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Banana Leaf Disease Classification And Prediction Using Deep Learning Techniques

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Abstract

Machine Learning methods are popularly used for patter recognition. The techniques of machine learning are useful to predict based on training process. Image classification is the fundamental task of computer vision field and machine learning methods are providing accurate results using powerful techniques. Deep learning is the best technique for image classification which contains various method to attain the prediction process. The performance of deep learning measured by the results produced by techniques which handles the raw images. The LeNet architecture of Convolutional Neural Network method and Effectiveness of Transfer Learning process are explored in this work. The methodology used for image classification is evaluated using performance measures to assure the accuracy of convolutional neural network for banana plant disease classification.

Keywords: Machine Learning, Deep learning, Image Classification, Convolutional Neural Network

1. INTRODUCTION

A methodical grouping and categorization of anything to its characteristics is called classification [1]. The main focus of classifying image is to reduce the disparity between computer vision and human vision through data-driven computer training. By dividing the image into the appropriate group according to the vision's context, the categorization of the image is accomplished. The traditional techniques for classifying images are a subset of machine learning, a branch of artificial intelligence (AI). A feature extraction module extracts main components from images like edges and textures etc. While the data is classified using a classification module based on feature selection process. This is the common practice of image classification with Machine Learning methods. Deep Learning approaches are one of the machine learning techniques which is mainly focusing the classification especially for images [2]. The identification of object and picture recognition functions can be attained using deep learning methods.

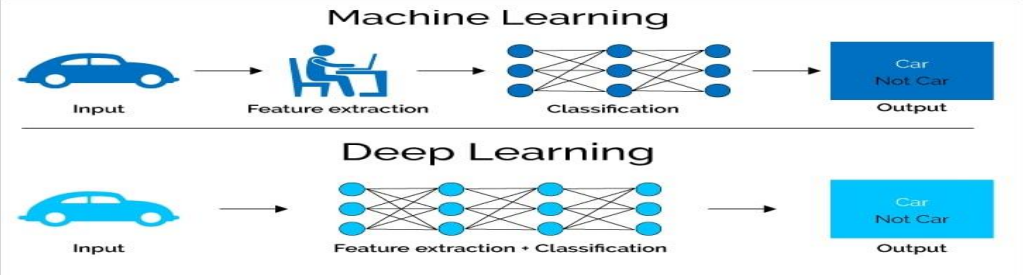

Fig:1 Machine learning vs Deep learning

The given image explains the difference between machine learning process and deep learning process. The deep learning methods are effective in image processing sector which can handle the images effectively for classification and pattern recognition. The image pre-processing is the initial step which is used for resizing of images and normalization functions. There are number of filters associated with deep learning techniques which are used to extract features from images that are broadly known as edges, corners and textures. The pooling layers of deep learning models are helpful to reduce the dimensionality of images. The widely used pooling techniques are average pooling and max pooling. The fully connected layers of deep learning models execute the output using learned weights and biases. Finally, the classification results are sent to output layer to display.

2. REVIEW OF LITERATURE

The deep learning methods are applied on biological images and the results are compared with traditional approaches such as text-based features selection techniques used by Decision tree models, Neural Network and Support Vector Machine. The reports highlighted that the convolutional neural network achieved high accuracy than other methods [3]. The novel deep learning which combines Binary Cross Entropy with Convolutional Neural Network is used for image classification. The ImageNet architecture is used to image classification with 102flower dataset. The proposed method achieved 95.62% accuracy in image classification [4]. The performance of Convolutional Neural network such as LeNet, AlexNet, ImageNet, VGG-16, VGG-19, ResNet50 and GoogLeNet model are analyzed for various datasets. The AlexNet, VGG-16 and ResNet50 models are achieved good accuracy in image classification among other architectures of Convolutional Neural Network [5]. Recurrent 2 Dimensional Convolutional Neural Network and Recurrent 3 Dimensional Convolutional Neural Network methods are proposed and executed for six datasets. The performance of proposed methods are effective in all six datasets [6]. The Convolutional Neural Network model is trained to learn features and Artificial Neural Network with Binary classifier is used to classify the massive amount of images. The performance optimization methods were used to get the improved accuracy of used model [7]. Neural Augmentation was proposed to classify the images using deep learning methods. The results are compared with augmented and non-augmented techniques. The proposed method reached good accuracy in image classification [8]. The Data Augmented based image style transfer is proposed and executed for three different image datasets such as skin melanomas diagnosis, histopathological images and breast magnetic reasoning imaging. The performance of deep learning methods are analyzed with mentioned three datasets [9]. Fine Tuning technique was used in Convolutional Neural Network to Classify the ImageNet dataset. This dataset contains four class labels which are accurately classified using CNN method [10]. Image Classification of CIFAR-10 dataset was done using Convolutional Neural Network. This classification includes feature extraction and accuracy of this method was compared with Support Vector Machine technique [11]. The image classification was attained using combine Convolutional Neural Network and Recurrent Neural Network. The multi-class classification was achieved using the CNN-RNN method [12]. The Fashion-MNIST dataset is classified using CNN and RNN methods along with Long Short-Term Memory method. The fine tuning and cross validation methods were applied to enhance the performance of proposed model. This achieved 89% accuracy which is high when compared with traditional methods of image classification [13].

3. TECHNIQUES OF DEEP LEARNING

The deep learning supports various types to provide accurate results using images. The different types are

- Classic Neural Network
- Convolutional Neural Network
- Recurrent Neural Network
- Restricted Boltzmann Machines
- Transfer Learning
- Generative Adversarial Networks
- Self-Organizing Maps
- Deep Reinforcement Learning

All these mentioned techniques are effective in the field of image classification which can solve various real-time issues with mode proficiency. These techniques are providing powerful performances in computer vision area which allows the process of handling visual inputs for effective prediction.

Classic Neural Network: The Classic Neural network is a foundational model which is processing like human brain system using Neurons. The learning process dependents on feedforward or backpropagation methods.

Convolutional Neural Network: This is a specialized type of artificial neural network which involved in image, video and audio classification. This model is developed based on human visual cortex that are processed using layers where every layer extract complex features [14].

Recurrent Neural Network: This type is use to handle the sequential data using backpropagation method. This has connections that loop back to themselves and allowing them to maintain memory for storing all previous inputs. This can be used for Natural Language Processing, Speech Recognition Applications and Time Series Analysis.

Restricted Boltzmann Machines (RBMs): this is the type of generative stochastic artificial neural Network that can learn the probability distribution over its set of inputs. They are foundational model is deep learning and were instrumental in the development of more complex architectures like Deep Belief Networks.

Transfer Learning: This is a machine learning technique where a model trained on one task is reused as the starting point for a model in a second related task. The transfer learning leverages the knowledge gained from solving one problem for improving the performance on a diverse but related problem.

Generative Adversarial Networks: These are a class of machine learning frameworks that pit two neural networks against each other in a competitive process. This adversarial setup drives the generation of highly realistic synthetic data.

Self-Organizing Maps: this is a type of Artificial Neural Network that use unsupervised learning to produce a low-dimensional, discretized representation of the input scene.

Deep Reinforcement Learning: This method combines machine learning methods and deep learning methods. It enables agents to learn optimal decision-making policies directly from raw sensory data without explicit programming.

4. DEEP LEARNING IN IMAGE CLASSIFICATION

The process of automatically identifying and categorizing objects or patterns in digital still images or moving photos is known as image recognition. The massive real-world applications, such as autonomous cars, augmented reality and surveillance systems, depends on it. Using deep learning techniques, Convolutional Neural Network (CNN)in particular have shown remarkable efficacy in image identification tasks by directly learning hierarchical representations of visual data from pixel values. They can categorize photos with previously unheard-of accuracy and automatically extract important information from the images. This is known as feature extraction process that helps to make perfect identification of objects in the image classification function. The major works of image classification using deep learning techniques utilized Convolutional Neural Network Methods. The CNN has number of architecture and layer process to execute the visual processing methods. The layers of CNN is connected with huge count of neurons which reflects the human brain process. The initial layer of CNN gathers the low-level information such as edges and textures where the following layers can observe the high-level detail. The connections between layers are complex and the results produced by convolutional neural networks are better when compared the performance of other techniques in deep learning. The familiar architectures of CNN are AlexNet, VGG-16, GooLeNet and ResNet which can provide cutting-edge results using benchmark datasets. Each architecture considered various layer process to analyze the image for feature extraction and classification. The pre-training process is useful for deep learning process where the high volume of dataset is utilized and the gained knowledge is transferred using Transfer Knowledge Techniques in Deep Learning.

5. PROBLEM STATEMENT

Banana plants are susceptible to various disease that significantly impact yield and quality. Early and accurate detection is crucial for effective disease management and crop protection. To develop a robust and accurate deep learning model, specifically a Convolutional Neural Network to automatically detect and classify common banana plant diseases from digital images. The collected images of banana plants including healthy leaves and those affected by various diseases (e.g., Sigatoka Leaf spot, Black sigatoka, Bacterial Wilt).

5.1 Architecture of Proposed Work

The following flowchart shows the steps for banana plant disease classification which combines two main process namely Image Processing and Convolutional Neural Network. This flow incorporates image processing methods to enhance the image quality for accurate prediction using deep learning techniques.

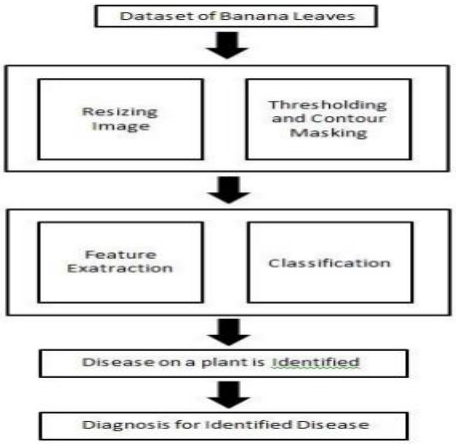

Fig:2 Architecture of proposed work

5.2 Dataset Collection

The banana leaf spot diseases dataset is used for this work which is collected from Kaggle repository. This collected dataset contains three class labels namely Sigatoka, Cordana, Pestalotiopsis. The sample images of collected dataset is presented below.

Fig:3 Banana Leaf Disease images

[Source: Kaggle repository]

The collected dataset contains 937 images which are collectively contains various disease such as Pestalotiopsis, Sigatoka, Cordana and Healthy.

6. METHODOLOGY

This work used Image processing and Convolutional Neural Network techniques for effective disease classification and prediction.

6.1 Image Processing

Image Processing is used to enhance the dataset which are further used for classification and prediction. Image resizing, Image cropping, Image Rotation and Flipping, Image Normalization, Noise Reduction, Color Space Conversion and Data Augmentation techniques are associated with images to enhance it. Image resizing is used for ensuring all images have the same dimensions for consistent input to the neural network. This will also used for maintaining the original image properties to avoid distortion. The image cropping is focusing on region of interest to reduce computational cost and improve model performance. This will also used for creating new samples by cropping different parts of an image [15]. The image rotation and flipping methods are used for generating additional training data by rotating and flipping images to expose the model to various orientations.

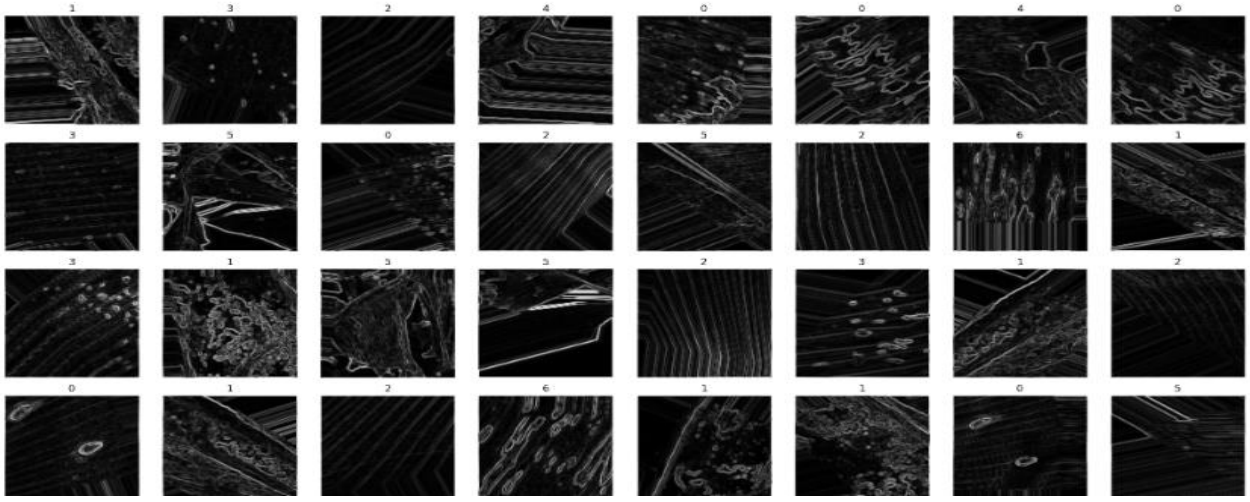

Fig:4 Image Processing Results

The processed images are used for classification process using deep learning methods. The improved feature extraction can be attained with image processing techniques which can use edge detection, noise reduction and normalization for highlighting main features. This will be useful for getting more accuracy in image classification.

6.2 Convolutional Neural Network

The collective of multilayered neural network is known as Convolutional Neural Network. CNNs are renowned for their resilience to minimal data volatility and require training to operate. The three primary components of CNN are the Polling Layer, Convolutional Layer and Fully Connected Layer. While fully connected layer is used for classification, the convolutional and pooling layers are responsible for extracting features from the input images. The convolutional layer's primary function is to automatically extract features from each input image. The pooling layer lowers the dimensionality of the features that are extracted in the convolutional layer. The input images are then categorized into predetermined classes in the fully connected layer, which uses an activation function to learn the high-level features.

Convolutional Layer: The input image is subjected to a convolution operation by the convolutional layer, which is then used to send the outcome to the following layer. The convolution simulates how a single neuron would react to sensory inputs. Only the data for its specific field is processed by each convolutional neuron. The convolutional layer's operation is described below

1. Align the image and feature
2. Multiply every pixel in the image by the matching feature pixel.
3. Determine the sum by adding the values. The amount is divided by the feature's entire pixel count.

Pooling Layer: Neuron Cluster outputs are combined at the pooling layer to create a single neuron in the following layer. The stack of image is reduced in size in this layer. After the activation layer, pooling is implemented. Average pooling, which uses the average value from each cluster of neurons on the previous layer, is employed in the proposed model.

Fully Connected Layer: This layer is used to combine the features collectively for creating a classification model. This proposed work used Sigmoid activation function to classify the outputs. The formula for Sigmoid Activation function is

$$S(x) = \frac{1}{1 + e^{-x}}$$

Where S(x) is representing Sigmoid function and e represents Euler's number. The result of sigmoid function is used to map any real value to a value between 0 and 1.

7. RESULTS AND DISCUSSION

The Convolutional Neural Network is executed for classifying the banana leaves which are diseased. The proposed model is trained with 70% of data images and the remaining data images are used to testing the model performance. The efficiency of proposed model can be measures using various terms like accuracy and loss value. The LeNet architecture model is selected for executing CNN for image classification. The accuracy of the model in training time and validation time are 96.5% and 90% respectively.

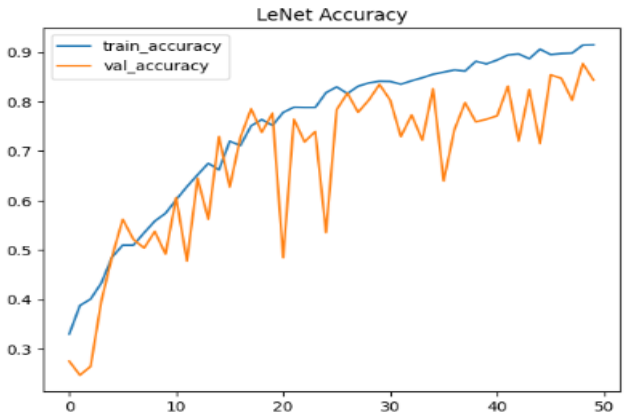

Fig: 5 Accuracy of LeNet model using CNN

This graph shows the training accuracy and validation accuracy using banana leaf images. The training accuracy of the model is comparatively high.

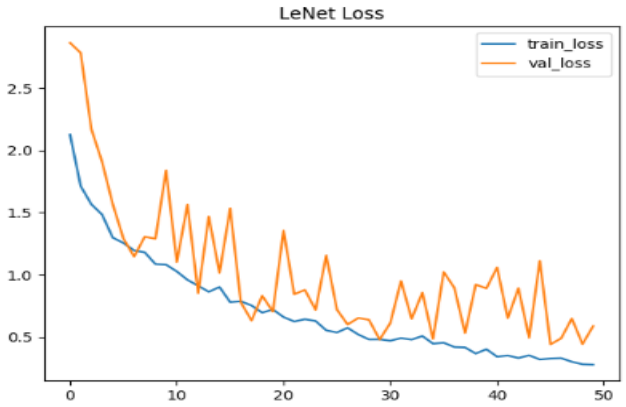

Fig: 6 Loss function of LeNet using CNN

This graph shows the loss function during training and validation time. From this result, it is highlighted that the training time loss value is lesser than the validation time loss function. This is common for all image classification methods but the loss value of LeNet is comparatively less than other architecture models of Convolutional Neural Network.

8. CONCLUSION

This research work proposed a novel approach for accurate and efficient detection of banana leaf disease using Convolutional Neural Network(CNN) architecture specifically LeNet. The proposed model is trained on a comprehensive dataset of banana leaf images which can be classified into four categories namely Sigatoka, Cordana, Pestalotiopsis and Healthy. The experimental results highlighted that the proposed model achieved 90% accuracy using test data. The model's ability to accurately identify diseases early on enables timely intervention and reduces crop losses. Furthermore, the advanced methods of Machine learning and deep learning can be used for tuning parameters for more accurate prediction.

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