Spinach Classification and its Health Benefits Suggestion using Deep learning.

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***Abstract-* Spinach is a popular green leafy vegetable known for its numerous health benefits. Accurate classification of spinach varieties is critical to ensure consistent quality and nutritional value. In recent years, deep learning techniques have shown remarkable success in classification. The proposed Deep Learning based Spinach Classification and Health benefit suggestion System (DL-SCHS) uses pre-trained VGG16 architecture for classification. The dataset of 2,500 images of 25 different spinach varieties, with each variety containing 100 images are used for training DL-SCHS. Our proposed system consists of three stages includes Pre-processing of the data, Training of the model, and Evaluation. During pre-processing, images are resized into 224 x 224 pixels and random transformations are applied for image augmentation. Canny filter is used for performing feature extraction. Training of the VGG16 model on the pre-processed data is implemented using the categorical cross-entropy loss function and the Adam optimizer. The experimental results showed that the VGG16 model achieved a higher accuracy of 94% on the testing set.**

Keywords: Spinach Classification, Canny Filter, Convolutional Neural Network (CNN), VGG16, Deep Learning.

I. INTRODUCTION

Spinach is a highly nutritious leafy vegetable that is rich in vitamins, minerals, and antioxidants. Spinach has been found to have several health benefits, including reducing the risk of cancer, improving cardiovascular health, and improving bone health. The classification of different types of spinach is challenging due to their similar appearances and lack of knowledge. Therefore, an accurate and efficient system for spinach classification can be highly beneficial for both the food industry and consumers.

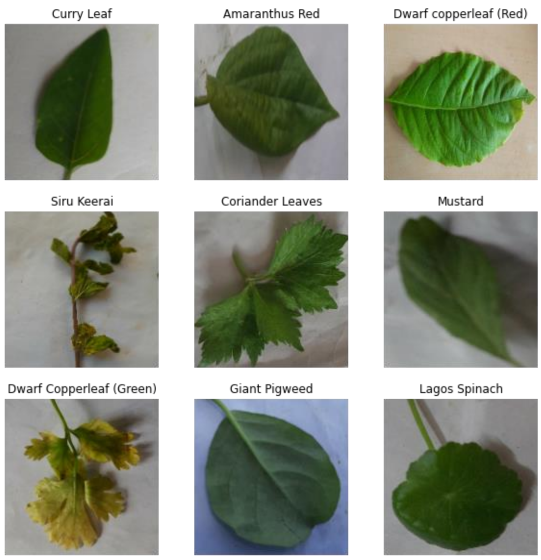

Figure 1. Sample spinach images

Deep learning has shown great promise in image classification task [1], [2], including plant classification. Proposed system introduces a deep learning-based spinach classification using VGG16 convolutional neural network. VGG16 is a pre-trained CNN model that has been widely used for image classification task [3-5], and it has shown superior performance on various image datasets. In DL-SCHS medium-scale image dataset of 25 spinach types is used with each type having 100 images. In order to implement the VGG16 model for spinach classification, the keras deep learning library with TensorFlow backend is used [6], [7]. Sample spinach images are shown in Figure1.

The dataset is pre-processed by resizing the images to a standard size of 224 x 224 pixels and are normalized. The performance of the VGG16 model was evaluated based on its accuracy and loss metrics on the testing set. The precision, recall, and F1 score were also calculated for each spinach class using the confusion matrix. The experimental results showed that the VGG16 model achieved a high accuracy of 94% on the testing set. The proposed spinach classification system can be useful in various applications, including food processing, agricultural research, and nutrition analysis. Additionally, the system provides the health benefits of the Spinach variety and its common name and scientific name.

The main contributions of proposed system:

- The system provides the health benefits of the Spinach variety.
- Retrieving its common name will be more helpful for common people in the region of south India.
- Predicting spinach with high accuracy using VGG16.

II. RELATED WORKS

Spinach is one of the most nutritious vegetables and is rich in vitamins, minerals, and antioxidants. People who are from city side, struggle to identify spinach variety. Many studies have been conducted using few varieties of foreign spinach and only a very few studies have been conducted for south Indian spinach.

Spinach classification and its health benefits using deep learning is a field that has gained a lot of attention due to the increasing awareness about the importance of a healthy diet. With the help of deep learning techniques, it is possible to accurately classify spinach varieties and identify their health benefits.

In recent years deep learning techniques are used for spinach classification by researchers. Hu et al. [8] proposed a convolutional neural network (CNN) for classifying spinach varieties. Around 1200 images are used for training and testing the model. The results showed that the CNN model was able to classify the spinach varieties with an accuracy of 97.6%.

Liu et al [9] Proposed a deep neural network (DNN) for classifying spinach based on its nutritional value. Spinach samples are collected from different regions and analyzed their nutritional content using spectroscopy. The results showed that the DNN model was able to classify the spinach samples based on their nutritional content with an accuracy of 93.5%.

Mirajuls Islam et al [10] Proposed a VGG16 for classifying the spinach variety. This is compared with the existing models includes InceptionV3, Xception and VGG19. The results showed that the VGG16 model was able to classify the spinach with higher accuracy of 97%, compared to others CNN models.

Owais A. Malik et al [11] Proposed a CV system that automates the spinach classification. The EfficientNet-B1 model was used for training the dataset. The results showed that the EfficientNet-B1 model was able to classify the spinach with an accuracy of 84%, compared to baseline model.

Putri et al [12] Proposed a CNN method for identifying the medicinal leaves. CNN tries to update the value of the filters. Backpropagation was correcting them to become more efficient at matching the output. The results showed that the CNN model with backpropagation was able to identify the medicinal leaves with higher accuracy.

M O Ramkumar, et al [13] Proposed a convolutional neural network (CNN) based on Resnet-50 to classify images and determine the level of Cercospora in infected plants. The system determines the amount of insecticide and fungicide to be applied.

Bhagavatula Aiswarya et al [14] Proposed a global approach to assess the nutritional value of spinach leaves. Around 150 images are used for training and testing the model. Chlorophyll and Nitrogen content are extracted using RGB component. The approach used machine learning algorithms, to predict the age of a leaf, which is a key factor for determining its edibility.

Vina Ayumi et al [15] Proposed a MobileNetV2 model for classifying the medicinal plant species. This is compared with the existing models includes VGG19 and VGG16. The results showed that the MobileNetV2 model was able to classify the spinach with higher accuracy of 81.82%, compared to others CNN models.

Sankar Sennan et al [16] Proposed a CNN model for identifying the Spinach. This is compared with the existing models includes SVM, Random Forest, VGG16, VGG19 and ResNet50. The results showed that the Proposed CNN model was able to classify the spinach with higher accuracy of 97.5%, compared to others CNN models.

The research conducted by these authors uses various deep learning techniques and convolutional neural networks to classify spinach based on features extracted from the spinach leaves. Many of these studies used transfer learning models to analyze and extract features from the spinach images [17-19]. The research highlights the importance of improving food habits and the need for a global approach to assess the nutritional value of spinach leaves. The studies conducted on spinach classification are critical to revolutionizing the food industry and promoting a healthy lifestyle. However, collecting more leaf samples and creating larger datasets can improve the accuracy of these studies.

Limitations of the Related Work:

- A significant limitation of the dataset is the lack of botanical names, which may be critical information for some consumers.
- A limited spinach variety alone taken as a dataset and considered for classification.
- Lack of South Indian spinach classification.
- Less efficient filters were used compared to proposed system.

III. PROPOSED METHODOLOGY

Spinach is especially important for human skin, bones, hair and other tissues. It is beneficial for nutrition and easily accessible to people. Most varieties of spinach have a similar appearance. Therefore, it is difficult for city dwellers and children to distinguish between spinach and its name.

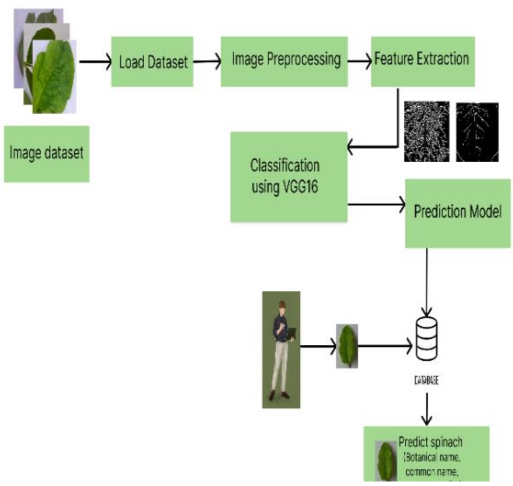

Figure 2. System Flow Architecture

The proposed work implements an efficient CNN categorization of spinach using Deep Learning method. About 25 spinach species with 100 photos each are collected for prediction. DL-SCHS collected additional data about spinach. System flow Architecture is shown below in Figure2.

Most people are unfamiliar with the botanical name of spinach. Databases stores botanical names of photos. Consequently, proposed algorithm will classify spinach and extract their common names. One should also be aware of the benefits of eating a particular spinach variety. The proposed system will return these medical benefits as a suggestion to the user.

A. Data Collection

The data collection for spinach classification and its health benefits suggestion system an appropriate data set for spinach classification is not yet readily available in order to fill in the gaps left by unavailable data we have generated our own dataset using data from a variety of sources which contains of 25 variety of spinach our collection is divided into 25 classes and each class includes 100 images along with their associated labels. Dataset Label size are ploted in Figure 3.

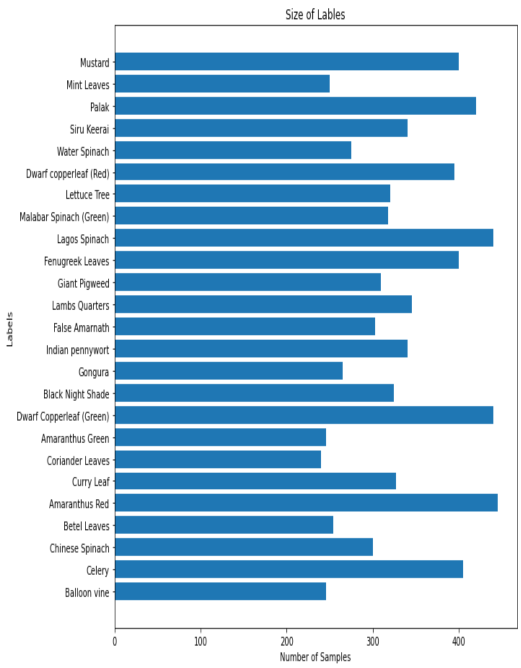

Figure 3. Number of Samples

B. Data Pre-processing

The first step is to convert the input image into grayscale. Grayscale conversion simplifies the image by reducing the colour information to a single channel, making it easier to extract the important features of the Spinach. Here veins and edges are extracted using canny filter [20], [21] in the proposed work.

A Canny Filter is then used to remove noise and soften the edges of the spinach region in the grayscale image. One of the unique characteristics of DL-SCHS, our proposed Deep Learning-based Spinach Classification System, is the use of the Canny edge detector. The Canny filter can be used to extract useful features that are necessary for correctly identifying various varieties of spinach leaves during the pre-processing stage. System can detect edges with varied degrees of complexity because to the Canny filter's multi-stage procedure, which enables us to capture the minute features of the spinach leaves [22-25]. Feature extraction of Amaranthus Green spinach were shown in Figure 4.

$$G(X,Y) = \left(\left(\frac{1}{2\pi\sigma^2}\right) exp\left(-\left(\frac{X^2+Y^2}{2\sigma^2}\right)\right)\right) \quad (1)$$

$$G = sqrt(GX^2 + GY^2) \quad (2)$$

Canny contains three variables that can be changed: the width of the Gaussian the wider the Gaussian, the messier the image and the lower and upper thresholds for the hysteresis thresholds.

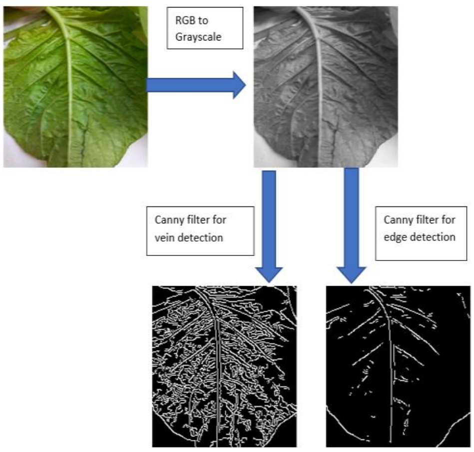

Figure 4. Feature Extraction

C. *Classification*

DL-SCHS (Deep Learning-based Spinach Classification System) is an innovative solution that leverages the power of deep learning to accurately classify various types of spinach leaves. By using a pre-trained VGG16 model, DL-SCHS is able to perform transfer learning, enabling it to effectively learn and identify unique features of different spinach leaf varieties. Proposed VGG16 workflow shown in Figure 5.

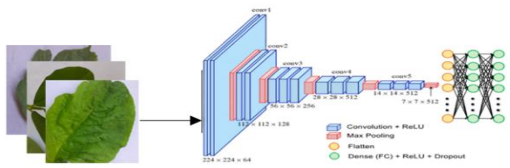

Figure 5. VGG16 Workflow

D. *VGG16*

The VGG16 model used in the DL-SCHS project is pre-trained on a large image dataset and consists of 13 convolutional layers that are essential for feature extraction [26-31]. These convolutional layers work with filters to extract features from the input images. In the project, we used the VGG16 model for transfer learning and removed the fully connected layers to prepare the model for classification of spinach leaves based on their features. VGG16 Architecture shown in Figure 6.

In DL-SCHS, the fully connected layers are modified to suit the specific spinach leaf classification task, ensuring that the system can accurately classify spinach leaves with high precision. DL-SCHS is a unique system that provides an accurate and efficient tool for classifying different types of spinach leaves, making it useful for young generation.

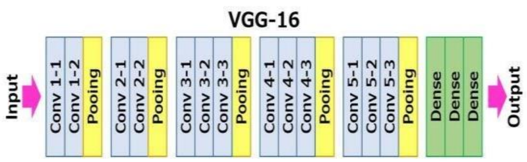

Figure 6. VGG16 Architecture

E. *Algorithm*

Input: Set of input images I1, I2, ... In

Output: Output labels Class1, Class2, Class3, and Class4 and health benefits suggestions

- Load the spinach leaves dataset into DL-SCHS.
- Pre-process the images in DL-SCHS by performing resizing, grayscale

conversion, data augmentation, canny edge detection, and feature normalization.

- Split the pre-processed dataset into training, validation, and testing sets in DL-SCHS.
- Load the pre-trained VGG16 model in DL-SCHS.
- Remove the fully connected layers from the VGG16 model in DL-SCHS to prepare for transfer learning.
- Add new fully connected layers in DL-SCHS for spinach leaf classification, customized to the specific requirements of the DL-SCHS system.
- Freeze the convolutional layers of the VGG16 model in DL-SCHS to preserve the pre-trained weights and reduce computational resources required for training.
- Compile the modified VGG16 model in DL-SCHS with a suitable loss function and optimizer to prepare for training.
- Train the modified VGG16 model on the training set in DL-SCHS.
- Evaluate the performance of the trained model on the validation set.
- Save the trained DL-SCHS model for future use.
- Take input images of spinach and pre-process them
- Use the trained model to predict the spinach name, common name, scientific name, and health benefits
- Display the predicted results to the user

Once the model is trained and evaluated, we will use it to predict the spinach name, common name, scientific name, and health benefits for input images. This will enable users to easily identify different types of spinach and learn about their health benefits.

IV. EXPERIMENTS AND RESULT

There have been several experiments conducted on Spinach Classification using Veins and Edges filtered using the canny filter then inputted to VGG16 CNN based model. The proposed method uses the South Indian Spinach dataset, which contains 2500 images of 25 Spinach variety.

The Spinach Classification employs various algorithms to train the dataset. Here are some comparisons of popular algorithms.

Table 1. Comparison of models

Method	Accuracy
MobileNetV2	81.82%
DNN	93.5%
Fine-tuned VGG16	86%
ResNet50	85.7%
EfficientNet-B1	84.50%
Proposed VGG16	Approx. 94%

Table 1. Represents the Comparisons between the recommended method's accuracy and that of the techniques applied in earlier studies

During performance evaluation, the DL-SCHS confusion matrix and classification report will also be generated to provide more detailed insights into the system's performance. The accuracy metrics will be plotted in Figure 7 to visualize the performance of the DL-SCHS model during training and validation, providing valuable information for further improvements to the system.

On a collection of Spinach pictures with associated severity classifications, the modified model should be trained. This entails selecting the proper optimizer, loss function, and training settings, such as the group size and number of epochs.

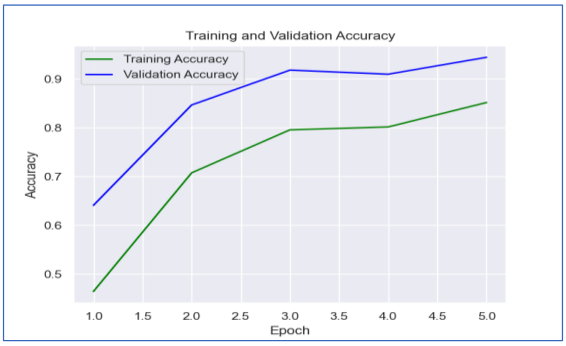

Figure 7. Training and validation Accuracy

$$Softmax(v_x) = e^{v_x} / \sum_y e^{v_y} \quad (3)$$

$$r(t) = \max(0, t) \quad (4)$$

The VGG16 was trained on the South Indian Spinach dataset using data augmentation techniques to increase the amount of training data. We anticipate that the VGG16 based model will enable the DL-SCHS system to accurately detect the Spinach used by new young generation people. In addition to Classification from Spinach feature, the system also used to provide common name, Scientific name, and Health Benefits Suggestion to Identified Spinach. Loss is reduced which plotted in **Figure 8**

Accuracy: The percentage of accurate forecasts that the model makes is what determines accuracy. Divide the total number of assumptions by the number of correctly predicted outcomes to calculate it.

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} \quad (5)$$

Precision: The fraction of accurate positive forecasts over all true positive is how precision is calculated.

$$\text{Precision} = \frac{TP}{\text{TP} + FP} \quad (6)$$

Recall: Recall quantifies the percentage of correct positive predictions over all actual positive occurrences.

$$\text{Recall} = \frac{TP}{TP+FN} \quad (7)$$

F1 score: When both recall and precision are important, a mixed metric is used.

$$\text{F1 Score} = \frac{2*TPV*TPR}{TPV+TPR} \quad (8)$$

Figure 8. Training and Validation Loss

Overall, the proposed methodology allowed us to classify different types of spinach leaves and provide useful information about their common and scientific names as well as their health benefits.

V. Conclusion and Future Work

These experiments for Spinach classification demonstrate the effectiveness of the VGG16 based model for classifying Spinach variety and common name, scientific name and health benefits output from the identified spinach and also the feature of veins and edges using canny filter. However, there is still a need for further research to improve the accuracy and robustness of these systems, as well as to develop more advanced Suggestion systems for spinach classification. While current Spinach classification systems focus primarily on 25 varieties of south Indian spinach and its health benefits suggestion, there is potential to integrate other modalities, such as where can user buy spinach products in real time also add some more Spinach variety improve dataset to improve Spinach classification and health benefits suggestion System. Future research could explore the use of multi-modal classification systems that combine Spinach Classification with other modalities.

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