Image Classification on Bacteria Dataset by Deep Learning Model

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Abstract - This work presents the concept of image dataset classification using CNN and proposed deep learning method. It uses the dataset of bacteria for classification purpose. The CNN and DBN system has a problem with accuracy, then proposed method is used for improving the system. The use of PCA method provides only identification of features in images but it does not help to improve accuracy of system. Due to this, it requires better deep learning method for improving accuracy of system. The CNN method uses only 2 convolutional layers for feature mapping. But the proposed method uses 5 convolutional layers and 3 overlapping layers. Due to this, it helps to improve accuracy of system as compared to other existing methods. In CNN, the layers based approach is main part in this system and convolutional layer is the first layer, then follows the hidden layer and output layer. This shows that proposed AlexNet shows better improvement in accuracy of datasets as compared to other methods and hence proves better.

Keywords: *Image Processing, Machine Learning, Deep learning, Bacteria classification, MATLAB etc.*

I. INTRODUCTION

Acquisition of images and image interpretation are necessary for accurate disease diagnosis. Recently, image acquisition technology has advanced significantly, allowing us to obtain radiological pictures (such as X-rays, CT scans, and MRI images, among others) with much greater resolution. We are only now beginning to reap the rewards of automated picture interpretation. Computer vision is one of the best applications for machine learning, although typical machine learning methods for picture interpretation mainly rely on expert-crafted features, for example, lung tumour identification necessitates the extraction of structure characteristics. Traditional learning approaches are unreliable due to the substantial diversity in patient-to-patient data. Machine learning has advanced in recent years thanks to its capacity to navigate through vast, complex data sets.

Deep learning is currently gaining significant interest across many industries, but particularly in the interpretation of medical images. It is predicted that by 2021, deep learning will account for $300 million of the global market for medical imaging. As a result, by 2021, it will receive on its own more funding for medical imaging than the entire analysis sector did in 2016. The most successful supervised machine learning method is this one. This method uses deep neural network models, a type of neural network that approximates the human brain more closely than simple neural networks by applying advanced mechanisms. The usage of a deep neural network model is implied by the phrase "deep learning." The neuron, a basic computational unit in a neural network that receives multiple input signals as inputs, combines them linearly using weights, and then passes the combined signals via nonlinear operations to produce output signals, is a notion that was inspired by research on the human brain.

The mapping of a set of virtual neurons and the attribution of numerical values or "weights" to the connections between them form the basis of an AI software for feature extraction and categorization. In the iterative learning process used by neural networks, each time a new data vector is provided, the

weights attached to the input values are changed. In order to be able to anticipate the right class label of input samples, the network learns throughout the learning phase by modifying the weights. The back propagation technique, which was proposed in the 1980s, is the most widely used Neural Network (NN) training procedure. The idea of Deep Neural Networks also originated in the 1980s. LeCun's work at Bell Labs in 1989 led to the first real, practical use of back propagation. To categorize handwritten digits, he combined back propagation and convolutional networks (MNIST).

According to theoretical findings, an architecture with insufficient depth may need a lot more computing components, and the number of these components grows exponentially as the quantity of the input increases. Additionally, it slows down learning. Multiple-level architectures make it easier to share and reuse components. As stated in [2], the shared weights and biases principle forms the foundation of the significance of filters in deep learning. This indicates that every single neuron in the first hidden layer finds various features in various parts of the input image. Because of this, the map from the input layer to the concealed layer is occasionally referred to as a feature map. Shared weights and shared bias are terms used to describe the weights and bias that define the feature map. On a convolutional layer, the shared weights and bias are frequently referred to define a kernel or filter. Sharing weights and biases has the significant benefit of drastically reducing the number of parameters in the network.

According to the survey done by various researchers, it is crucial to identify the type of bacteria if a patient has an undiagnosed bacterial infection. However, because it is challenging to identify the type of bacteria using conventional methods, it is crucial to develop a method that quantifies bacteria similarity in order to identify bacteria species and provide patients with potential medical therapies. In K-Means, the distinction between pixels was ignored, and the measure of comparability was the distance between k-neighbourhoods. The pixels may be nonlocal in this way. Additional investigations will be carried out to uncover additional relevant aspects. It is crucial to identify critical features for bacteria differentiation. To achieve this, it suggests employing trained deep neural networks to classify and analyse a dataset of bacterial images. Other driving methods can be executed with extraordinary focus using this method.

2. CHALLENGES FOR DEEP LEARNING

The greatest revolutionary advancement in radiology since the introduction of digital imaging may be deep learning technology used for medical imaging. The majority of researchers think that within the next 15 years, deep learning-based apps will replace humans and that intelligent robots will not only do the majority of diagnosis but also aid in disease prediction, prescription of medications, and treatment guidance. Although the idea of using deep learning-based algorithms to analyse medical imaging data is an exciting and developing area of research, there are a number of obstacles standing in the way of its advancement. These difficulties are:

1. Dataset

Deep learning needs a sizable training dataset since the quality and quantity of the dataset have a significant impact on the classification accuracy of the classifier. However, the lack of dataset availability is one of the main obstacles to deep learning's success in medical imaging. On the other hand, developing significant amounts of medical imaging data can be difficult because annotation involves a lot of time from medical professionals and, in order to avoid human mistake, numerous expert opinions are needed.

2. Privacy and Legal Issue

Compared to sharing photographs from the real world, sharing medical data is significantly more sophisticated and challenging. Data privacy is essentially a sociological and technical issue that needs to be approached collaboratively from both vantage points. When privacy is spoken up in the healthcare industry, HIPAA comes to mind. Patients now have legal protections for their personally identifiable information, and healthcare practitioners are now required to safeguard it and limit its use and distribution. One crucial challenge to deal with is how to communicate sensitive data while restricting disclosure and its distribution by making sure the data has enough utility, i.e. While 0.04% of US citizens have a unique 3-digit Zip code, gender, and birth year, 87% of US citizens have a unique 5-digit Zip code, gender, and birth date. Unfortunately, the limited data access restrictions also lower information content that might be very important.

3. Data Interoperability and Data Standards

One of the main obstacles is the lack of data standards and interoperability. Currently, data types vary from hardware to hardware, leading to significant visual fluctuation caused by sensors and other factors. Additionally, the variety of applications in the medical sector necessitate the combination of multiple distinct datasets for improved algorithm learning and accuracy. Interoperability is the cornerstone of crucial advancements in the health industry, but it still needs to happen. Health data needs to be standardized and shared between providers, much like the ATM network concept. HIPAA, HL7, HITECH, and other health standardization agencies have established some standards and guidelines to attain interoperability level.

4. Black Box and Deep Learning

When it originally started more than a century ago, medical imaging challenged established paradigms. Deep learning algorithms have given fresh life to medical imaging applications and opened up new opportunities. Although it resolves issues that were previously believed to be intractable by machine learning algorithms, deep learning is not without issues. One of the biggest problems is the "black-box problem," which refers to the fact that although the math used to build a neural network is straightforward, how the output was arrived at is incredibly complex. For example, machine learning algorithms take a lot of data as input, search for patterns, and build predictive models, but understanding how the models worked is problematic.

3. BACTERIA CLASSIFICATION

As a major contributor to the recycling of nutrients and carbon, bacteria are crucial to the functioning of ecosystems and the global biogeochemical cycles. Nitrogen is a crucial nutrient for primary production, despite the fact that di-nitrogen is the planet's main source of the element and is inaccessible to most living things, notably plants. Numerous bacteria have the ability to reduce N2 to ammonia and assimilate it. It looked at the microbial communities in soil and demonstrated how modifications to their structure and composition may also have a direct impact on ecosystem functions. All of these factors highlight the urgent need for a better understanding of the patterns of bacterial diversity, distribution, and activity in the mangrove ecosystem. This is a necessary first step towards getting a clearer picture of how the mangrove rhizosphere ecosystem functions and how it affects global biogeochemical cycles.

In order to identify the source of the infection in a hospital and stop the spread of new cases, it is essential to distinguish different bacteria clones. Ribotyping, amplified fragment length polymorphism, multilocus sequence typing, and pulsed-field gel electrophoresis are the most popular methods for separating bacterium clones. All of them, nevertheless, are extremely unstable and call for expensive tools and materials. In order to get accurate findings, they must be carried out repeatedly.

Research on pathogen categorization is conducted within several pathogen subgroups, such as bacteria, fungus, and protozoa. When it comes to bacteria, this topic was initially looked at in 1998 when tuberculosis bacteria were classified using a multi-layer Perceptron. Then, a variety of techniques were employed to differentiate between various bacterial species using hand-crafted elements including borders, forms, colors, contrast, and other morphological characteristics. Deep learning-based techniques were also used. The majority of the study was devoted to identifying only a single kind of bacteria, such as germs that cause tuberculosis. Additionally, a lot of research went into categorizing the bacteria colonies. SVM was used by the authors, as well as a one-class variant of SVM using an RBF kernel and a two-layer CNN.

4. RESEARCH METHODOLOGY

Supervised convolutional models have recently irrevocably altered the field of computer vision and machine learning. Convolutional Neural Networks have replaced the conventional matching of manually created low level vision characteristics with complementary classifiers thanks to the recent development of massive supervised datasets and quicker training models employing Graphic Processing Units. Deep feed forward networks, or CNNs, are built around a hierarchy of abstract layers and simultaneously learn

the classifier and low level information. Even under challenging situations including posture, scale, and occlusions, it has been demonstrated that these networks perform on par with neurons in the primate inferior temporal cortex. The DNN overcame the gradient problem by substituting a memory cell with long- and short-term nonlinear capabilities for the conventional artificial neuron. Based on this, the main objective of this work is to design an image classification model on Bacteria image dataset by Deep Learning Method.

Image Classification using Proposed Approach

AlexNet is a convolutional neural network that is 8 layers deep. It includes five convolutional layers and three absolutely related layer networks. It can load a pretrained version of the community educated on more than one million pictures from the ImageNet database. The pretrained community can classify snap shots into 1000 item classes, including keyboard, mouse, pencil, and plenty of animals. The community takes a photograph as input and outputs a label for the item inside the photo together with the probabilities for each of the object classes. The image Data store robotically labels the pixel based on folder names and shops the facts as an Image Data store object. A photograph data store allows you to keep large photograph data, including facts that does not in shape in reminiscence, and efficaciously read batches of photographs for the duration of schooling of a convolutional neural network. Divide the records into schooling and validation statistics units. Use 70% of the pics for education and 30% for validation. The community calls for input pics of length 227-via-227-by using-three, but the pictures within the picture data stores have extraordinary sizes. Use an augmented photo data store to robotically resize the education pics. Multiple Convolutional Kernels (filters) extract exciting features in a picture.

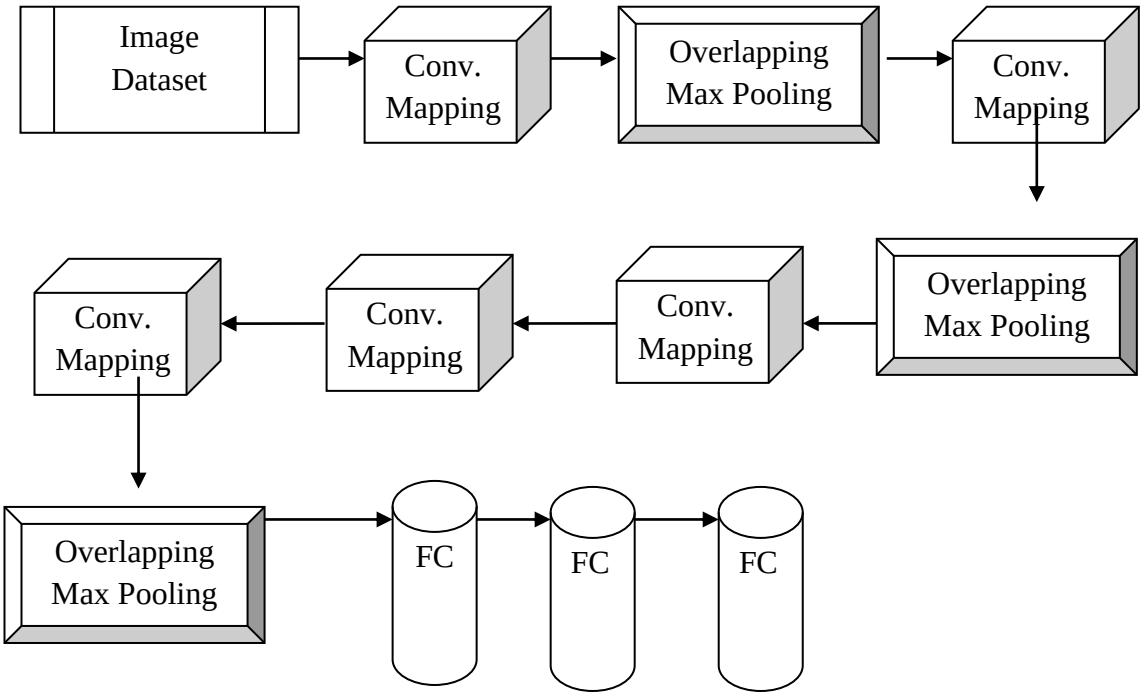

Figure 2: Architecture of Proposed Network

- In this study, AlexNet is used to analyse a database of bacterial images, and the DNN network system is used to reduce errors. When compared to other conventional networks, using DNN improves network error-reduction capabilities.
- Because AlexNet is a pretrained model that can handle big picture datasets at once and also produces superior classification results, using it in a system helps to increase accuracy.

- A collection of bacterial images is used in the suggested system model to analyse the effectiveness of deep neural networks. Initial training and test datasets are used, and the same datasets are then subjected to pre-processing.
- In order to increase system accuracy, feature extraction is conducted to images and then trained using previously learned deep neural networks. However, it results in some RMSE values that the DNN system reduces. At the destination, the final output is displayed.
- The second and third blocks make up the majority of this architecture's four main building blocks, which span the categorization process from the input microscope pictures.
- The data pre-processing block improves the amount and quality of the data as well as corrects difficulties with overfitting and dataset imbalances.
- First, to conform to the expected input of the model, the input images to be recognized were scaled from their original dimensions to 224*224, and the number of channels was set at three. Then, to artificially boost the quantity of photos for the training process, data augmentation was used. Finally, three sets: training, validation, and testing were created from the newly acquired datasets.
- Output for the final classification of bacteria will be generated

Performance Evaluation

This painting provides the concept of image category the usage of deep gaining knowledge of. The use of deep learning provides higher accuracy compared to present gadget learning strategies and CNN. The exhibition of a healing framework is assessed dependent on a few standards. A part of the regularly utilized exhibition measures is everyday exactness, normal evaluation. The accuracy of the healing is characterized because the part of the recovered records which are to be sure relevant for the inquiry. A first-rate recovery framework needs to have high esteems for accuracy and evaluation. The evaluation is the part of critical records this is again by the inquiry.

$$Accuracy = \frac{No.of\ Images\ Correctly\ Classified}{Total\ Number\ of\ Images}$$

5. RESULTS & DISCUSSION

This work provides the concept of image classification using deep learning. The use of deep learning provides the better accuracy as compared to existing machine learning techniques and CNN. This work is studied on bacteria dataset in which three types of datasets with total 60 images are used for implementation as shown in Table 1. The examinations are performed on a few kinds of flower dataset pictures in MATLAB stage and is implemented by use of programming.

Table 1: Description of Dataset

Dataset	No. of Images
Bacteria Image Dataset	
Acinetobacter	20
Lactobacillus	20
Staphylococcus	20

This work presents the concept of image classification using CNN and proposed Alex net based deep learning method. The CNN system has a problem with accuracy, then proposed method is used for improving the system. This work describes the implementation of two deeper variants, namely with 2 and

5 convolutional layers. This work presents an image classification analysis under deep learning approach. It also performs comparison of CNN based approach with deep hashing in terms of accuracy. The data is taken from bacterial dataset is shown in figure 3. After this, training data is generated using CNN as shown in fig 4. These are the images taken from training data. The proposed system model is presented for optimization of data. In this, database of flowers images is taken and then various operations are applied on it before it goes to clustering.

This fig. 5 shows accuracy curve and loss curve with number of epochs. AlexNet is a convolutional neural network that is 8 layers deep. It consists of 5 convolutional layers and 3 fully connected layer networks. It divided the data into training and validation data sets. It uses 70% of the images for training and 30% for validation. The network uses input images of size 227-by-227-by-3, but the images in the image data stores have different sizes.

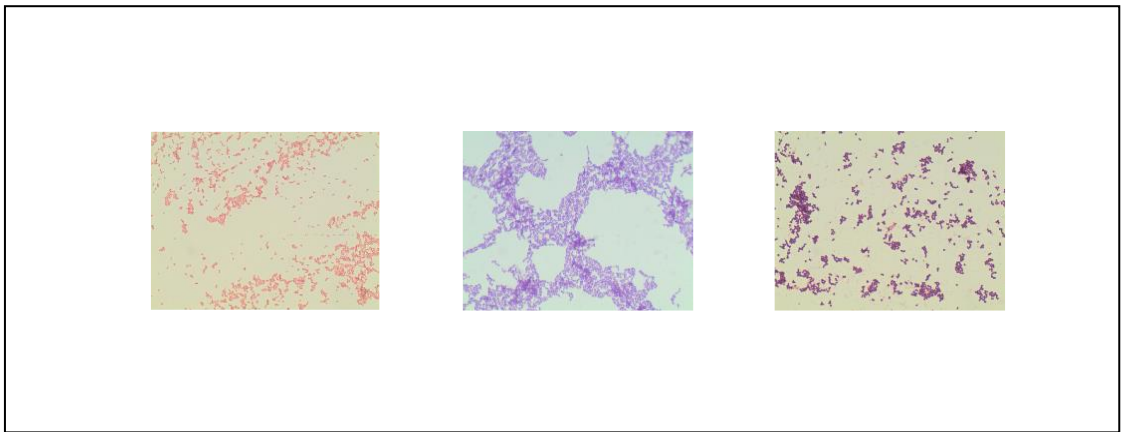

Figure 3: Input Set of Training Images

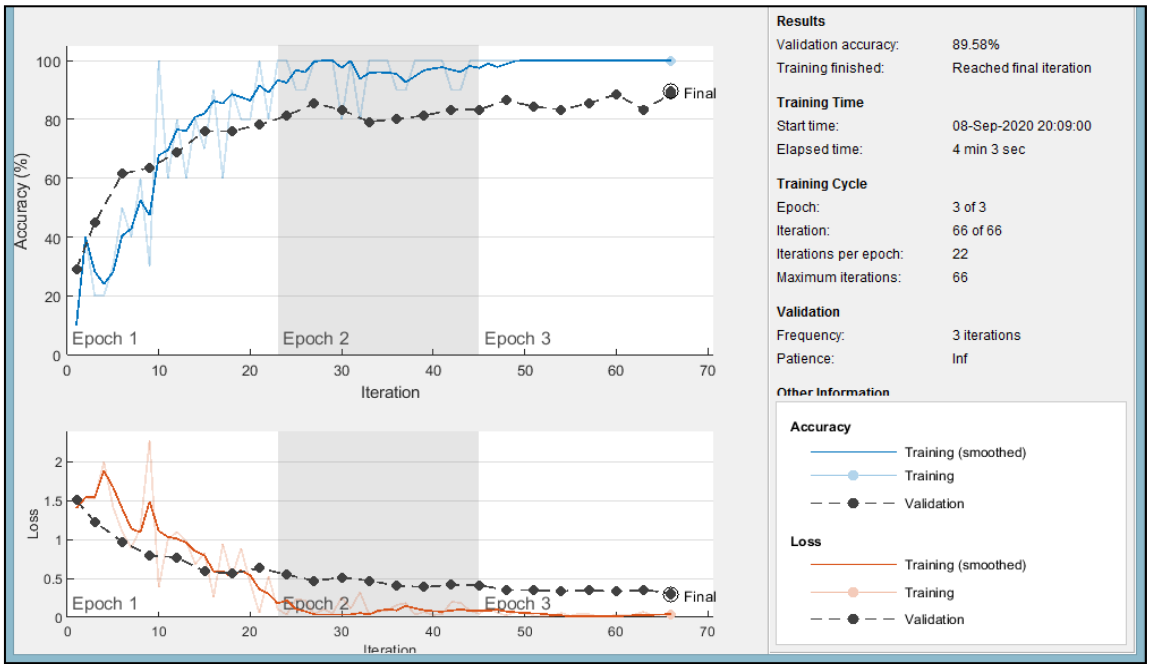

Figure 4: Performance Accuracy of Image Dataset using CNN

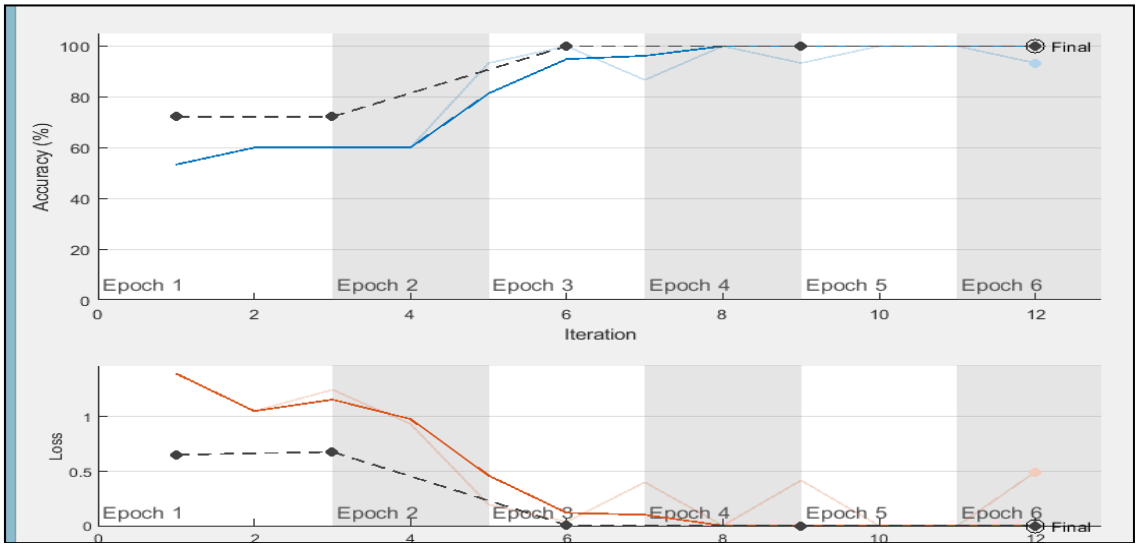

Figure 5: Performance Accuracy of Bacteria Dataset using Proposed Alex Net

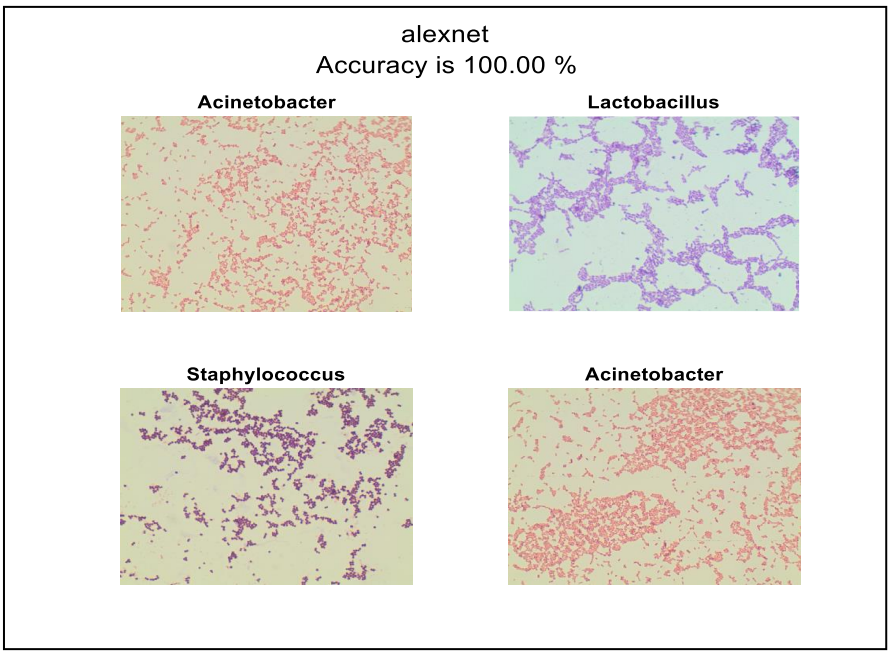

Figure 6: Final Image Classification Output by Proposed Method

Table 2 shows the performance comparison of proposed system with actual CNN method. This shows that proposed AlexNet shows better improvement in accuracy of datasets as compared to other methods and hence proves better.

Table 2: Performance Comparison of System

Database	Parameter	CNN	Proposed
Bacteria	Accuracy	91%	99%

6. CONCLUSION

This work presents the concept of image dataset classification using CNN and proposed deep learning method. It uses the dataset of bacteria and flower for classification purpose. The CNN and DBN system

has a problem with accuracy, then proposed method is used for improving the system. It overlooked the separation among pixels and likeness was given as the separation between k-neighbourhoods. The use of PCA method provides only identification of features in images but it does not help to improve accuracy of system. The CNN method uses only 2 convolutional layers for feature mapping. But the proposed method uses 5 convolutional layers and 3 overlapping layers. Due to this, it helps to improve accuracy of system as compared to other existing methods. It shows an idea of picture combination on two obscuring pictures by utilization of DCT. For this, it utilizes vitality of Laplacian and difference of Laplacian. The accuracy is defined as the how much data is accurate in all set of images. In CNN, the layers based approach is main part in this system and convolutional layer is the first layer, then follows the hidden layer and output layer. This shows that proposed AlexNet shows better improvement in accuracy of datasets as compared to other methods and hence proves better.

In future, Strategy may decrease the pixilation impacts experienced at high-commotion levels in picture denoising coming about because of discontinuities between the expectations of adjoining patches.

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