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Neural Network Based Disease Detection and Classification in Citrus Plants

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ABSTRACT

Agricultural productivity is one on which the Indian economy largely depends. In agricultural field, most of the research work is on the disease detection and classification in plants as plants plays an important role in human life. It is difficult to find and treat as the disease in plants is completely natural. In this regard, there is a need of an automatic disease detection and classification system with technology which can be useful to reduce oversight work on large plants. It can also recognize disease symptoms, i.e., even after they appear on the leaves of plants at a very early stage.

Neural network has been widely used for detection and classification of diseases in plants. In this article, the plant disease region is segmented and extracted from the leaves of the plants using Fuzzy C Means clustering. The wavelet transformation, whose approximation values are extracted for further processing in order to extract the texture characteristics with Gabor with Principal Component Analysis. Features such as mean value, standard deviation, and entropy of the obtained sub bands are calculated and stored in a feature vector. The extracted features are fed into the Probabilistic Neural Network classifier to classify the disease of the affected plant or not. The proposed technique is tested on Citrus plant leaves image for detection and classification of citrus plant namely healthy, anthracnose, black spot, canker, scab and melanoses. The proposed technique achieves 93% classification accuracy when compared to the existing method on citrus plant.

Keywords - Citrus Plant, Fuzzy C Means, Gabor, Probabilistic Neural Network, Wavelet Transformation

1. INTRODUCTION

Many of the developing countries are based on the agricultural sector. More than 60 % of the population depends on this sector in India. Agricultural section is the segment of an economy related with the improvement of plants and raising of animals and fish for monetary and residential uses. The farming land is apparently the most vital fragment of the economy as it is imperative for human presence through the generation of sustenance, accommodation through wood, and sartorial. Agricultural business was one of the main features in human advancement and it was a factor prompting the ascent of stationary human development.

Most of the African countries and some Asian countries like Burma, Thailand etc. have major dependency on the agricultural sector. The climate has a direct effect on the agriculture and fisheries. The formation of carbon dioxide in the atmosphere can increase some collection yields in some places, although it is necessary to understand these points of interest, soil moisture, accessibility to water and in particular conditions. The recurrence and severity of the drought and waves could cause difficulties for farmers and weaken security of supply. In general, climate change makes it difficult to grow crops in the way it is done at similar spots from that they done before. Climate change is also a factor along with other advancing components that influence agricultural production, like changes in cultivating practices and modernization.

As the effect of the heat growth in the climate which has been led to the build-up of the pests and disease which are affecting the flowering in the plants. The former director at International Central Research Institute for Dryland Agriculture (CRIDA) from Hyderabad, Shri, B. Venkateshwarlu has stated that “Changes in the climate influences the availability, access and absorption. The decrease in production makes food less available, which has a great impact, especially in the poor, where they cannot afford to buy food, which in turn affects their health.” If proper care is not taken during this space, it'll have a severe impact on the plants and have an effect on the quality, quantity or productiveness of the product and in turn the economy of India. The citrus plants, provides nutrients such as Vitamin C and every year 50% of citrus plants is affected due to plant diseases. This cause badly effects the production and quality of citrus plants.

The agricultural production at the worldwide stage has been affected by the plant diseases because the combined effect of the pests and diseases on plants can end up to loss of over 50% within the major crop, 20% just in case of prime food and cash crops. This made a really large effect on the income of the farmers and also it affects the GDP of the countries. The fastest growth in the field of in technology has raised the agricultural output and also ready to feed the rising populations [1]. During the past the leaf samples are taken to the local agricultural centers to find the disease. The farmers and also the agrarian professionals visually screen the crops to seek out that any attack has taken place on these crops and plants and classify them. This practice is more monotonous, overwhelming and subjective. The choice of making capability of the person depends on many factors. The ability to evaluate be influenced by on the physical conditions like exhaustion, vision conceptual state stress surroundings, climate improper lighting etc. The wide growth of internet and also the rise of the utilization of the smart phones having high computing capabilities and high-resolution cameras now are often utilized to detect the diseases within a shorter time.

This technical support for the detection of plant infections is perceived by specialists with the naked eye, so the detection and location of the infection of the crops is completed. In a couple of nations, farmers do not have legitimate offices or may be believed that specialists not able to identify the plant diseases. Moreover, counseling specialists even cost high and additionally tedious further. In such conditions, the proposed system seems to be helpful in checking huge fields of yields. The programmed recognition of the sicknesses which is really made simple by observing the side effects on the plant leaves to make it less demanding and reduce the expense. The bolsters machine's vision is very professional video and image based programmed process and robot controls.

It is striking evidence, a more relentless assignment and within the meantime, less precise, and will only be possible in limited territories. While if programmed identification, system is employed it'll take less endeavors, less time and switch out to be more exact. In crops, variety of broad diseases is visualized as dark colored, pale spots, premature tardy sear and a few are parasitic, bacterial and viral infections. Image Processing is employed for estimating promoted territory of disease and to make a decision the excellence within the shade of stimulated region. Segmentation may be a procedure to group a picture into diverse portions. Humans can simply identify, distinct and interpret the precise objects whereas the processing machines don't have such intelligence in identifying these objects, hence many various methods are developed for the segmentation. Those plant diseases are categorized as the fungal and bacterial diseases.

The research work related to the proposal is discussed in section II, followed by the proposed work discussion with a block diagram in section III and experimental setup and discussion on the results compared to the existing system and given in the section IV and V respectively. The section VI concludes with suggestions for future enhancements.

2. RELATED WORK

The related work deals with papers related to detection and classification problems and focuses on the various algorithms that were implemented throughout the papers that were taken into consideration. The papers elaborate on the different algorithms that were used to overcome the problem of noise reduction in the image, the performance measures and the drawbacks. All these are considered to come up with a technique that enhances the performance ultimately.

Authors in [7], use images to explain how diseases are recognized and the stage of a cotton plant is estimated. Most of the symptoms of the disease are reflected in the cotton cloth. Contrary to previous approaches, the authors propose the processing of images taken on site by an untrained person under uncontrolled conditions with a normal or mobile camera. These ground images have a messy background which make it very difficult to cut leaves. The proposed work uses two cascading classifications. The first ranking segments are run in the background using local statistics. Then another classifier based on the hue and brightness of the Hue Saturation and Value (HSV) color space is then trained to recognize diseases and find their stage of infections. The algorithm developed is general and can be applied to any disease.

The identification of plant diseases in agriculture is very difficult [8]. If the identification is incorrect, there will be large losses in agricultural production and in the economic values in the market. Sensing leaf diseases requires a lot of effort, knowledge about various plant diseases and need more time for treatment. Therefore, we can use the images to identify leaf diseases in MATLAB [4].

The authors [9] state that the diseases in plants are completely natural, so the disease detection in plants is difficult and it plays an important role in the field of agriculture. If adequate precautions are not taken in this area, a serious impact will occur on the crop, which will affect the quality, productivity and quantity of the products. The automatic disease detection in plant is beneficial because it greatly reduces surveillance work on large plants and detects disease symptoms in early stage as they spotted on plant leaves. The authors also present an algorithm for the image segmentation used in the automatic detection and classification of plant leaf diseases. Later, an investigation of the various disease classification techniques can be performed for the detection of disease in the leaf of the plants.

The authors describe that automatic plant disease detection [10] is an essential research topic, as it can be helpful to check large plots and then automatically recognize disease symptoms as soon as they occur in plants. This proposal contains a software system for the automatic disease detection and classification of plant leaf. The processing system contain four main stages: first, is the color transformation structure which is created to input the RGB image [2], in next stage the green pixels are masked and removed based on the threshold. This is followed by a segmentation process, in which the graph statistics are calculated for the suitable segments. In the last stage, the extracted entities that passes the classifier. The efficiency of the proposed algorithm, successfully recognized and classified the diseases.

The authors in [11] reduced the noise from images with the bilateral filter and adaptive histogram equalization were used for image enhancement. They also proposed enhancement segmentation algorithm for the diseased and healthy plants classification based on unsupervised learning. The segmentation results were evaluated in the lab domain on a certain part of the plant and obtained better accuracy. In [12] the authors have presented a detailed survey on various image preprocessing methods, segmentation techniques, feature extraction, selection, and classification methods for automated citrus plant disease detection and classification. They also have discussed the importance of feature extraction and deep learning techniques.

A hybrid approach was proposed by Muhammad Sharifa [5] for citrus plant disease detection and classification based on an optimized weighted segmentation and feature selection techniques is considered as the existing system. The authors used Support Vector Machine (SVM) [3] to select the features and classify them. The results obtained showed that the preprocessing method improved the contrast of lesion part, which improved the segmentation accuracy. Citrus disease image gallery, combined and collected datasets were used for the citrus disease detection and classification which achieved 80% of accuracy.

In paper [13] a PSO based detection techniques was proposed by the authors, in which the features were randomly selected by the particle and classification rule was generated [13]. The best classification rule were selected for accuracy and applied to the testing data to detect the severity level of citrus plant diseases.

With these research motivation and issues, we propose to use the Fuzzy C Means (FCM) clustering for finding disease affected region and neural network-based algorithm to classify the citrus plant diseases.

3. PROPOSED WORK

In proposed scheme, we use the Fuzzy C Means (FCM) clustering for finding disease affected part. By the same method the segmented region is completely analyzed by wavelet (single-level) transformation, its approximation values are taken out for further processing to extract the texture features by using Gabor. After those features are extracted & processed, dataset is completely trained and classified by using the Probabilistic Neural Network (PNN) of machine learning algorithm. In the proposed system, complex-valued responses of a set of multi-resolution are the raw features, so the Gabor filters were used on it. This cross operator provides an easy approximation of the width of the gradient, and the classic operator recognizes the edges and their orientations. It also has higher accuracy and less computational time.

Fuzzy clustering is a way of clustering in which every information factor can belong to a couple of clusters. Clustering includes assigning statistics points to clusters such that items within the equal cluster are as similar as feasible, even as items belonging to different clusters are as dissimilar as feasible. The clusters are identified through the similarity measures such as distance, connectivity, and intensity which can be chosen based totally at the facts or the software. The FCM algorithm given below could be very similar to the K-Means algorithm:

• Select the number of clusters.
• FCM begins with an initial estimate of cluster centers, which should mark the average location of each cluster.

• FCM assigns a membership score for each group to each data point.
• The probability that a pixel belongs to a particular group represented by the membership function. High membership values are assigned to pixels near the center of gravity of their groups, while pixels with low membership values are assigned to pixels whose data is far from the center of gravity.
• Convergence can be identified by comparing membership changes or cluster center with two successive iteration phases.

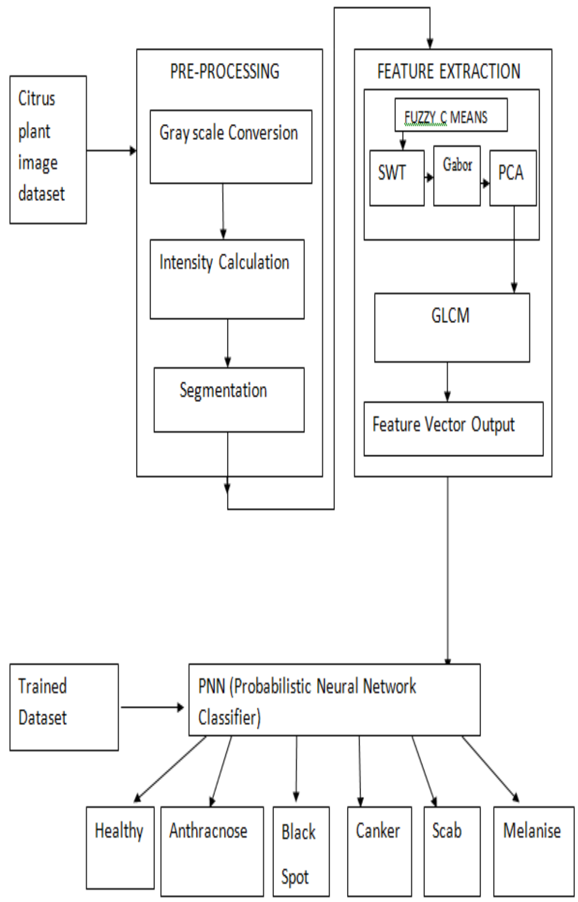

Fig.1. Proposed System Block Diagram

This system is useful for the agriculture farmers to detect the disease in the farm and suitable measures are taken to reduce the disease in the plant by the application of suitable pesticides to detect and classify the plant disease. The phases of the proposes system are as follows:
1. Pre-Processing – (Scale Conversion, Intensity Measure, Binary Conversion)
2. Segmentation -Fuzzy C Means (FCM)
3. Feature Extraction - Wavelet Transformation (change the wavelet family type) with Gabor, PCA & Gray Level Co-occurrence Matrix (GLCM) Features
4. Classification - Probabilistic Neural Network (PNN).

In the next section, the implementation and experimental setup of each phase of proposed system is discussed in detail.

4. EXPERIMENTAL SETUP

4.1. Preprocessing

The dataset/database image is imported to the current working directory. The input image is read from the directory, without reading the image, the system can't process to further stage. So initially reading the image is most important part of the system. After reading the input image as shown in Fig.2, then we go for preprocessing stage. In this stage, if the input image is in RGB, then convert the RGB image into grayscale form as shown in Fig.3.

The grayscale image is used on most process and that input grayscale is taken up for image enhancement. If the input grayscale image is affected by any kind of noise, then we need to neglect the noise from the image by using the filtering technique, else input grayscale image has poor visibility, then we need to improve the visibility by increasing the level of contrast/brightness for getting the enhanced image as shown in Fig.4.

Fig. 2. Input Image

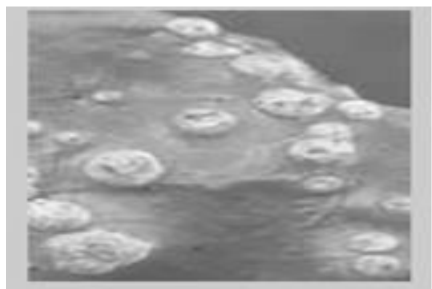

Fig. 3. Gray Scale Image

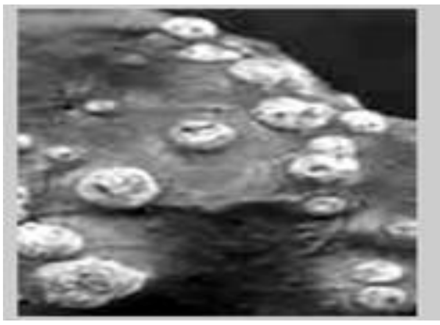

Fig. 4. Enhanced Image

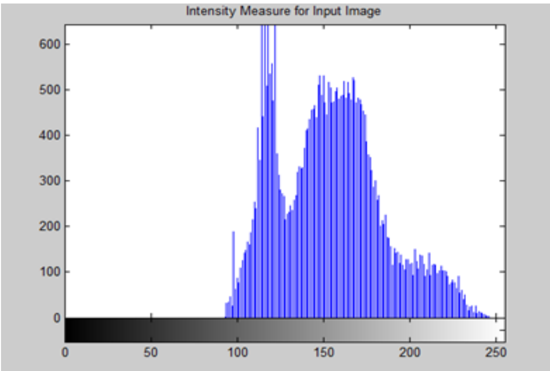

Fig. 5. Intensity Measure (Histogram) for Gray Scale Image

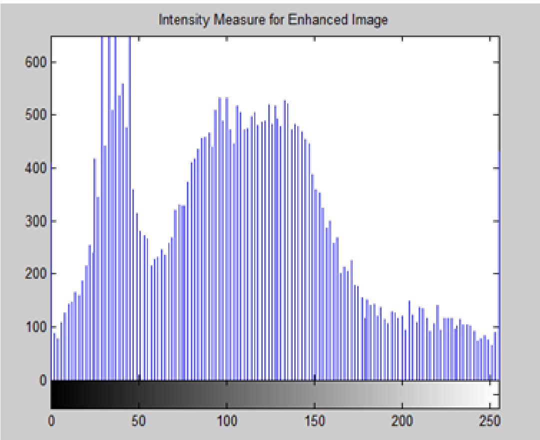

Fig. 6. Intensity Measure (Histogram) for Enhanced Image

4.2 Feature Extraction

After image enhancement, the next phase is feature extraction, so the enhanced image is segmented by FCM clustering method as shown in Fig.7. for obtaining the diseased region. The segmented diseased region is taken up for feature extraction purpose, and its obtained region features are gathered by using the Gabor features technique.

The wavelet (single-level) transformation is used as shown in Fig.8, its approximation values are taken out for further processing to extract the texture features by using Gabor as shown in Fig.9. Texture features values are applied to the Principal Component Analysis as input, for the purpose of dimension reduction.

GLCM [6] is used on the dimension reduced data for parameter calculation such as correlation, homogeneity, mean, skewness etc. such that 12-13 parameters are computed from the reduced data.

Fig. 7. Disease/Infected Region Segmentation – by using Fuzzy C Means Clustering

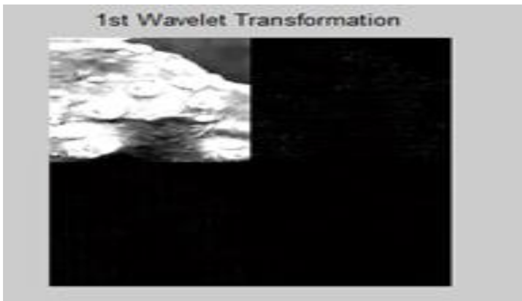

Fig. 8. Wavelet Transformation (First Level)

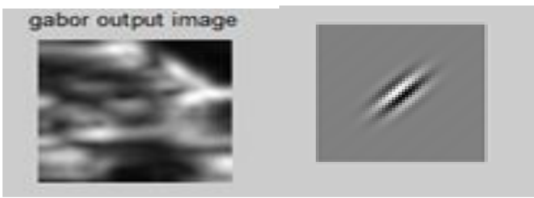

Fig. 9. Gabor (Texture) Features

4.3 Classification

In the next step of the feature extraction, the extracted data are combined into a single matrix. During preprocessing predicted label/class are separated, based on the class are presented to PNN classifier in numeric format like “0” & “1” The PNN architecture used for classification is shown in the Fig. 10. If their corresponding output is 0 – disease not affected & 1 - disease affected image. Based on the feature extracted data, the predicted class/label is given to the classifier and predicts the corresponding result/class.

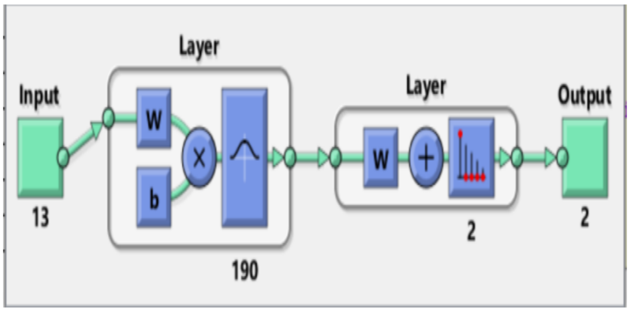

Fig. 10. PNN architecture

4.4. Experimental Results

In this work, a Fuzzy C Means clustering is designed to obtain the segmentation of the citrus leaf images and then the features are obtained from Wavelet Transform-Gabor. The features are selected, in case of high dimensionality in features and it can be reduced by using PCA. Whereas, dimensionality reduced features are applied to GLCM for parameter calculation, those parameters are combined them into single matrix and it's used for classification of various diseases using PNN.

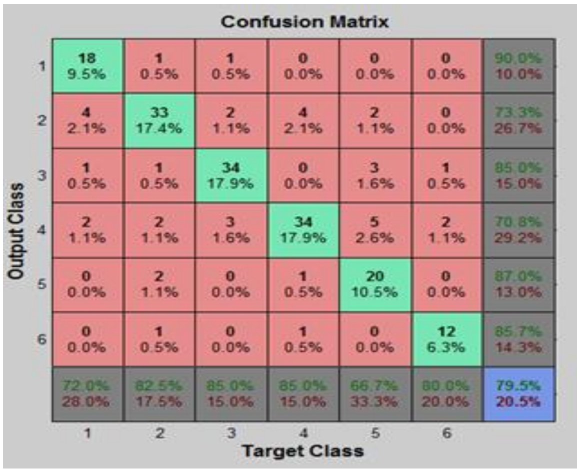

Fig. 11. Accuracy --- by using Confusion Matrix

The citrus image dataset is divided into training set and testing set in 80-20 ratio and used for training and testing the algorithms respectively. It has been found that the PNN had shown better results in identification and classification of diseases on plant leaf and fruits. The results shown in Fig. 11 are overall accuracies obtained from the different diseases.

If the detection of the disease in early stage can prevent the huge loss to the farmer and thus the productivity increases and there by the economy also increases. The advancement of drone technology where the data is collected and this data can be analyzed with these types of systems easily and also this information can be utilized for spraying the pesticides depending on the severity of the diseases selectively by using drones itself so that time, effects on the humans can also be reduced. The evaluation of the model is performed and Fig. 12 represents the ROC curve the different classification for the results obtained in the prediction of the diseased citrus leaves.

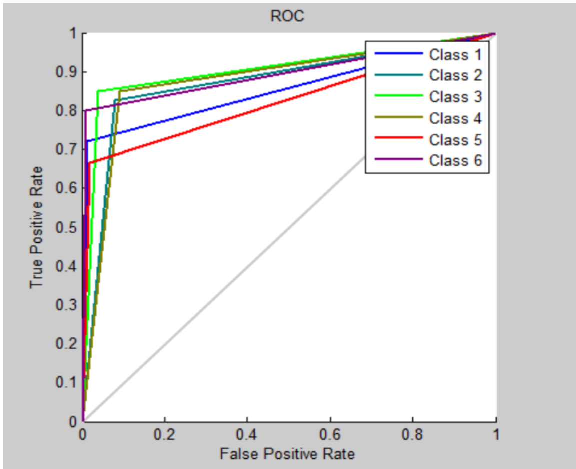

Fig. 12. ROC curve

The different levels of classification are Class1-Anthracnose disease, Class2-Blackspot disease, Class3-Citruscanker disease, Class4-Citrusscab disease, Class5-melanose disease, Class6-Normal and not affected with disease.

5. RESULTS AND DISCUSSION

In this section, the performance of existing systems SVM [5], PSO [13] and proposed system PNN classifiers compared, which are used to identify and predict the citrus plant diseases and are evaluated in measured in terms of accuracy, precision, recall and f-measure.

Accuracy measures the ratio of correct citrus disease detected and classified over the total number of citrus plant images evaluated. Accuracy is measured as,

$$Accuracy = \frac{True\ Positive\ (TP) + True\ Negative\ (TN)}{TP + False\ Positive\ (FP) + TN + False\ Negative (FN)}$$

Precision is used to measure the presence of citrus disease positive classes that are correctly detected to the total predicted patterns in a positive class. It can be measured as,

$$Precision = \frac{TP}{TP+FP}$$

Recall is used to measure the fraction of positive patterns that are correctly detected. It can be measured as,

$$Recall = \frac{TP}{TP+TN}$$

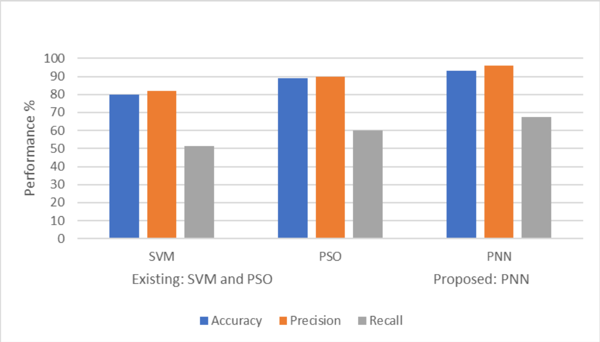

Fig.13 Comparison of Performance of PNN based proposed system with SVM and PSO

Fig.13 shows the accuracy, precision and recall of SVM and PSO-based citrus diseases detection and PNN-based citrus diseases.

The accuracy, precision and recall of PNN based proposed system for detection and classification has greater performance compared to SVM and PSO-based detection.

5. CONCLUSION

The proposed work, through the various stages of development namely dataset collection, data preprocessing, then segmentation, feature extraction, later training the classifier. For performing classification, the citrus image datasets of diseased and healthy leaves are collectively trained to detect and classify the diseased and healthy images.

Single level wavelet transformation and Gabor is used for feature extraction with PCA and gray level co-occurrence matrix. PNN classifier to train the datasets are available publicly which gives a clear way to detect and classify the disease in plants. Further, deep learning algorithms can be used to train the network (pre-trained network model) over a large amount of data has been classified & it's better identification and classification of the different disease over a wide variety of plants.

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