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Optimizing Image Quality for Dog Skin Disease Diagnosis: Bacterial, Fungal, and Hypersensitivity Cases with MATLAB

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A B S T R A C T

Skin diseases in dogs, such as hypersensitive dermatitis, fungal infections, and bacterial dermatoses, present diverse clinical signs that complicate diagnosis in veterinary practice. This study employs MATLAB as an image-processing tool to enhance diagnostic accuracy through a structured pipeline. A dataset of 500 canine skin images obtained from Kaggle was processed using enlargement, histogram equalization, Gaussian filtering, and Sobel convolution. These methods improved image quality by enhancing contrast, reducing noise, and clarifying lesion boundaries. The experimental results demonstrate that the processed images allow veterinarians to more easily detect key diagnostic features, including changes in lesion texture, color, and shape. Enhanced visual clarity supports faster identification of disease patterns and reduces diagnostic ambiguity in clinical settings. This study highlights the potential of MATLAB-based image processing as an effective decision-support tool for veterinary dermatology, enabling quicker and more reliable treatment planning. Future work may integrate deep learning classification to further automate disease recognition.

1. Introduction

Canine skin disorders, such as bacterial dermatoses, fungal infections, and hypersensitivity dermatitis, are particularly difficult to diagnose and treat. Due to the range of clinical symptoms, the diagnosis is complicated and requires a high level of precision. MATLAB was chosen because of its image processing capabilities, which can improve image quality and allow for more precise analysis. It enables the processing of dog skin images to clarify details that are not visible to the naked eye, which helps veterinarians identify the type of disease more quickly and precisely. The use of MATLAB facilitates the management of skin diseases in dogs and helps make better treatment decisions as it increases diagnosis efficiency, reduces examination time, and improves accuracy.

The health and beauty of a pet's appearance are crucial since treating the sickness costs more money. Additionally, the condition of a sick pet will discourage the pet and disrupt its appearance if it has a disease on its skin. If the pet is infected with an illness that can be transferred, the owner must take steps to determine the type of sickness and its treatment so that appropriate actions can be taken [1].

Dermatitis has a wide range of causes and severity, ranging from mild to severe, spreading throughout the body. Clinical symptoms include itching, reddish skin loss, and, in severe cases, the entire fur falling off. Skin damage can develop in all three layers: epidermis, dermis, and hypodermis. Dermatitis treatment will be more effective if the causes and severity are identified. Thus, research into determining the causes of dermatitis is critical. It is critical to assess skin damage by skin histology. Similarly, the association between dermatitis incidence and maintenance practices, gender, and dog breeds should be investigated. This study uses histological observations to assess the severity of skin tissue and its origins, as well as to differentiate the incidence in racial and local dogs based on gender and how they are cared for [2].

To the professional, hence there are frequent errors in supplying handling solutions. To help overcome these issues, an expert system for identifying skin disorders in dogs has been devised to simulate the job of an expert [3].

Images are essential in digital industries including photography, graphic design, and image processing. To properly process and analyze photos, approaches that allow for the extraction of valuable information are required [4].

Matlab applications in medical imaging technologies have been built using algorithms that are still being developed for a variety of reasons, including identification or detection, segmentation, simulation, and even medical device programming. Matlab's application in medical imaging technology, particularly in digital imaging, has been developed through algorithms that continue to be developed for a variety of purposes, ranging from identification/detection, segmentation, simulation, and even medical device programming. Matlab's application in medical imaging technologies, particularly digital diagrams, involves the segmentation process for abnormality identification, simulation, and program creation [5].

Several studies have demonstrated MATLAB's potential in the medical domain. Sadad et al. applied a fuzzy logic approach using MATLAB and achieved an average success rate of 99.35% with only 0.65% error [6]. Kridayati et al., analyzed mathematical models of disease transmission using MATLAB, applying the Routh-Hurwitz criterion and the Pontryagin Principle for optimal control, with simulation results showing a cost efficiency of 10.673 and optimal control use of 49.9% [7]. Winarni and Sofiyati studied the transmission model of scabies disease and found that suppressing the spread could be achieved by increasing treatment levels for latent individuals and reducing contact with infected individuals [8]. Meanwhile, Fadli et al. showed that histogram equalization using MATLAB significantly improved the contrast of lung X-ray images, enabling better interpretation by medical professionals [9].

This research emphasizes the importance of improving image quality for the diagnosis of canine skin diseases such as bacterial infections, fungal infections, and hypersensitivity dermatitis. MATLAB provides tools that improve efficiency and accuracy in the diagnostic process, allowing veterinarians to deliver more precise treatments. Future steps in this research include expanding the dataset with more diverse cases of canine skin diseases and conducting additional clinical evaluations to validate the accuracy of the image processing results, so that the method can be more effectively implemented in routine veterinary practice.

2. Research Method

This research aims to improve image quality by using several techniques such as enlargement, pre-processing, enhancement, and convolution. The dataset used is taken from Kaggle and consists of 500 images and includes four categories, namely: fungal infection, bacterial dermatosis, hypersensitivity dermatitis, and healthy skin. However, the author only uses three categories, namely fungal infection, bacterial dermatosis, and hypersensitivity dermatitis. Each category has a different number of photos. The overall workflow of this research, starting from enlargement, followed by pre-processing, enhancement, and finally convolutional operations, is illustrated in Figure 1.

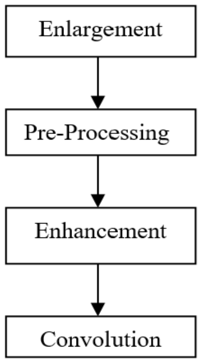

Figure 1. Stages of The Research Flow

2.1. Enlargement

To improve the resolution and clarity of dog skin lesion photographs, a 2x enlargement technique is applied. In the case of bacteria, expansion helps to reveal micro-patterns that are difficult to perceive at their natural size. Fungal infections make the fungus' structure and shape more evident, making identification easier. Enlargement can help spot discoloration and fine textures in hypersensitive dermatitis patients. This technique was chosen to improve diagnosis by using each lesion type's distinct qualities, allowing for more accurate analysis during image processing with MATLAB.

Image enlargement involves normalizing the dimensions of the face image, which means enlarging or shrinking the face image to predefined dimensions. The purpose of this normalization is to ensure that the facial dimensions of all input images are the same so that when the images are extracted, the facial image data matrix does not suffer from dimensional differences [10].

A method known as image enlargement enables image quality improvement by adding additional pixel values to the previous image, resulting in an image with a higher pixel density than the previous image [11].

The resulting image has the lowest image sharpness and smoothness, so it is common to enlarge the image directly to obtain a better image but reduced brightness [12].

Connects two data points to a straight line, which improves image quality and increases the resolution of outline images. This technique enlarges the image size by increasing the pixel size, especially in images [13].

Enlargement techniques increase diagnostic accuracy by enlargements skin lesions, making bacterial micropatterns, fungal structures, and textural changes in dermatitis more visible. 2x enlargement allows for more detailed visualization, assisting in the accurate diagnosis and classification of each ailment type. In bacterial infections, invasion patterns are more noticeable; fungal infections can be detected by the form of the spores; and dermatitis is more obvious in color and texture changes. The scoop was confined to two-dimensional images and rudimentary enlargement. Limitations include the inability to detect 3D properties of lesions and dependency on the original image quality, so results may vary depending on the resolution used.

2.2. Pre-Processing

A pre-processing technique called histogram equalization was employed to improve the contrast of dog skin lesion photographs. This process helps to even out the intensity distribution of the pixels, allowing you to view the minute details of bacterial infection, fungal patterns, and dermatitis texture. If bacterial infection occurs, the differences in texture and color become more obvious, which makes it easier to identify abnormal patterns. If a fungal infection occurs, the clearer differences show the fine structure of the fungus. Soft skin discoloration is easier to find in hypersensitive dermatitis. This method was chosen because it helps improve classification accuracy, maximizes visual differences relevant to the features of each lesion type, and allows further analysis with MATLAB.

Pre-processing involves resizing, which is done to speed up the computation time by reducing the image size [14].

Pre-processing is the initial stage of segmenting characters in vehicle number plate identification. In addition, it has been explained that the initial research procedure involves changing the color capacity of the image in *.jpg format, which consists of three colors (red, green, and blue) (RGB) into gray color capacity. The function of this color capacity change is to facilitate histogram normalization of the image and to be able to use the Otsu method to obtain the lowest value to distinguish between two color variants, namely black and round. The purpose of this stage is to prepare and transform the image to improve the image quality through the application of the binaryization process [15].

One of the processes carried out to remove noise in the image data to be used is pre-processing. Resizing, grayscale, and thresholding are included in this pre-processing stage. Image data is generated with binary colors of black (0) and white (1). The first process is to retouch the image to remove noises or unneeded elements from the image, which is fed for the next process. At this point, the process of improving image quality is known, which is intended to increase success in the digital image processing stage [16].

Pre-processing is the initial stage of image enhancement to remove noises [17].

Pre-processing is done to improve the quality of images that will be processed later on. It also can improve the results of classification or segmentation algorithms by extracting high-value features and filtering out low-value features [18].

Pre-processing is used to make the image to be processed lighter and simpler; this process is done before processing [19].

To obtain images that can be processed as data for input, the pre-processing process involves reducing the image size to speed up the computation time [20].

To make the class features clearer and simpler, pre-processing is used to enhance and improve the image quality. Pre-processing is used to remove different color and texture features. To generate color features, pre-processing only resizes the original image [21].

Pre-processing techniques such as histogram equalization improve diagnostic accuracy by improving image contrast, making the details of dog skin lesions more visible. This helps in identifying bacterial infections by accentuating patterns and textures; fungal infections by clarifying spore structures; and hypersensitive dermatitis by accentuating differences in skin color and texture. The scope of the study included enhancing image contrast to clarify lesion details. Study limitations include reliance on the initial image quality and possible distortion of details during the process. This technique does not cover the analysis of complex features or dynamic changes in lesions.

2.3. Enhancement

Grayscale conversion is critical for enhancing image quality in the diagnosis of canine skin problems. It simplifies data processing by reducing complexity while maintaining essential information. A Gaussian filter is then applied to smooth the image and reduce noise. This filter softens the image, removing tiny details that could mask sickness symptoms. Gaussian smoothing can help to highlight uneven textures in diseases like bacterial infections or fungal infestations by minimizing noise. This phase improves the accuracy and reliability of the following studies, such as edge detection or feature extraction, leading to more precise sickness identification.

There are several types of computer image processing. One of the most popular areas of image processing is image quality improvement. By using image enhancement, the quality of images that are initially blurred or not to the owner's liking can be improved [22].

Image quality improvement This type of operation aims to improve the image quality by changing the image parameters. This operation brings out the special features of the image. Examples of image enhancement operations are dark and light contrast enhancement, object edge enhancement, sharpening, false color rendering, and noise filtering [23].

Enhancement techniques are critical for improving the accuracy of skin disease diagnosis in dogs. By adjusting the grayscale scale, the image becomes simpler, allowing you to focus on the texture and pattern of the lesions. Gaussian filters minimize noise, making illness patterns like bacterial and fungal diseases apparent. Edge and feature detection algorithms can aid disease classification by recognizing lesion borders more precisely with reduced noise. This study exclusively evaluates skin lesion photos for bacterial, fungal, and hypersensitivity illnesses. This technique can improve image quality well but cannot guarantee a completely correct diagnosis result since it depends on the analysis algorithm employed and the quality of the original image. The study did not consider additional clinical characteristics, such as medical history or clinical symptoms, which are typically required for a complete diagnosis.

2.4. Convolution

The convolution technique using the Sobel operator is very effective in the diagnosis of canine skin diseases. Used to clarify image edges by calculating intensity gradients in the horizontal and vertical directions, this technique improves lesion detection. It helps to show the boundaries of lesions, which is often important for differentiating bacterial infections, fungi, and hypersensitivity dermatitis. Examples of commonly used Sobel filters are as follows: Horizontal Sobel filter [-1 0 1; -2 0 2; -1 0 1] and vertical Sobel filter [-1 -2 -1; 0 0 0; 1 2 1]. These two filters identify changes in intensity horizontally or vertically, thus clarifying the edges of the lesion in the image. This convolution allows for more accurate analysis and better diagnosis due to a clearer description of the skin lesion.

Convolution is the sum of multiplying each kernel by each point in the input function. Convolution, also known as two-dimensional convolution, is the process of obtaining a pixel based on the transmitted pixel values and is used to transform images by using external masks or subwindows to produce new images. It is very helpful for performing filter operations on images [24].

The convolution layer consists of a structure with several fixed-size filters that allow the application of complex features to the input image. The main purpose of convolution is to extract features from the input image [25].

Various convolution techniques can be used to detect the edges of digital images. Using edge detection operators, you can change the gray degree of a point and also calculate the gray degree of neighboring points (convolution or neighborhood operation) [26].

Convolutional algorithms using the Sobel operator are more reliable in detecting skin disorders in dogs. Sobel assesses the intensity gradient of skin lesions, allowing it to distinguish between bacterial, fungal, and hypersensitivity illnesses. Disease classification becomes more accurate as sharp edges are recognized. This study aims to identify distinct visual patterns linked to three types of diseases: bacterial infection, fungal infection, and hypersensitive dermatitis. The Sobel convolution technique improves image quality and edge detection in skin lesions. The study's drawbacks were a reliance on the quality of the input images and variances in skin texture. The convolution technique failed to detect non-visual characteristics such as the biological genesis or severity of the sickness, necessitating further clinical research.

3. Result and Discussion

Using a Kaggle dataset of 500 images, with each category having a varied amount of images. I collected one sample from each group. The color image samples in the dataset are transformed to grayscale before being handled with techniques like enlargement, pre-processing, enhancement, and convolution.

3.1. Enlargement

To improve picture quality for the detection of canine skin illnesses such as bacterial, fungal, and hypersensitive dermatitis using MATLAB, image enlargement is used to boost the visual clarity of the affected area. In this scenario, two-fold enlargement was used to strike a balance between greater detail and computational efficiency. Enlargement allows for the identification of finer skin patterns and lesions, which may be required for a proper diagnosis. MATLAB often employs bicubic interpolation in this technique because it can maintain edges sharp while reducing artifacts. Furthermore, two-fold enlargement meets diagnostic tool specifications, making automatic and manual exams more readable and exact. The following is Table 1 of results from processing enlarged images of dog skin diseases.

Table 1. Result Table of Enlargement

Image	Before	After
Bacterial.jpg	1080×1920	2160×3840
Fungal.jpg	640×640	1280×1280
Hypersensitivity.jpg	640×640	1280×1280

Table 1, the results of the MATLAB work for picture expansion show that this method can improve image resolution while maintaining diagnostic accuracy.

Bacterial.jpg, when resized from 1080x1920 to 2160x3840, provides additional information, making it easier to detect the skin texture. When Fungal.jpg and Hypersensitivity.jpg are resized from 640x640 to 1280x1280, the sharpness improves dramatically, making aberrant patterns easier to detect. The improved enlargement has the potential to provide a more accurate and efficient image-based diagnosis system, as well as to enhance the role of technology in the precise study of canine skin diseases. A method for canine skin disease identification that leverages MATLAB's enlargement techniques, such as 2x enlargement, focuses on improving picture resolution to improve visual interpretation. This approach is simpler and more efficient for small datasets or processing resources. While deep learning delivers high accuracy with trained models, picture enlargement has a benefit during the pre-processing step, maximizing visual detection without the need for huge amounts of training data or long training cycles.

3.2. Pre-processing

Pre-processing techniques are essential for image analysis of canine skin diseases as they improve image quality before further analysis. Histogram equalization improves image contrast by flattening the pixel intensity distribution, so details are more clearly visible, especially in the diagnosis of bacteria, fungi, or hypersensitivity. Images that are not preprocessed may contain noises or contrast imbalances that can obscure important features. Histogram equalization was chosen because it can overcome uneven lighting and bring out edges and fine details, which are crucial for distinguishing the different types of skin diseases displayed in the image.

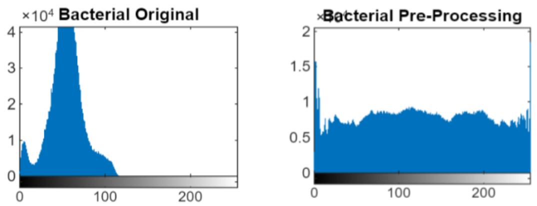

Figure 2. Histogram Bacterial Before and After Pre-Processing

Pre-processing operations, such as histogram equalization in Figure 2, change the frequency from Y = 4×10^4 to 2×10^4, suggesting a more even pixel intensity distribution. This result implies increased contrast and visual detail. This change is very advantageous to diagnostic systems. Improved contrast and detail distribution allow a more accurate diagnosis of skin diseases such as bacterial infections. Clearer images allow for more precise identification and informed clinical decisions, thus improving the quality of dog care.

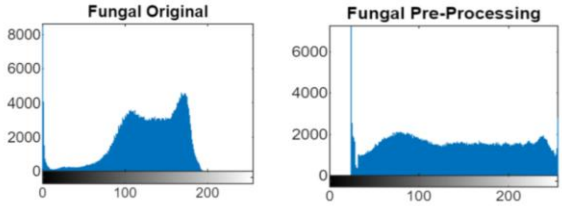

Figure 3. Histogram Fungal Before and After Pre-Processing

Figure 3, pre-processing measures such as histogram equalization reduce the incidence of fungal infection on the dog's skin from Y = 8000 to Y = 6000 and This shows that pixel intensities are more equally distributed across the range, providing for better visibility of important details in the image. The lower frequency means that pixel intensities are more evenly spread over the range. These data demonstrate that the diagnostic approach can more effectively detect and analyze fungal infections, resulting in improved dog skin care recommendations.

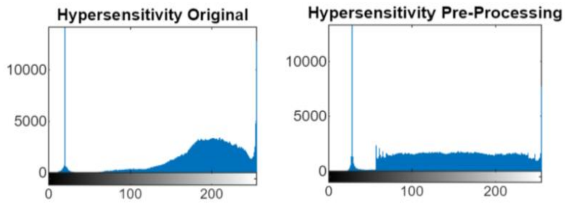

Figure 4. Histogram Hypersensitivity Before and After Pre-Processing

Figure 4, after applying the pre-processing technique to the hypersensitive dog skin pictures, the histogram indicates that the frequency on the Y-axis remains constant at 10,000 both before and after processing. The histogram after pre-processing shows a more uniform distribution of intensity, but the frequency value remains constant. The change in the distribution of the histogram, even though the frequency values remain the same, shows that the pixel intensities are now more evenly distributed. This indicates that the image has more contrast and detail. These improvements help the diagnostic system find and analyze dog skin hypersensitivity more accurately, which allows for more accurate diagnosis and better treatment decisions.

In picture pre-processing, histogram equalization is used to flatten the pixel intensity distribution, increase contrast, and highlight significant details in photos of animal skin diseases. This method improves image quality simply and effectively, as evidenced by the evenly distributed histogram after pre-processing. In comparison to other deep learning systems, such as CNNs (convolutional neural networks), this method has limitations. Deep learning removes vital aspects from data, including low-quality photos, and can learn from complex data to identify deeper patterns. Deep learning yields higher-quality results, particularly in classification, but it requires more data and computational resources. Histogram equalization improves visibility, while deep learning enhances automated detection.

3.3. Enhancement

MATLAB uses a range of enhancement techniques to improve image quality while detecting canine skin problems. This enhances diagnosis accuracy for bacterial, fungal, and hypersensitivity infections. Enhancement is essential to highlight critical features such as textures, lesions, or edges that may be concealed by noise or poor contrast. This technique uses a Gaussian filter to smooth the image while keeping edge information and reducing high-frequency noise. This filter's isotropic nature makes it exceptionally effective at reducing noise while keeping key features. The improved image quality allows for more accurate and effective diagnosis through the use of boosting techniques and Gaussian filters.

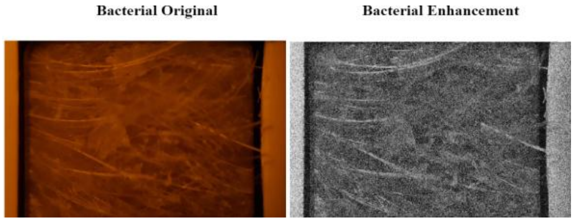

Figure 5. Bacterial Before and After Enhancement

Figure 5, the results of applying the enhancement approach to images of canine skin bacterial lesions show that the image quality has improved significantly. A Gaussian filter enhances the visibility of details such as lesion borders and skin texture. Furthermore, it reduces high-frequency noise, which might interfere with identification. This method improves the detection of bacterial lesions, which can be difficult to diagnose. These findings have significant implications for the development of image-based diagnostic systems, as crisper images enable the system to detect and classify canine skin problems. This increases diagnostic accuracy, shortens examination and treatment times, eliminates misdiagnoses, and enables more effective therapies.

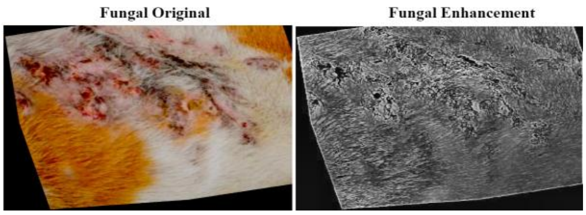

Figure 6. Fungal Before and After Enhancement

Figure 6, illustrates how applying enhancement techniques to an image of a fungal lesion on a dog's skin can greatly increase awareness of key aspects. After applying a Gaussian filter, the changes in skin texture and fungal infections become more visible than in the original image, which looks to be hidden or distorted by sound. This approach identifies lesion boundaries and clarifies the polluted region. Skin problems in dogs are now more easily diagnosed thanks to improved visual capacities. Better image quality reduces the probability of misdiagnosis. These findings demonstrate that improved methodologies are required to make more efficient and effective clinical decisions when developing image-based diagnostic systems.

Figure 7, shows the significant visual improvement obtained by applying the enhancement method to the dog skin hypersensitivity lesion image. Using a Gaussian filter makes previously obscured or fuzzy details, such as inflammation, lesion boundaries, and skin texture, more evident. The image before restoration has a higher contrast, making it simpler to spot the damaged area. This visual improvement significantly aids in the detection of hypersensitivity illnesses, which are notoriously difficult to identify. Image-based diagnostic techniques use more precise and clear images, allowing them to identify canine skin disorders more quickly and reliably. These findings suggest that improvement strategies can help to develop a more efficient diagnostic system, reduce misdiagnoses, and accelerate clinical decision-making.

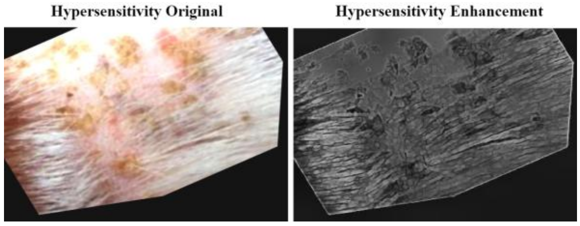

Figure 7. Hypersensitivity Before and After Enhancement

To increase image quality for canine skin disease diagnostics, MATLAB enhancement methods rely on traditional image processing techniques such as Gaussian filters. These techniques work well for clarifying visual features like lesion borders and textures, but they require manual tweaking. In contrast, deep learning-based techniques, often known as deep learning, can do automatic detection without requiring considerable pre-processing. Deep learning techniques typically provide higher-quality images by detecting more complex and adaptive features. While typical improvement approaches are simpler and faster to implement, they necessitate a considerable amount of training data and processing power.

3.4. Convolution

Image quality optimization for dog skin disease diagnosis with MATLAB employs the Sobel operator convolution approach. The convolution technique extracts features such as boundaries or contours, which are useful for identifying disease-affected areas. The Sobel operator was chosen for its ability to produce clean and clear results using pixel intensity gradients in both horizontal and vertical directions. Sobel surpasses other solutions because it detects tiny intensity variations, which is critical when determining skin texture. This technique improves image-based diagnosis accuracy by making it easier to identify essential characteristics of skin disorders.

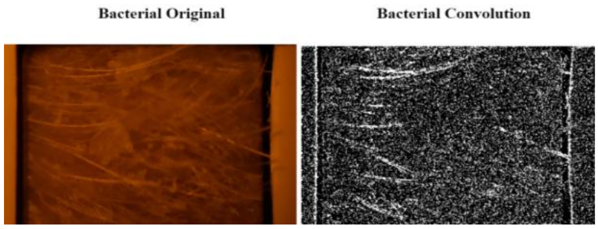

Figure 8. Bacterial Before and After Convolution

Figure 8, the results of using the convolution technique using the Sobel operator on the bacterial images show that the edge clarity and texture details of the infected dog skin are significantly improved. The images after convolution showed clearer and sharper contours, which made it easier to identify lesions and affected areas.

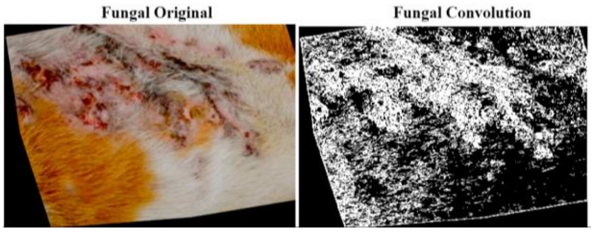

Figure 9. Fungal Before and After Convolution

Figure 9, the application of the convolution method with the Sobel operator on fungi images reveals that the specifics of the infection on the dog's skin become more evident and distinct. Convolution defines the margins of fungal lesions, increasing the contrast between the infection and the surrounding tissue and facilitating the detection and investigation of previously difficult-to-see infections. This method is effective for enhancing the visibility of fungal infection patterns in the original photograph. Convolution in image-based diagnostic systems can improve the visibility of fungal infections, allowing for more precise evaluation and monitoring of canine skin diseases.

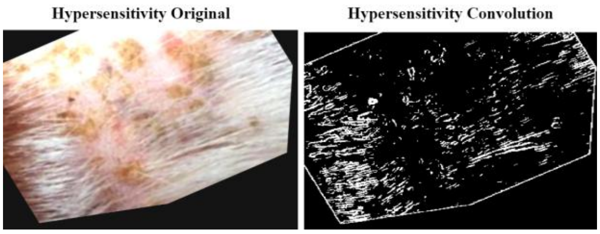

Figure 10. Hypersensitivity Before and After Convolution

Figure 10, the use of a convolution technique with the Sobel operator on hypersensitivity images demonstrates that the complexity of skin lesions in dogs becomes more visible and distinct. Convolution highlights the borders and patterns associated with hypersensitive dermatitis, increasing contrast and making it simpler to detect the affected area. The improved visibility of lesions enables more effective and timely evaluation. The use of convolution in image-based diagnostic systems has the potential to increase visualization quality, assist veterinarians in accurately diagnosing and assessing hypersensitive dermatitis, and improve treatment and monitoring of canine skin illnesses.

The strategy of using MATLAB enhancing techniques to dog skin pictures, such as convolution and contrast enhancement, intends to increase lesion detail visualization. Unlike deep learning-based methods, which employ neural networks to automatically find and classify elements in images, enhancement techniques focus on increasing image quality before further analysis. Deep learning-based methods give high accuracy through models learned with vast amounts of data, whereas enhancement techniques improve image readability and detail without requiring complex data training, making them ideal for applications with minimal resources.

4. Conclusion

Image processing techniques such as enlargement, pre-processing, enhancement, and convolution are critical for detecting and analyzing dog skin illnesses. Enlargement of picture details allows for more accurate lesion identification. Furthermore, histogram pre-processing enhances contrast and distinguishes between healthy and diseased tissue. Then, image enhancement improves visibility for better detection and shows lesion boundaries. After that, convolution improves sharpness and pattern detection, helping the system differentiate bacterial, fungal, and hypersensitivity infections. Overall, this technique uses MATLAB to enhance the quality of images in the processing of dog skin disease datasets.

More accurate diagnosis of dog skin diseases can speed up treatment and improve prognosis in several ways. A more accurate diagnosis allows for the early recognition of the right disease, such as a bacterial infection, fungus, or hypersensitivity dermatitis. This allows veterinarians to choose a more specialized and successful treatment, which reduces the time it takes to find the right treatment. Appropriate and early therapy increases the efficacy of the healing process, minimizes the risk of complications, and improves the quality of life and overall well-being of canine patients. When image quality is enhanced with MATLAB, diagnostic accuracy improves dramatically.

One of the limitations of image processing techniques in everyday clinical practice is the need for specialized hardware and skills that are not always available in all clinics. Furthermore, the uncertainty of relatively long processing periods and initial image quality may limit their application in real-time. Imaging flaws have the potential to undermine diagnostic consistency.

In the future, deep learning could be utilized to improve disease classification automation and accuracy. The expanded ability of deep learning algorithms to explore and find complicated patterns allows for faster and more accurate diagnosis.

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