone a massive revolution in recent years due to technological change. There is growing demand for pet owners to identify novel approaches that can track and manage the health of their pets to avoid the onset and successful management of numerous diseases. Amidst these disorders, canine dermatitis as a popular inflammatory skin disease, presents a significant issue since it is a multifactorial disease and it is painful to dogs having it. Conventional ways of treating dermatitis have tended to be based on specific visits to a veterinary and subjective evaluation, which might not lead to timely and perceptive data on the condition of the pet. This loophole signifies a greater need to have a more active and ongoing monitoring system that can be exploited by utilizing the current technological advances.

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Although the cases of canine dermatitis are perhaps ordinary in the veterinary practice, the overall effect of this phenomenon is significant and should be addressed technologically. Dermatological cases constitute twenty-five per cent of all veterinary visits in the world, amounting to millions of sick animals each year. In addition to the prevalence statistics, the relevance of the work is proven in a number of critical dimensions that altogether lead to the necessity of the development of sophisticated monitoring solutions.

Animal welfare Animal welfare Chronic pruritus and skin inflammation severely reduce the quality of life of the affected dogs. Itchiness, discomfort and pain in dermatitis are chronic and may cause behavioral changes and sleep disorders as well as decreased physical activity, which undermine the well-being of companion animals. Canine dermatitis also has an economic burden as treatment expenses such as doctor consultations, diagnostic tests, drugs, and follow-up treatment costs over time. In the case of working dogs that are used in security, assistance or agricultural work, the condition may lead to less productivity and early retirement and this will be a huge economic loss to owners and organizations.

The role of public health in encouraging the role of good dermatitis management is further emphasized by the fact that certain conditions of the canine skin like dermatophytosis and bacterial infections have zoonotic potentialities that is they can be passed on to the human being especially children, elderly and immunocompromised individuals who have close contact with animals that have dermatophytosis. Regarding the technological innovation perspective, the system is an effective example of

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implementing the IoT and artificial intelligence in veterinary medicine, which sets the framework that can be modified and implemented to track other chronic conditions in companion animals, contributing to the development of the area of veterinary telemedicine and smart pet care.

Most importantly, however, the importance of early detection by constant monitoring is difficult to overestimate because it helps to intervene in time before a serious complication, including secondary infections, chronic skin thickening, or systemic involvement, will occur. Early intervention minimizes the complexity of treatment, reduces the recovery period, minimizes the need to use more medication and finally it lowers the total cost of healthcare and enhances animal welfare. The originality of the current study is the integrated technological solution of the ongoing presence of the disease and the detection and prevention at the initial stage, which has yet to be properly studied within the scope of veterinary medicine despite the established benefits of the same solution within the context of human health.

Dermatitis is inflammation of the skin because of the reaction of the immune system to the perceived foreign objects like allergens, bacteria, etc., which have crossed the skin barrier or gotten into the body through inhalation or ingestion. Depending on the sensitivity of a dog to the invading substance, the inflammation may result in localized (single area) or generalized (all over) itching of mild to severe intensity. When itching persists, it may become reddened, rashed, and infected, and make the situation worse.

In dogs who have autoimmune disorders, the immune system becomes activated against the body as it perceives normal cells as undesirable and this causes chronic inflammation. Lesions can appear in some parts, which is usually termed as psoriasis. It is a skin inflammatory disease in dogs, which is characterized by pruritus (itching), erythema (redness), and other lesions that have a great influence on the quality of life of a dog in everyday life.

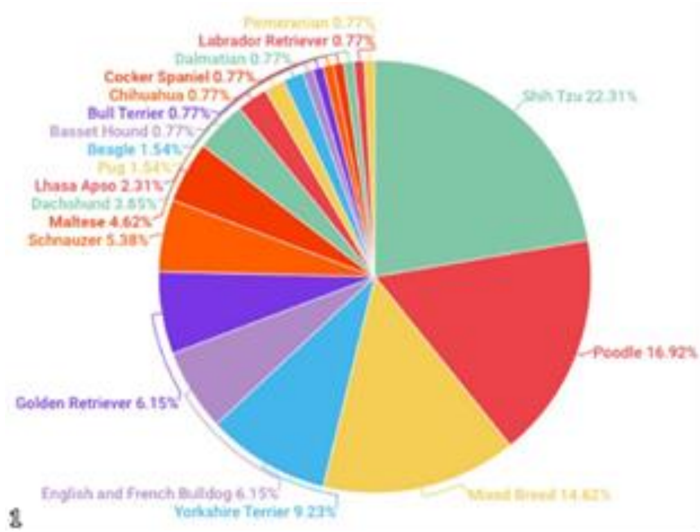
The condition presents itself in the form of numerous etiologies such as allergic reactions like flea allergy, food allergy, atopic dermatitis, microorganism or fungal or parasitic attacks, and environmental irritants. Typical clinical manifestations are excessive scratching, discoloration of skin, loss of hair and secondary development infections. Conventional diagnosis depends on the veterinary examination, skin scrapings, and allergy testing, which frequently leads to a late diagnosis and treatment initiation.

When we consider globally, dog dermatitis is a major health issue with companion animals. Worldwide, veterinary consultations for dogs, skin diseases are among the most common. About 20-25 percent of all cases are due to skin diseases. Among these, canine atopic dermatitis (CAD) is the most common disease, with an estimated prevalence of 3-15 percent of the total canine population. However, it is region-dependent and not always well-studied. Recent epidemiological data indicate that this condition can have a significant impact in different geographic areas. In the United States, more than surveys.

A prevalence rate of 4.7% for atopic or allergic dermatitis was found in 31,000 dogs. Studies conducted in teaching hospitals report even higher rates in their populations, with 12.7% of dermatology patients at the University of Montreal being atopic and as high as 25.65% in Brazilian facilities, indicating an upward trend in diagnosis. A Chinese study of over 2.4 million canine patients found 41,551 definite CAD diagnoses, equivalent to 46.24% of all cases of pruritus, highlighting how the disease is associated with chronic diseases. Discomfort.

The burden of the disease is not limited to the clinical manifestation of the disease, but it also has a serious impact on the welfare of the animal as well as the quality of life of the owners, with about half of the owners having to deal with it. The economic impact is huge and it is an institution that must be managed over the long term.

Funding is provided for diagnostic tests, medication and follow-up care. This is more likely to occur with specific breeds. Breed-specific studies have shown that Boxers, Labrador Bulldogs, West Highland White Terriers, Pugs and Retrievers have a global predisposition and Cocker Spaniels have an odds ratio of up to 5.22.



In tropical/subtropical regions such as South Asian nations, the prevalence in Sri Lanka may be higher due to climatic conditions that favor year-round exposure to environmental factors such as dust mites and molds. However, the broader South Asian regional epidemiological data has limited information, which emphasizes the need for surveillance systems and early detection technologies.

Remote health monitoring has new opportunities due to the emergence of the Internet of Things (IoT). IoT refers to the process that means connecting devices via the internet so that they are able to gather and share information. In the context of pet care, IoT can be utilized to develop systems that continuously monitor various health parameters and environmental conditions, thereby providing real-time data and alerts to pet owners and veterinarians. Integrating IoT with cloud computing and smart sensor networks can significantly enhance the ability to monitor and manage canine dermatitis.

This study mainly focusses on dermatitis and low thyroxine of dogs. The dermatitis is a skin disease type and Skin diseases may be caused by fungal infection, bacteria, allergy, or viruses,

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etc. A skin disease may change texture or color of the skin. In general, skin diseases are chronic, infectious and sometimes may develop into skin cancer. So, it is very important to identify them early and do the treatments as soon as possible. Therefore, the aim of this study is the development of an IoT-based canine dermatitis monitoring system for continuously monitoring the dog in real-time in order to identify and provide early detection and solution for the dog dermatitis.

II.Literature Review

Hekler et al. [1] explores the synergy between human and artificial intelligence in skin cancer classification. Hekler use CCN technology for the research. Dermatologists independently assess 300 images, enabling a direct performance comparison. The research reveals synergistic benefits and challenges the adversarial perception of AI vs. dermatologists. On the other hand, Hwang et al. [2] emphasizes the development of artificial intelligence (AI) models to classify common dog skin diseases. Considering the commonness of dog ownership and their associated health-related advantages, the paper outlines the dangers, including dermatophytosis. The conventional method of diagnosis through veterinary knowledge is not easy and thus the study automated and enhanced efficiency in diagnosis of bacterial dermatosis, fungal infection, and hypersensitivity allergic dermatosis.

Blubaugh et al. [3] investigate the pruritogenic and inflammatory effects of chloroquine (CQ) injections in a canine model. Recognizing pruritus as a common clinical sign in canine dermatological diseases, the research aimed to establish a predictive model for non-histaminergic itch in dogs. While previous studies identified histamine-independent pathways in humans and mice, the validity of a CQ-induced pruritus model in dogs remained unclear. While Marsella [4] contributes to the evolving understanding of canine atopic dermatitis (CAD), emphasizing its complex aetiology involving genetic factors, environmental triggers, and immune responses. Shifting from the traditional hypersensitivity view, the research delves into skin barrier impairment, dysbiosis, and the challenges in distinguishing CAD-specific changes from general inflammatory responses.

Kim et al. [5] explores tight junction (TJ) protein expression in a dog model of atopic dermatitis (AD), focusing on ZO-1, occluding, and claudin-1. The investigation, conducted on skin biopsies from atopic and normal beagle dogs using immunohistochemistry, reveals a significant decrease in ZO-1 intensity in atopic dogs, both subjectively and objectively. The study sheds light on the potential role of altered TJ proteins in AD pathophysiology, emphasizing the necessity for further research to discern the clinical implications. However, limitations include a small sample size and the focus on nonregional skin, warranting larger population studies and consideration of allergen exposure in future investigations.

Hrovat et al. [6] investigates the behavior and neurohormonal status of dogs with spontaneous hypothyroidism during levothyroxine treatment. Prior studies hinted at a connection between hypothyroidism and behavioral abnormalities, prompting interest in controlled trials assessing the impact of levothyroxine on behavior. The study, utilizing the Canine Behavioral Assessment and Research Questionnaire (C-BARQ) and measuring serotonin and prolactin concentrations, reveals a significant increase in activity levels after 6 weeks of treatment.

Guglielmini et al. [7] investigates the electrocardiographic (ECG) and echocardiographic changes in dogs with hypothyroidism before (T0) and after (T60) levothyroxine supplementation. Focusing on electrical activity and mechanical function, including the myocardial performance index (MPI), the research addresses a gap in understanding the comprehensive cardiac effects of hypothyroidism and the impact of levothyroxine treatment. Anyhow, the study acknowledges limitations, including a sample size constraint, the need for long-term investigation, and the limited clinical significance of MPI in identifying cardiac dysfunction in hypothyroid dogs.

Mitchell et al. [8] investigates the presence of Acinetobacter spp. on healthy canine skin, shedding light on potential reservoirs for infection and their antibiotic susceptibility. Acinetobacter species, recognized for antimicrobial resistance and nosocomial pathogenicity in humans, are increasingly noted in veterinary contexts. Despite a small sample size, the study reveals a significant proportion (25%) of healthy dogs carrying Acinetobacter spp.

Leeb et al. [9] mainly focuses on the genetics of inherited skin disorders in dogs, providing a comprehensive overview of canine Geno dermatoses and their known genetic aetiology. The review aims to address the diversity of phenotypes in canine Geno dermatoses, emphasizing the significance of precise genetic diagnosis for counselling owners, understanding disease prognosis, and making informed breeding decisions. The collaborative approach, involving veterinarians, dermatology specialists, and dermatopathologists, underscores the interdisciplinary nature of advancing genetic analyses in veterinary medicine.

Rathnayaka et al. [10] addresses the pressing issue of skin disease detection in dogs, proposing an intelligent system that combines both CNN and Natural Language Processing. The study emphasizes the significance of early detection in canine skin diseases, utilizing deep learning techniques for accurate identification. The proposed mobile application integrates disease classification, severity level detection, ontology-based knowledge extraction, and an AI-based chat-bot to provide comprehensive information to dog owners.

Kim and Song [11] address the need for a reliable software tool to assist pet owners with limited knowledge in diagnosing their dogs' diseases and be a pre-diagnosis system for mobile platforms, allowing pet owners to assess their dogs' health based on observed abnormalities. The system utilizes a disease-symptom database derived from textbooks and encyclopedias and employs the Possibilistic C-Means (PCM) clustering algorithm for associating symptoms with diseases. The literature review explores existing smart pet care products utilizing IoT technology, focusing on food feeders, water dispensers, and litter boxes. It identifies gaps in current market offerings, such as limited integration across devices and insufficient health data collection. Existing solutions often lack comprehensive monitoring and control features. Academic

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research highlights the need for holistic pet care systems that record detailed health status.

The currently available literature is dedicated to image-based classification or theoretical knowledge, but not a set of IoT-based continuous monitoring systems that would integrate environmental sensors, physiological measurements, and deep learning to detect dermatitis in real time.

TABLE I
SUMMARY OF RELATED LITERATURE

Study	Technology /Method	Application	Key Findings	Limitations
Hekler et al. [1]	CNN for skin classification	Human-AI synergy in skin cancer detection	Synergistic benefits of human-AI collaboration	Focus on human skin, not veterinary applications
Hwang et al. [2]	AI classification models	Dog skin disease identification	Automated classification of bacterial, fungal, and allergic conditions	Limited disease categories; classification only
Blubaugh et al. [3]	Chloroquine -induced model	Canine pruritus investigation	Established non-histaminergic itch model	Laboratory model; not real-world monitoring
Marsella [4]	Review of CAD etiology	Understanding atopic dermatitis mechanisms	Identified skin barrier impairment and dysbiosis	Theoretical review; no practical monitoring solution
Kim et al. [5]	Immuno histochemistry	Tight junction protein analysis	Decreased ZO-1 in atopic dogs	Small sample size; invasive methods
Hrovat et al. [6]	Behavioral assessment (C-BARQ)	Hypothyroidism and behavior	Levothyroxine increased activity levels	Indirect dermatitis correlation
Guglielmini et al. [7]	ECG	Cardiac effects in hypothyroidism	MPI changes with treatment	Limited clinical significance for dermatitis
Mitchell et al. [8]	Bacterial identification	Acinetobacter presence on skin	25% of healthy dogs carry Acinetobacter	Small sample; no monitoring system
Leeb et al. [9]	Genetic analysis review	Inherited skin disorders	Importance of genetic diagnosis	Genetic focus; not environmental monitoring
Rathnayaka et al. [10]	CNN + NLP	Mobile app for skin disease detection	Combined image classification with chatbot	No continuous monitoring; manual image capture only

III. METHODOLOGY

The major idea of this study is to identify the dermatitis of the dogs and find the nearby doctor to provide an instant remedy in a perfect manner. The system is designed with IoT and Deep Learning techniques. The following shows the system architecture of IoT and Deep Learning. The key idea of IoT is to detect the symptoms of dermatitis using sensors. The symptom of dermatitis as follows,

A. System Architecture of IoT

Figure 1 shows the system architecture of IoT components. Here Esp32 act as central hub between sensors and mobile app via google firebase database. The key idea of this phase is identifying the symptoms of dermatitis using sensors and pass that information to the mobile app. The following sensors in Table II are used for identifying the symptoms.

Esp32 collect all the data and pass the sensor reading to the cloud firebase and it will finally pass to the mobile app to check the health condition of the dogs in real-time. The IoT sensor with symptoms monitoring act as a first verification of dermatitis identification.

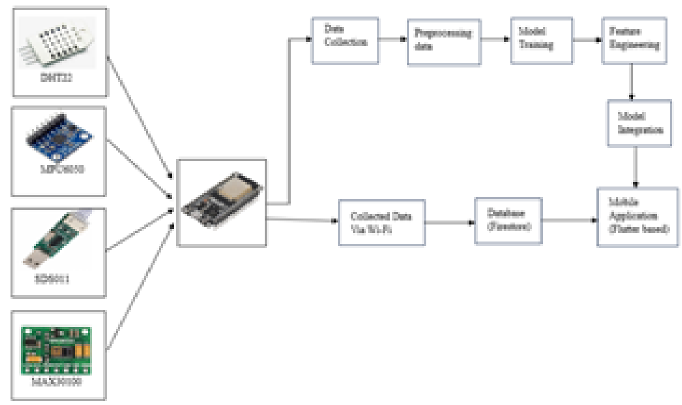

Fig. 1: System Architecture (IoT and Mobile)

TABLE II
SENSORS AND USAGE

Sensors	Usage
MPU6050	Moment detection of a dog
DHT22	Humidity and Temperature detection
MAX30100	Detect SPO2, Temperature, and Heart rate of the dog
Dust Sensor	Detect dust particles of the environment

B. System Architecture of Deep Learning

Figure 2 shows the deep learning architecture of the dog dermatitis detection. The image dataset will be collected, and it will be pre-processed by needy parameters. Then the transfer learning and OWN CNN baseline models will be applied to train the model. Finally, the best model will be selected for embedded into the mobile app. The model with the mobile app will act as a second verification to the dermatitis detection. A specific app with a camera feature is used to check the model. When the user of the app captures an image, it will classify whether it is dermatitis or not. When both verifications are met, the system will suggest a nearby doctor to further process.

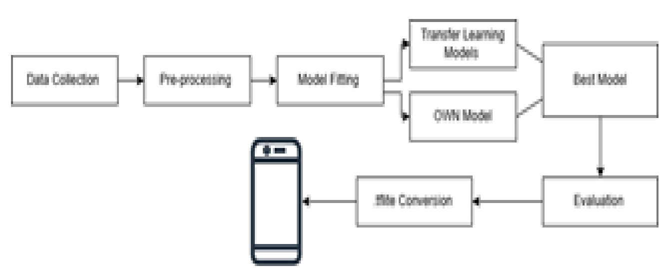

Fig. 2: Deep Learning Architecture

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To overcome the limitation of a small number of publicly available datasets of dog dermatitis images, a custom dataset was created and used in this study. The sample size of the data is 1,035 high resolution images of dogs obtained via various sources. In the first place, an informed consent was given to pet owners privately during regular visits and dermatological inspections to animal clinic in kirillawala, as a result of which 520 images were obtained. Second, the research team recorded 300 images by the use of mobile phone cameras (smartphone specification: Samsung Galaxy M32) when visiting the homes and veterinary clinics of pet owners. Third, publicly available databases of veterinary databases and peer-reviewed research publications were used to find 150 images. Lastly, 65 pictures were gathered at pet health forums and online communities with the correct permission and owner authorization.

The size of the image was 224x224 or 2048x 2048 pixels as minimum and maximum resolution. The images were saved in JPEG and PNG and had the RGB color space. The condition of capturing was varied to capture natural daylight and indoor artificial lighting at different angles to achieve model robustness and applicability in the real world. The camera devices used were professional veterinary cameras and smartphone cameras to collect in the field and re-create the conditions of the standard user capture.

The annotation was done on a standardized basis and there were two categories of images. The initial group named as Normal and consisting of 596 pictures contained healthy skin without any visible signs of inflammation, lesions, discoloration or an abnormal texture. The skin pigmentation, hair coat, and pathological changes were normal and absent in these images. The second category named Dermatitis and containing 439 images consisted of a skin with typical characteristics of erythema (redness), papules (small raised bumps), pustules (pus-filled lesions), scaling (flaky skin), hyperpigmentation (darkened skin), lichenification (thickened skin), alopecia (hair loss), excoriations (scratch marks), or a combination of all. The inter-rater reliability was determined with the help of Cohen kappa coefficient and the result was k = 0.87, which has high levels of agreement among annotators and also guarantees quality data that has been labeled.

Preprocessing of data was done in a systematic manner in order to train the model. The size of images was reduced to 224x 224 pixels to ensure the consistency of model inputs using bicubic interpolation. The normalization of the pixel values was done by dividing by 255 to the range [0,1]. The only data augmentation involved in the training set was random rotation (+-15deg), the horizontal flipping (50:50) etc. The brightness, contrast, and zoom (0.9-1.1x) were also changed to augment the generalization of the model. An 80-20 split was used to split the dataset into training and testing subsets, with 829 and 206 training and test images, respectively. Stratified sampling was used to ensure that the class distribution in both subsets was similar. The test set was not augmented with any data so that the performance test could be evaluated without bias.

The comparatively unbalanced dataset containing 57.6 percent normal and 42.4 percent dermatitis images was handled in the form of class weighting in training the model. Class weights were calculated in the form of 1/class frequencies and the weight normal and weight dermatitis obtained were 0.87 and 1.18 respectively. This strategy helped the model to give due consideration to the minority group (dermatitis) in the process of training. There were quality assurance factors that were incorporated during the data set preparation. All the pictures were checked manually in terms of their quality including blur, overexposure, or occlusion. The final dataset was not included with images that had ambiguous diagnoses. Table III shows the dataset used for this study.

TABLE III
IMAGE DATASET

Class	Total	Train (80%)	Test (20%)
Normal	596	477	119
Dermatitis	439	352	87
Total	1,035	829	206
Class Balance	57.6% / 42.4%	-	-

The classification of dermatitis was done in two methods: transfer learning using pre-trained models and a new CNN architecture. Transfer learning takes advantage of the pre-trained model that has been trained on large-scale data, that is, ImageNet (1.4 million images and 1,000 classes) and re-trained on the particular problem of canine dermatitis detection. There were four architectures that were evaluated in order to determine the most effective model to use in this application.

In the initial transfer learning, VGG16 and VGG19 (Visual Geometry Group) networks, which use 3x3 filter sequential convolutional blocks were used. VGG16 is made up of 16 layers that include 13 convolutional layers and 3 fully connected layers having an approximation of 138 million parameters.

To implement it, the pre-trained weights were loaded and the last classification layers were changed to custom layers in the order Global Average Pooling, Dense layer with 256 units and ReLU activation, Dropout with 0.5 probability, and Dense layer with 2 units and SoftMax activation to be used in the binary classification. Tasks specific learning Fine-tuning was done by unfreezing the final 3 convolutional blocks and freezing previous layers to preserve general feature extraction efficiency.

The second transfer learning involved the use of ResNet50 (Residual Network), which is a 50-layer network that uses residual connections also referred to as skip connections. The major novelty of ResNet50 is that it allows overcoming the vanishing gradient problem by identity shortcuts that enable the flow of gradients in the network itself. ResNet50 has a large number of parameters (25.6 million), making it parameter-efficient compared to the VGG architectures. The pre-trained ImageNet weights were used and the last fully connected layer was substituted by a custom classifier that is specific to the detection of dermatitis. It was fine-tuned by unfreezing the final

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residual block following the initial training to adjust the model to the characteristics of the canine skin disease.

The third transfer learning method employed MobileNetV2 which is a lightweight model designed to be deployed efficiently by depth wise separable convolutions to run on mobile devices. MobileNetV2 has a depth multiplier of 1.0, meaning that it has about 3.5 million parameters, much smaller than the VGG and ResNet models. The design objective was to be able to optimize itself to mobile deployment with low computational needs and still be able to achieve acceptable accuracy. Its implementation was based on the binary dermatitis detection task, but only adapted the top classification layer, preserving the inverted residual blocks with linear bottlenecks of MobileNetV2.

All training settings of the transfer learning models were the same to evaluate them fairly. Adam optimizer was used with the learning rate of 0.0001 to allow a stable convergence. The loss function to be used in the binary classification was categorical cross-entropy. The size of the batch used was 32 images and 10 epochs of training. Early stopping with patience of 3 epochs to avoid overfitting was used as well as model checkpoints to store the best performing model given the validation accuracy.

Besides transfer learning methods, a tailored CNN based on the strategy was developed to extract canine dermatitis features (OWN CNN). The architecture comprises of eight consecutive layers.

The third layer goes on to 128 filters with the same structure with the fourth layer of 256 filters, keeping the 3x3 kernel size with ReLU activation and 2x2 max pooling. The fifth layer compresses the feature maps to a one-dimensional vector. The sixth layer consists of a fully connected dense layer of 512 units and ReLU activation, and is followed by dropout with probability of 0.5 to regulate. One more dense layer is the seventh layer that has 256 units, ReLU activation, and a 0.5 dropout. The binary classification of the output layer is a dense layer of 2 units and SoftMax activation.

The custom CNN architecture design had three major principles. To extract progressive features, it was first incrementally added that filter counts grew to 256 so that the network was able to extract hierarchies of features starting with low level edges and then high level dermatitis indicators in the form of textures and patterns. Second, the aggressive regularization with 0.5 probability dropout layers was used to ensure that the model does not overfit the small dataset. Third, the design was to have about 2.4 million trainable parameters, which would be adequate to the task yet have a balance with the dataset size available to avoid overfitting and yet have adequate representational power.

The custom CNN was slightly different in the training structure to maximize performance in comparison to the transfer learning models. The loss function was categorical cross-entropy. The size of the batch used was 32 images and 10 epochs of training. The technique of data augmentation such as rotation, horizontal flipping, and brightness adjustment was used during training to improve the model robustness and generalization ability.

IV. Results and Discussion

A. IoT Results

Figure 3 shows the IoT setup for dermatitis detection. All the sensors related to dermatitis were fixed in ESP32 board to check the dogs. The designed mobile app shows the sensor reading as in Figure 3. If any pet lovers want to identify the health condition of their pets in real-time for dermatitis, they can use this IoT setup and Mobile app is developed.

Fig. 3: IoT setup with ESP32 and Mobile Reading

B. Deep Learning

Based on Table IV, the OWN CNN model for the dataset provides more accuracy than other transfer learning models. Hence, the study utilized that model to embedded into mobile app to use as second verification.

TABLE IV
MODELS

Model	Epochs	Training Accuracy	Testing Accuracy
VGG16	10	0.71	0.76
VGG19	10	0.56	0.66
ResNet50	10	0.82	0.78
MobileNetV2	10	0.66	0.56
CNN01	10	0.92	0.91

Figure 4 shows the classification of dermatitis with IoT data and model trained. When the dog gets dermatitis, the app automatically suggests the nearby doctor as shown in the result. Hence, it is a good opportunity for pet lovers to provide instant remedies with any further delay.

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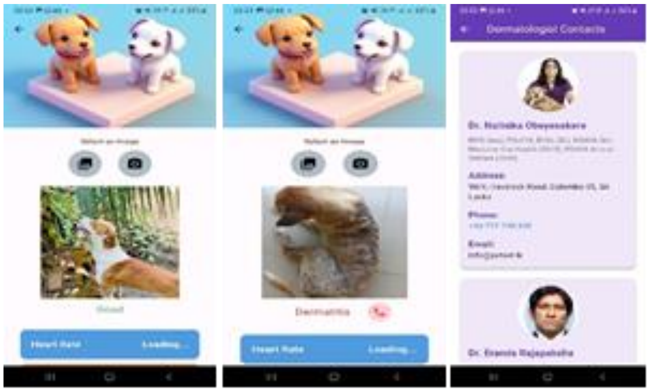

Fig. 4: Dermatitis classification and nearby doctor finding

V. CONCLUSION

The development and implementation of the IoT-Based Dog Dermatitis Monitoring System represent a significant stride forward in the field of pet care and technology integration. This initiative has led to the development of a broad solution through detailed research, data collection and model training processes to enable pet owners get real-time information on the dermatitis status of their canine friends.

The process started with a deep insight into the issue of having the ability to monitor and manage the symptoms of dermatitis in their dogs among pet owners. We adopted and utilized the latest technologies which include Internet of Things (IoT), cloud computing, and machine learning and embarked on a mission to come up with an innovative solution that would challenge these issues.

Through a well-thought amalgamation of hardware, software algorithms and cloud-based services, we developed a complex monitoring system that would be able to continuously monitor the health parameters and the environmental factors of a dog.

The model training step formed the foundation of this research project in which we carefully selected a rich image databank of dog skin and used the latest convolutional neural networks (CNNs) to be able to identify dermatitis cases. The results of the evaluation testified to the effectiveness and soundness of the trained model, which opens its path to the monitoring system.

The effective adoption of the IoT-Based Dog Dermatitis Monitoring System has an enormous potential in transforming the process of caring about pets throughout the world. This system will enable the pet owners to act proactively in the management of their dog dermatitis condition because it will give the owners information that can be acted upon as well as the ability to intervene in good time. What is more, the system is scalable and adaptable, which makes it suitable to be implemented in a range of environments, such as homes, veterinary service, and research institutions.

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