DETECTION OF LYME DISEASE RASHES USING DEEP LEARNING-BASED APPROACH

BY

MD. SAD ADNAN
ID: 213-25-054

This report was submitted partially satisfying the requirements for a master's degree in computer science and engineering.

Supervised By

Dr. Md Zahid Hasan
Associate Professor
Department of CSE
Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY

DHAKA, BANGLADESH

SEPTEMBER 2022

APPROVAL

This thesis/internship titled "**DETECTION OF LYME DISEASE RASHES USING DEEP LEARNING-BASED APPROACH**", submitted by MD. Sad Adnan, ID No: 213-25-054 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 21st September 2022.

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City University

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I hereby declare that, this project has been done by me under the supervision of **Dr**. **Md. Zahid Hasan, Associate professor, Department of CSE,** Daffodil International University. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

Supervised by:

Dr. Md. Zahid Hasan
Associate Professor
Department of CSE
Daffodil International University

Submitted by:

MD. Sad Adnan
ID: 213-25-054
Department of CSE
Daffodil International University

ACKNOWLEDGEMENT

First I express my heartiest thanks and gratefulness to ALMIGHTY ALLAH for His divine blessing which makes me possible to complete the final year thesis successfully.

I really grateful and wish my profound indebtedness to Dr. **Md. Zahid Hasan**, **Associate professor**, Department of CSE, Daffodil International University, Dhaka, deep knowledge & keen interest of my supervisor in the field of Machine Learning to carry out this project. His endless patience, scholarly guidance ,continual encouragement , constant and energetic supervision, constructive criticism , valuable advice ,reading many inferior draft and correcting them at all stage have made it possible to complete this project.

I would like to express my heartiest gratitude to **Dr. Touhid Bhuiyan**, Head**,** Department of CSE, for his kind help to finish our thesis and also to other faculty members and the staffs of CSE department of Daffodil International University.

Finally, I must acknowledge with due respect the constant support and patients of my parents.

ABSTRACT

Lyme disease is the maximum not unusual place vector-borne disease with inside the United States. Lyme disease is resulting from the bacterium Borrelia burgdorferi and, rarely, the bacterium Borrelia mayonii. It is transmitted to human beings via way of means of the bites of an inflamed black flea. Typical signs encompass fever, headache, fatigue, and the feature pores and skin rash referred to as migraine. If left untreated, the contamination can unfold to the joints, heart, and nerve system. Lyme disease is recognized primarily based totally on signs, bodily signs (including a rash), and contacts to inflamed ticks. Lab exams are beneficial whilst used successfully and accomplished in a confirmed way. Most instances of Lyme disease may be effectively dealt with antibiotics inside some weeks. Prevention of Lyme disease consists of the usage of insect repellents, instantaneously elimination of ticks, insecticide spraying, and eliminating of tick habitat. Ticks that transmit Lyme disease can also from time to time transmit different tick-borne diseases.

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CHAPTER 1
Introduction

1.1 Introduction

Lyme disease, also known as Lyme borreliosis, is a vector-borne disease. It is caused by the bacterium Borrelia, which is transmitted through airborne droplets of the flea genus. Migration. The most common sign of infection is a red, swollen rash. Erythema migratory (erythema migratory) at the site of the flea bite about a week. The rash is usually no longer itchy or painful. Eruptions it occurs in about 70-80% of people infected. Early prognosis can be difficult. Other Early signs of symptoms may also include fever, headache, and fatigue. Symptoms may include an inability to support the joints, any or all parts of the face. Severe headache with pain, stiff neck, or palpitations. Month or Years of joint pain and swelling may return. There may be pain or tingling at times hands and feet in the plane. About 10 to 20% despite appropriate treatment People had joint pain, memory problems, and fatigue for at least six months. Green lemon the disease is transmitted to humans by the bite of an infected tick. Genus Exudes.The tick of interest in the United States is usually the Ixodes phylum. It is present on the shoulder blades and must persist for at least 36 hours for the bacteria to spread.

In Europe, the tick species Ixodes ricinus can spread bacteria more quickly. in theb north In the United States, the bacteria Borrelia burgdorferi and B. mayonii causes Lyme disease. in Europe and from Asia, Borrelia afzelii, Borrelia garinii, B. spielmanii and 4 others. It causes illness. The disease does not appear to be transmitted from person to person. animals or food. Diagnosis is based on a combination of symptoms and medical history.

It comes into contact with the tick and tests your blood for specific antibodies. Blood tests are often negative in the early stages of the disease. Check every tick usually not required. Avoid this by wearing clothing that covers your hands and feet.
Avoid tick bites with DEET repellent or picaridin. use pesticides Reducing the

Number of ticks can also be effective. Ticks can be eliminated by: tweezers. If the removed tick is full of blood, a dose of doxycycline it prevents infection, but is generally not recommended because infections are rare. Much Antibiotics, including doxycycline, amoxicillin, and cefuroxime Develop an infection. Standard treatment usually lasts 2-3 weeks. Some people after treatment, you may experience fever, muscle aches, and joint pain, which may last for 1-2 days. It has been shown that patients do not need long-term antibiotic treatment. Persistent symptoms. Lyme disease is the most common tick-borne disease in our country. Northern Hemisphere. It is estimated at 476,000 people per year. More than 200,000 people are diagnosed and treated in the United States and Western Europe. Infections most commonly occur in the spring and early summer. Lyme disease was first diagnosed as a separate disease in Lyme, Connecticut, in 1975. It is confused with juvenile rheumatoid arthritis. This bacterium was described for the first time. 1981 Willie Bergdorfer Good symptoms after chronic treatment It was recorded and called Lyme disease syndrome (PTLDS) after treatment. PTLDS is distinct from chronic Lyme disease, which is no longer maintained. Scientists use it in different ways by different groups. some health care providers Although it has been suggested that PTLDS is caused by persistent infection, Even after standard treatment, persistent signs of infection were found. Research is ongoing, but there is currently no vaccine for Lyme disease. Everyone. Several vaccines are available to prevent Lyme disease in dogs...

1.2 Problem Statement

Lyme disease additionally called the "Silent Epidemic" may be very a great deal malfunded and it influences greater than 300,000 humans every year. It is estimated that about 476,000 people each year in the United States and more than 200,000 in Western Europe are diagnosed and treated. Symptoms after chronic treatment have been well documented and are referred to as posttreatment Lyme disease syndrome (PTLDS)

Lyme disease is as a result of the bacterium Borrelia burgdorferi and rarely, Borrelia mayonii. It is transmitted to human beings thru the chew of inflamed blacklegged

ticks. Typical signs and symptoms consist of fever, headache, fatigue, and a feature pores and skin rash known as erythema migrants.

In this thesis I have tried to detect this disease by image of rash and Using Machine learning techniques.

1.3 Research Objectives

a) Consider the shortcomings of a purely visual structural study of a superbly effective Lyme disease detection device.

b) Practice skills based purely on the fidelity of the system vision to increase the accuracy of the throw and maintain the clarity.

1.4 Research Questions

a) a) With just an idea of a structure capable of successfully detecting spatial cases of Lyme disease, how can a control system not be identified?
b) b) How can the system view method be improved to increase the accuracy of successfully distinguishing between types and instances?

1.5 Report Layout

Chapter 1 Introduces to the study, the purpose of the study, and the main questions.

Chapter 2 reviews the relevant literature in depth.

Chapter 3 Let me explain the recommended method.

Chapter 4 describes my assessment of the end result and compare it with my current work.

Chapter 5 Research completed the study of the influence of fate.

CHAPTER 2

Literature review

2.1 Related work

Previously a number of researcher's have used different algorithms and techniques for the detection of Lyme disease but unfortunately, they are not very good at detecting this disease in real life due to different background noises by people which is big challenge in this project.

Among the researchers Dmytro Chumachenko et.al [1] on their work used a multilayered neural network and found that the prediction error was calculated at 3.8% although due to current war ongoing on Ukraine they were unable to do field research correctly and used an automated approach, so in field or real world the accuracy could drop drastically.

Most skin cancers today are considered the deadliest form of cancer found in humans. Most skin cancers are identified into several categories, including melanoma, basal cell carcinoma, and squamous cell carcinoma, of which melanoma Unpredictable peaks. Early detection of most melanomas can help with treatment. It may play an important role in medical imaging, and this has been demonstrated in many modern systems.

We propose a computerized approach to the detection of skin melanoma using imaging equipment. An image of the skin lesion is put into the camera and then analyzed using a new image processing method. It puts an end to pores and most skin cancers. Imaging equipment examination for lesion evaluation of multiple malignancies Evaluate texture, length and shape for shooting to evaluate parameters such as asymmetry, contour, color, diameter (ABCD), etc. Segment and Characteristic Steps. The extracted feature parameters are used to classify the image into normal skin and skin with pores. Melanoma is the most cancerous lesion. [2]

Automated methods have been improved to capture images with a single device, preferably a traditional virtual camera, to distinguish between benign and malignant pigmented skin lesions. This study presents a completely new method for the detection of malignancies in benign pigmented lesions using macroscopic imaging. Images are captured with a conventional virtual camera with a spatial resolution of more than 1 megapixel and use natural thinking and unique situations in specific viewing periods. [3]

2.2 Scope of the Problem

Diagnosis can be difficult because many of the signs and symptoms of Lyme disease are often found in other conditions. Ticks that transmit Lyme disease can also spread other diseases.

If you don't have a Lyme disease-related rash, your doctor may ask about your medical history and conduct a physical exam, especially if you've been out in the summer when Lyme disease is common.

Enzyme immunoassay (ELISA), the most common test used to detect Lyme disease, detects antibodies against B. burgdorferi. However, it should not be used as the sole basis for establishing a diagnosis, as it can sometimes lead to false-positive results.
Although this test may not be positive in the early stages of Lyme disease, the rash is clear enough to warrant diagnosis without further testing in people living in areas where fleas are common. carry Lyme disease.

Western blot test. If the ELISA test is positive, this test is usually done to confirm the diagnosis. In this two-step approach, western blots were used for several B. burgdorferi proteins

We use machine learning to identify Lyme disease as accurately as possible from rash images.

2.3 Challenges

There are several problems with this study found, which are following:

a) **Data collection:** There is no reference dataset for classification on the Internet. There was a dataset online but had very low-quality data with a lot of irrelevant data, I had to optimize this dataset.

b) **Raw Image Processing**: Collected Images were not up to the mark and had different quality I had to optimize all the image for them to be in good quality so that my model could be trained on them.

c) **Select Machine Learning Approach**: This is very important step to select approach for my model training, I had to go through different approaches which are present and determine if they will be suitable for my work and then apply them to my work if they are.

d) **Accuracy Improvement:** I had to improve the accuracy of the models and try to find a balance of optimal model.

CHAPTER 3

Materials and methods

3.1 Working Process

There are 5 stages to complete the whole mission. Here is the next part:

a) Collect prepared images and datasets
b) Image preprocessing
c) Apply machine learning algorithms
d) Diagnosis of Lyme disease
e) Analyze the results

The entire workflow, from image acquisition to image analysis, is shown in Figure 1 and detailed in the next section.

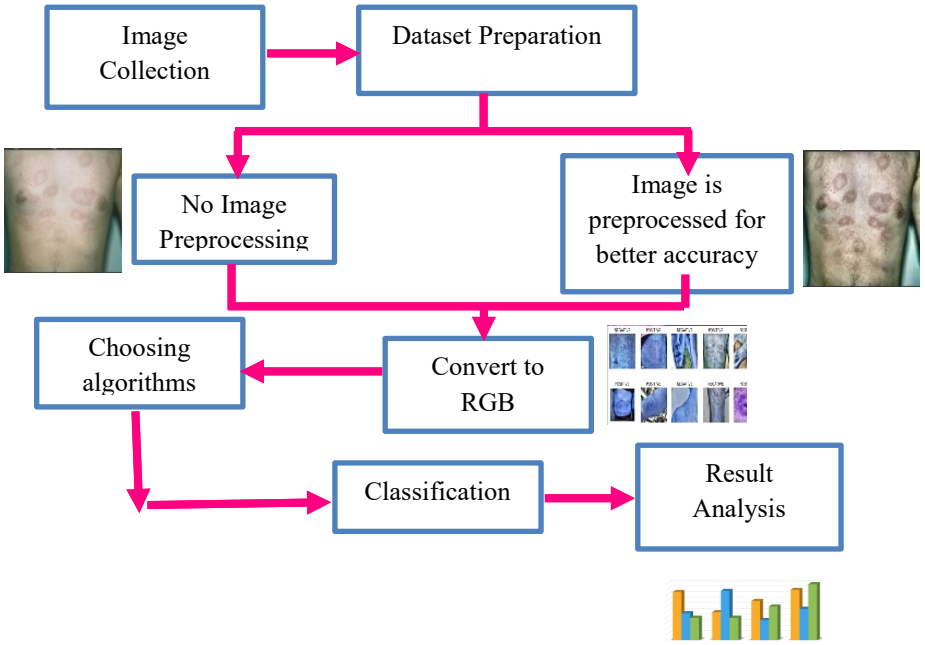

Figure 1: Recommended Model Workflow

3.2 Dataset Preparation

After we collected the dataset we prepared the dataset for training, as this is a very important phase of the research our steps were careful, we saw that the data were different in nature and can be useful and is of various body parts, we than classified the dataset and distributed them to their respective classes.

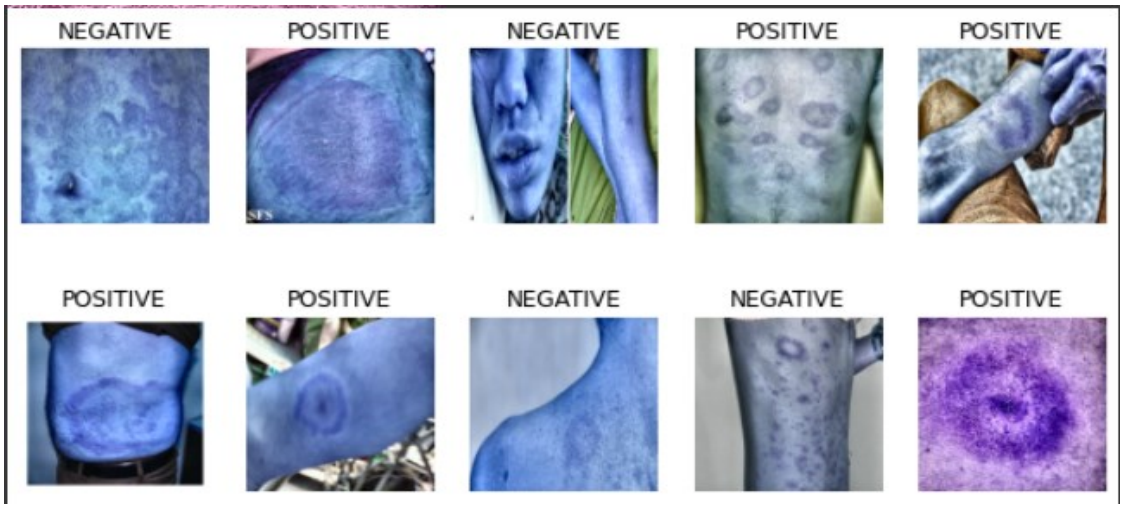

Figure 2: Lyme disease Detection Result

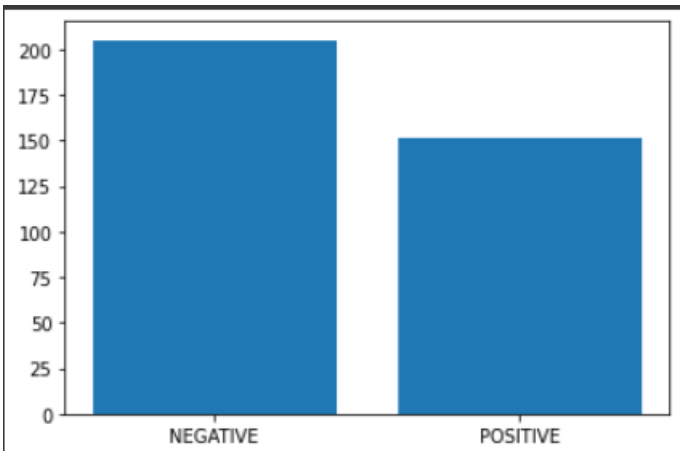

Figure 3: Total Image Data

Of the very few images collected, some of the images did not match in size and color, and some were noisy. Image quality has been improved using the contrast-enhancing CLAHE method. Training a model requires a large amount of data, but the collected data is not sufficient. Therefore, there is an overfitting problem and various data augmentation techniques such as rotation, translation, scaling and cropping are applied to solve this problem.

3.3 Image Pre-processing

Preprocessing is a phenomenon taken into account in minimally reflective photography, where the input and output are equal penetration images.

Image data processing is one of the least studied issues in the data science community. Each developer has their own way of doing things. Some of the tools and frameworks used for image preprocessing include Python, Pytorch, OpenCV, Keras, Tensorflow, and Pillow. [4]

When building a machine learning/computer vision project, you always need data. In this case, image data. Unfortunately, some problems with image data include complexity, inaccuracies, and mismatches. That's why it's important to pre-process (clean and properly format) your data to get the desired results before creating a computer vision model. [6]

The identification information collected through the sensor containing the dominant image is usually obtained by the values of the characteristics of the image matrix (brightness) represented using the output images. Improve image information beyond

distortion by expanding more or less important image features for additional processing. Although mathematical adjustments of the image (e.g. rotate, scale, translate) are taken into account among the preprocessing strategies, the comparison strategies still apply here.

3.3.1 Image Enhancement Technique

Contrast is improved by the histogram equalization method also known as grayscale conversion. This method allows for a consistent distribution of penetration steps across the entire penetration measurement. Adjusting the histogram can give you worse results than the first frame because the histograms in the next frame are nearly identical. Large peaks in the histogram can be caused by faint areas. Therefore, histogram balancing can introduce unwanted image noise. This means that it does not adapt to the building compared to its neighbors. Small differential contrast can be completely lost if the number of reduced pixels in a particular dark area is usually small. [5] In this strategy, the image is segmented into image parts or rectangles, and histogram equalization is performed on the individual image parts or rectangles. In this case, artifact interference between adjacent blocks is limited to bilinear separations or discontinuities.

3.3.2 Contrast Limited Adaptive Histogram Equalization

To solve the problem of noise across clip boundaries we used The CLAHE method. Before calculating the cumulative distribution function (CDF), the histogram is truncated as much as possible to improve it to predefined values. CLAHE precomputes the CDF and extracts the histogram with predefined values to limit the gain. This limits the slope of the CDF and thus limits the transform function. The clipping limit, or value to which the histogram is clipped, is determined by normalizing the histogram and thus the size of the neighborhoods. CLAHE uses two important factors: block size and clip boundaries. These two parameters determine the quality of the image. Figure 5 shows the application of the CLAHE method with a

threshold of 0.1 and a block size of 8X8 after converting a low-contrast user-captured image from BGR to grayscale.

(a) **(b)** **(c)**

Figure 4: (a) Low contrast original image (b) Grayscale BGR image and (c) CLAHE contrast enhancement method applied (CL = 0.1, BS = 8x8)

3.4 Convolutional Neural Network

A convolutional neural network is a special type of artificial neural network that uses a math operation called convolution instead of the usual matrix multiplication in one or more layers. It is specially designed to process pixel data and is used for image recognition and processing. CNN is a normalized version of a multilayer perceptron. Multilayer perceptron usually refers to a fully connected network. In other words, each neuron in one layer connects to all the neurons in the next layer. The "everything connected" of these networks makes them vulnerable to data overfitting. Common methods to control or prevent overeating are to penalize training stats (e.g. weight loss) or disconnect them (disconnect, reset, etc.). CNN takes a different approach to regularization. CNNs take advantage of increasingly complex model sets by using hierarchical data models and smaller, simpler samples squeezed into sets. their filter.

So in terms of size and complexity, CNN connections come in last. [8]

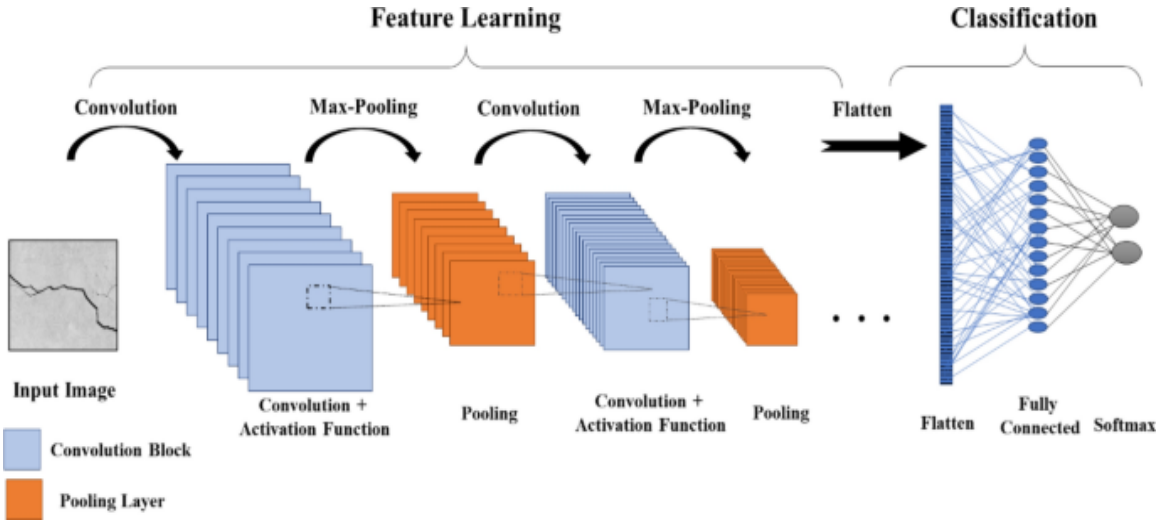

Figure 5: Transformational Neural Network Architecture.

3.4.1 Convolutional Layer

As mentioned in the footnote, composite classes play an important role in the way CNNs work. The class limit depends on the usage of the training core. These kernels are usually small, but depend on the total size of the input. This layer transforms each tape spatially of the input data to provide an accurate 2D current map as the data overwrites the tape. When the input is repeated, the kernel completes the computation of the cost-dependent scalar artifacts. When an object other than a cyberspace object is seen, the core experience community is the "flame", which can be collectively referred to as the trigger. Each kernel has the same activation graph, the purpose of which is to determine the complexity of generating a set of output convolutional layer sizes. Composite classes are capable of extending their output, greatly reducing the complexity of their prototypes. It runs through three hyper parameters: Intensity, Step Length, and Zero Damping. It is practically possible to modulate the intensity of the output length distributed in a complex layer with a large number of neurons for the layer at the same input location. It is also available to represent the step required to locate an open field by specifying the magnitude in the spatial dimension of the input. For example, if you set your stride to 1, then you can do an actively triggered response training with a large number of triggers. In addition, finding steps in the direction of a higher quota reduces the amount of overlap associated with producing

smaller spatially sized outputs. Besides the powerful way to further control the size of the output dimension, no padding is taken into account because of the easy way to buffer the input bounds. These methods help to control the spatial size of the convolutional layer output. for this calculation we have used The following equation:

$$\frac{(V-R)+2Z}{S+1} \qquad (1)$$

Here, V stands for e, and enter the length of the number, including height × width × depth, R and Z indicate the comfortable training length, and the number of 0s is entered separately. S means no. If the predicted final result of this equation is not an integer value, the previous step is corrected because the neuron can no longer correctly recover from the pre-sorted input.

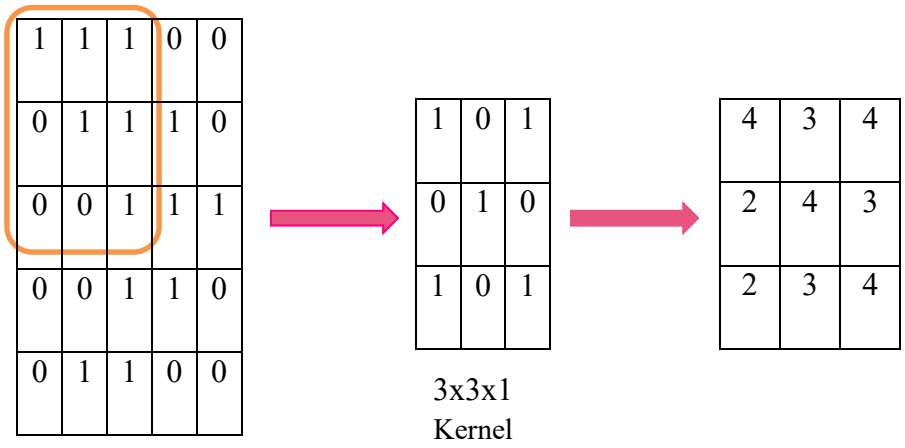

Figure 6: A 5x5x1 image that is reduced to a 3x3x1 multiplier becomes a 3x3x1 reduced element.

3.5 Transfer Learning

a machine learning technique known as Transfer learning which mainly uses knowledge gained from existing prototypes to solve problems and reuses them as previous facts to solve problems. Diverse topics. Deeply integrated neural network models can take days or even weeks to train on very large data sets. One way to

shorten this process is to reuse model weights from pre-trained models that have been developed for standard computer vision reference datasets, such as recognition tasks. ImageNet image. The best performing models can be downloaded and used directly or incorporated into a new model for your own computer vision problems. [7]

3.5.1 VGG16

There are two models of VGG: VGG-16 and VGG-19. In this Research, we have used VGG-16 to classify our dataset. VGG-16 is mainly composed of three parts: convolution layer, Pooling and fully connected layer.

Convolutional layer: This layer applies filters to extract features from the image. The most important parameters are the size and height of the core.

Pooling Layer: Its function is to reduce the size of the space to reduce the number of parameters and computations in the network.

Fully Connected: A complete connection is a connection that is completely connected to the previous layer, as in a simple neural network. This figure shows the architecture of the model.

3.5.2 Resnet50

ResNet-50 is a 50-layer convolutional neural network (48 convolutional layers and 1 MaxPool layer and 1 middle group). Residual Neural Network (ResNet) is an artificial neural network (ANN) that forms a network by stacking blocks on top of each other.

You can download pre-trained versions of the network trained on over a million images from the ImageNet database. A pre-trained network can classify images into 1000 types of objects, such as keyboards, mice, pencils, and many animals. The network input image size is 224 x 224.

3.5.3 InceptionV3

Inception v3 is a deep complex neural network trained to classify single label images from the ImageNet dataset.

The original v3 template released in 2015, has a total of 42 classes and has a lower error rate than its predecessor. Let's see if the various optimizations improve the original V3 model.

Major fixes for Inception V3 style:

a) Subdivide into many smaller rings
b) Spatial factorization in asymmetric convolution
c) The usefulness of the auxiliary classifier
d) Effective network reduction

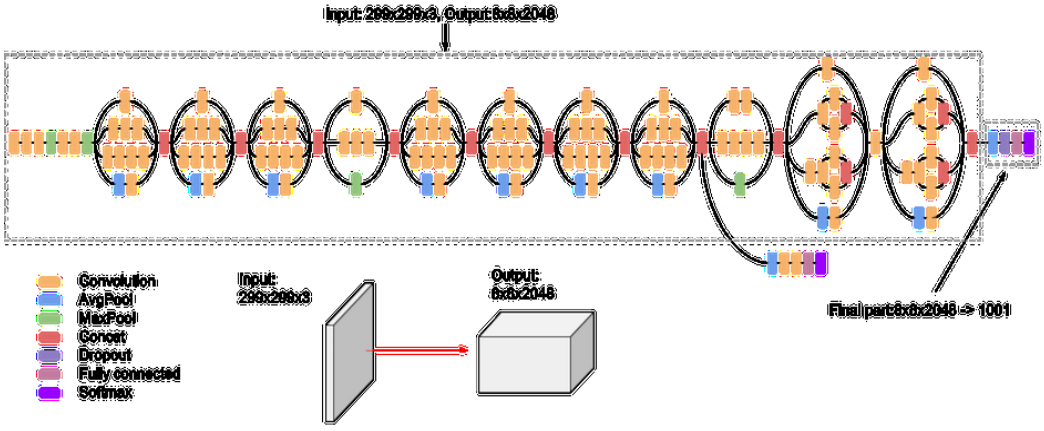

Figure 7: Diagram of InceptionV3

3.6 Training and Testing

Initially, the data set is divided into two parts, such as training and testing datasets. This data set partitioning method is performed randomly when the training set consists of about 356 images, of which 81.64% is used to train the model and the

remaining 18.36% is used for training. model training. Official form. The same test was performed once with the raw image and once with the contrast enhanced image.

All models are trained using transfer learning

All models are trained using transfer learning using categorical cross-entropy as the loss function as shown in equation (1). The learning rate is set to 0.001, using categorical cross-entropy as the loss function as shown in equation (1). The learning rate is set to 0.001,

$$L_{CE} = -\sum_{i=1}^{n} t_i \log(p_i) \tag{2}$$

With the Adam optimizer, SoftMax is used as the activation function for all the architectures shown in equation (2).

$$f_i(\overrightarrow{a}) = \frac{e^{a_i}}{\sum_k e^{a_k}} \tag{3}$$

The entire test procedure is shown in Figure 1. The complete test is performed on Windows operating system with 64-bit, Intel Core i7-1065G7 processor with RAM of 16GB and hard disk of 512GB SSD with Python programming. The language of the Google Colab environment.

CHAPTER 4

Experimental Results and Discussion

4.1 Results and Discussion

In this test, we evaluated several robust CNN architectures for the detection of Lyme disease using transfer learning. Initially, the experiments were performed using raw images, but the results turned out to be unacceptable. The raw image is then replaced with an image with increased contrast, with surprising results. Vgg16, Resnet50 and InceptionV3 are some of the main CNN architectures used in this test. Out of this CNN architectures, VGG16 shows the best accuracy of 95.78% while using upgraded dataset using contrast enhancement technique where InceptionV3, Resnet50 and CNN achieved 77%, 92% and 78%(Figure 11) respectively.

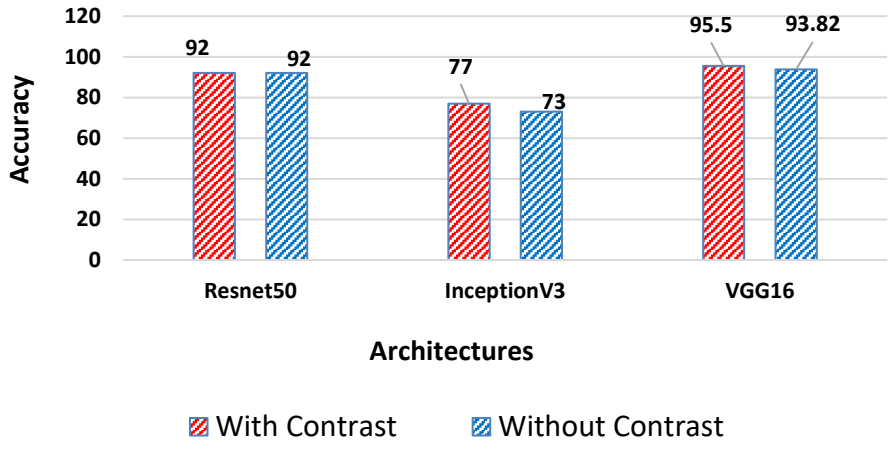

Figure 8: Check the correctness of different transfer learning architectures

The confusion matrix (Table I) allows to evaluate the possibility of testing an infinite number of models. The values of true positive, true negative, false positive and false negative are found in the confusion matrix. Values are placed diagonally in the correlation table to evaluate the accuracy of the model's predictions. Accuracy, sensitivity, recall, accuracy and F1 scores were calculated based on the misclassification table using the following formulas (3-6).

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \quad (4)$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \quad (5)$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} \quad (6)$$

$$\text{F1 Score} = 2 \times \frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}} \quad (7)$$

Raw images and contrast-enhanced images are shown in Tables II and III, respectively. Considering the raw and high-contrast images, all performance metrics such as accuracy, sensitivity, memory, precision, and F1 scores are calculated for each architecture. extensive training. Table II shows that VGG16 outperforms the other two CNN architectures using raw images. On the other hand, Table III shows that InceptionV3 achieves the best accuracy among the remaining two CNN architectures when using high contrast images

TABLE I. CONFUSION MATRIX OF CNN ARCHITECTURES USING CONTRAST-ENHANCED IMAGE

Architectures	Predicted ➡ / Actual ⬇	POSITIVE	NEGATIVE
VGG16	POSITIVE	140	11
	NEGATIVE	5	200
	Predicted ➡ / Actual ⬇	POSITIVE	NEGATIVE
InceptionV3	POSITIVE	133	18
	NEGATIVE	10	195
	Predicted ➡ / Actual ⬇	POSITIVE	NEGATIVE
Resnet50	POSITIVE	105	46
	NEGATIVE	36	169

TABLE II. PERFORMANCE MATRICES OF CNN ARCHITECTURES USING RAW IMAGE

Architectures	Accuracy (avg)	Precision (avg)	Recall (avg)	F-1 (avg)	score
InceptionV3	0.73	0.75	0.73	0.73	
Resnet50	0.92	0.92	0.92	0.92	
VGG16	0.94	0.94	0.94	0.94	

TABLE III. PERFORMANCE MATRICES OF CNN ARCHITECTURES USING CONTRAST-ENHANCED IMAGE

Architectures	Accuracy (avg)	Precision (avg)	Recall (avg)	F-1 (avg)	score
InceptionV3	0.77	0.77	0.77	0.77	
Resnet50	0.92	0.92	0.92	0.92	
VGG16	0.96	0.96	0.96	0.95	

CHAPTER 5
Conclusion and Future Work

5.1 Conclusion

This proposed approach achieved the highest accuracy in detecting Lyme disease in wobbly images using different CNN architectures such as InceptionV3, Resnet50 and VGG16. To reduce the amount of redundant data in the dataset, we extracted multiple attributes from different images. Subsequently, contrast enhancement (CLAHE) was used to improve the accuracy of the study. In the end, VGG16 performed better with 95.78% accuracy than InceptionV3 and Resnet50. Since every effort has been made to accurately detect Lyme disease in this experiment, our future goal is to increase the volume of images in our dataset and we will use multiple images. to improve the accuracy of this task.

5.2 Future Work

More precise and powerful models will be developed to improve the accuracy of the Lyme disease detection system. Likewise, a smartphone app will then be created that will detect Lyme disease and display the disease data to the user. This application will greatly contribute to the early and convenient detection of this disease and the protection of people from its harmful effects.

REFERENCES

[1] D. Chumachenko, P. Piletskiy, M. Sukhorukova and T. Chumachenko, "Predictive Model of Lyme Disease Epidemic Process Using Machine Learning Approach", *Applied Sciences*, vol. 12, no. 9, p. 4282, 2022. Available: 10.3390/app12094282.

[2] Hiam Alquran, Isam Abu Qasmieh, Ali Mohammad Alqudah, SajidahAlhammouri, EsraaAlawneh,Ammar Abughazaleh, FirasHasayen, "The Melanoma Skin Cancer Detection and Classification using Support Vector Machine", IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT), 2017.

[3] Maryam Ramezani, Alireza Karimian, and Payman Moallem," Automatic Detection of Malignant Melanoma using Macroscopic Images", J Med Signals Sens 4(4), 2014.

[4] "Getting Started with Image Preprocessing in Python", *Engineering Education (EngEd) Program | Section*, 2022. [Online]. Available: https://www.section.io/engineering-education/image-preprocessing-in-python. [Accessed: 19- Sep- 2022].

[5] "A Tutorial to Histogram Equalization", *Medium*, 2022. [Online]. Available: https://medium.com/@kyawsawhtoon/a-tutorial-to-histogram-equalization-497600f270e2. [Accessed: 19- Sep- 2022].

[6] "Why should I do pre-processing and augmentation on my computer vision datasets?", *Roboflow Blog*, 2022. [Online]. Available: https://blog.roboflow.com/why-preprocess-augment/#:~:text=Image%20preprocessing%20are%20the%20steps,%2C%20orienting%2C%20and%20color%20corrections. [Accessed: 19- Sep- 2022].

[7] "Transfer Learning in Keras with Computer Vision Models", *https://machinelearningmastery.com/how-to-use-transfer-learning-when-developing-convolutional-neural-network-models/*, 2019. [Online]. Available: https://machinelearningmastery.com/how-to-use-transfer-learning-when-developing-convolutional-neural-network-models/. [Accessed: 19- Sep- 2022].

[8] "Convolutional neural network - Wikipedia", *En.wikipedia.org*, 2022. [Online]. Available: https://en.wikipedia.org/wiki/Convolutional_neural_network. [Accessed: 19- Sep- 2022].

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