CHAPTER 9

SUMMARY AND CONCLUSION

Computer aided identification of plants is an area of research that has gained more attention in recent years and has proved to be a very important tool in many areas including forestry, agriculture, and pharmacological science. In addition, with the deterioration of environment, more and more rare plant species are on the verge of extinction. Many of the rare plants have died out, and hence, the investigation of plant recognition can contribute to environmental protection.

The field of leaf recognition for plant identification has experienced an increased need for fast and efficient classification algorithms to aid in keeping track of the most precious plants on earth. This demand has led to the development of several techniques which have revolutionized the area of automatic plant classification. The increase in the number of techniques has given rise to the dilemma of deciding which of these methods possess the best properties and potentials for effective classification. This problem is of particular importance in the botany field where the distortion of information may lead to inaccurate diagnosis. Thus, automated tools that help to identify plants are the current urgent need of the botanical field.

A general process of a Computer Aided Plant Classification Through Leaf Recognition (CAP-LR) contains four steps, namely, building the leaf database, image enhancement, segmentation (extraction of leaf), feature extraction and classification. The main aim of this research work is to propose techniques that enhance each operation of plant identification through leaf recognition.

An enhancement system called ‘Enhanced Wavelet based Denoising with inbuilt Edge Enhancement and Automatic Contrast Adjustment Algorithm (WEC Method)’ was proposed to enhance the leaf image. This method

combines wavelets, CLAHE (contrast adjustment), edge enhancement and relaxed median filter (noise removal), to improve the visual quality of the leaf image using a single procedure.

Texture based color feature segmentation technique called, 'Enhanced Wavelet based Segmentation using Clustering and Texture based Color Features (WCF Method)' was proposed to extract the leaf image from its background. The Proposed method extracted the color features using L*u*v color space and wavelet based coefficients to extract texture features to produce a high dimensional feature space. This high dimensional feature space is transformed to a low dimensional version using a mean-shift filtering approach. The results were then clustered using K-means algorithm.

During feature extraction, five types of features, namely, geometric, texture, color, fractal and leaf features are extracted. These features were combined to form four fused feature vectors, namely, GLFS (Geometric + Leaf), CLFS (Color + Leaf), TLFS (Texture + Leaf) and FLFS (Fractals + Leaf). Two feature selection algorithms, Genetic algorithm and Kernel principal component analysis algorithm were combined with shared and merged operators to select optimal feature sets.

The result of feature selection algorithm was then used by classifiers to recognize the leaves. A 2 level classifier is used for this purpose, where the output of first classifier is used to improve the performance of the second classifier. For this purpose, three classifiers namely, Back Propagation Neural Network, Wavelet Neural Network and Support Vector Machines were used. Using these three classifiers, nine classifier models of the two level classification models were developed for plant identification through leaf recognition.

Experiments were designed to evaluate the proposed algorithms of each step of CAP-LR. Two datasets, one standard dataset (flavia) and one real life dataset (created by the researcher) were used during experimentation. The enhancement algorithm was evaluated using four metrics, namely, Peak Signal

to Noise Ratio (PSNR), Figure of Merit (FoM), Mean Structural Similarity Index (MSSI) and Speed of enhancement (Seconds). The segmentation algorithm was evaluated by analyzing its visual results and speed of segmentation. The feature extraction and selection algorithms were evaluated in terms of number of features selected and time taken to select the most prominent set of features. Their effect on identification and recognition was also analyzed. The proposed CL-CL models were evaluated using three parameters, namely, recognition rate, error rate and speed.

Experimental results proved that the proposed algorithms when compared with the conventional algorithms were efficient in terms of all selected performance metrics.

Thus, from the results, it can be seen that maximum accuracy is produced while using leaf features followed by fractals, while considering single feature vectors. With fusion features, the leaf with fractal combination produced maximum advantage towards classification. The intersection operation on GA and KPCA selected features proved that they provide more effective results when compared with GA, KPCA and GA, KPCA with union operation.

During recognition, best results were produced when WNN was used for first level and SVM is used for second level. From the results, it can be seen that when different classifiers are used for level 1 and level 2 classification, the process of leaf recognition for plant identification is efficient in terms of parameters namely recognition rate, error rate and speed. In general, models that used different classifiers for first and second level produced better result when compared to the models that use the same classifier for both the levels and the models that use clustering for first level and classification for the second level.

The various results showed that the model that used WNN for the first classifier and SVM for the second classifier, with leaf + fractal feature set using GA ∩ KPCA for feature extraction and selection produced the best results.

This study proposed techniques to enhance the operation of leaf recognition for plant identification. The positive results obtained from the various experiments prove that the proposed models are effective in discriminating the various leaves and identifying the correct plant corresponding to an input leaf image. Hence, the botanists can safely use it to increase their effectiveness in recognizing the plants and thus save precious plants to improve the quality of human and earth life.

FUTURE RESEARCH DIRECTIONS

The following research studies can be considered in future to improve the CAP-LR systems. While creating leaf image databases, the research work considered only frontal and fresh leaves. In future, leaves that are wrinkled, occulted, and dry leaves can be considered and analyzed with CAP-LR. In a similar fashion, discoloration or discolored leaves is another challenging field of research that can be considered. To improve the speed of leaf recognition for plant identification, advanced operations like parallel processing of tasks can be studied. Parallel processing of tasks can be used to group together the execution of algorithms during the various stages of recognition.