Chapter 6

Epilogue

6.1 Preamble

Segmentation and classification algorithmic models for precision agriculture practices such as disease mapping at seedling level, selective harvesting and grading are proposed. Novel methods of lesion area segmentation and corresponding classification models are devised for disease mapping stage of precision agriculture of tobacco crop. We proposed two different models such as filter based model and texture based model for the classification of tobacco leaves for the purpose of harvesting. In addition, a novel method of symbolic representation of cured tobacco leaves is proposed for grading of cured tobacco leaves. Besides, an attempt is made towards creating our own datasets for seedling diseases, harvesting and grading of tobacco leaves.

In this chapter, the summary of all the proposed methods is presented. In sequel, the major contributions of the research work are listed. Subsequently, scope for further research based on the work presented in this thesis is envisaged.

6.2 Summary

In this thesis, a novel method of lesion area segmentation for classification of diseases on tobacco seedling leaves is proposed. The proposed lesion area segmentation is proved to be more accurate and precise in extracting lesion areas by evaluating it using region based performance measures. Further, models for classification of lesion areas into
disease types viz., anthracnose and frog-eye spot based on K-NN classifier and PNN classifier are devised. Further, we proposed two different models viz., filter based model and texture based model for classification of tobacco leaves for the purpose of harvesting. Thereafter, a novel method of representing cured tobacco leaves by the use of inter valued symbolic feature vector is proposed. Finally, a model for grading cured tobacco leaves is designed.

In chapter 1, a brief introduction on necessity of computer vision techniques for stages of precision agriculture is presented. A case study on tobacco crop with respect to precision agriculture is also elaborated. A brief survey on existing related works on precision agriculture using computer vision is presented. Objectives of the current work are listed in this chapter. General performance measures for evaluation of segmentation and classification models are also presented.

The method of collection and preprocessing that we followed for creating datasets of tobacco seedling diseases, tobacco harvesting and tobacco grading are presented in chapter 2. In addition, details on these datasets are also presented in this chapter.

In chapter 3, a novel model for classification of tobacco seedling diseases is proposed. To support this, a novel method of lesion area segmentation using contrast stretching transformation and morphological operations is proposed and it is evaluated using region based performance measures.

In chapter 4, we proposed two different models viz., filter based model and texture based model for classification of tobacco leaves for the purpose of harvesting. The filter based model is designed based on combination of first order edge extractor and second order filter. Two combinations such as (i) combination of laplacian filter and sobel edge detector and (ii) combination of laplacian filter and canny edge detector are exploited to design maturity spots detection algorithm. A method of finding the degree of ripeness of a leaf is proposed for effective classification of tobacco leaves. Alternatively, the texture based model is designed based on texture features such as LBP, LBPV, GLTP, Gabor response and Wavelet decomposition. Fusion of these texture features in different combinations is explored to improve the performance of the classification model. Feature
selection on fused vectors is also envisaged. To support this, we explored wrapper feature selection methods such as SFS, SBS, SFFS and SFBS. Further, a model for classification of tobacco leaves into three types viz., unripe, ripe and over-ripe based on K-NN classifier.

In chapter 5, a novel method of representing cured tobacco leaves by the use of interval valued symbolic feature vector is presented for the purpose of grading cured tobacco leaves. We exploited the Munsell color system to extract color features such as mean and standard deviation of hue of cured tobacco leaves of different grades. The novel interval representation depends on the minimum and maximum of respective individual features. In addition, we also have implemented a method of approximating the interval valued data by the use of mean and standard deviation of respective individual features (Guru and Prakash, 2009). The presented representation schemes reduces the time taken to grade a given test sample of a cured tobacco leaf, as there is only one representative vector for each class instead of n number (number of training samples of each class) of representative vectors in the knowledge base. The corresponding symbolic classifier is also devised.

The robustness and effectiveness of all the proposed models are brought out through extensive experiments on seedling dataset, harvesting dataset and grading dataset in the respective chapters. Nevertheless, the superiorities of the proposed models in terms of classification accuracy and F-measure are established.

In brief the following are the major contributions of the research work presented in this thesis.

**6.3 Contributions**

- Creation of a tobacco seedling dataset containing 100 sample images of infected leaves (Anthraconose-50, Frog-eye spot infected -50) and 50 sample images of uninfected leaves.
- Creation of a tobacco harvesting dataset containing 1300 sample images of tobacco leaves. Among 1300 sample images of tobacco leaves, there are 323
sample images of unripe leaves, 667 sample images of ripe leaves and 310 sample images of over-ripe leaves.

- Creation of a tobacco grading dataset containing totally 887 sample images of cured tobacco leaves of different grades.
- A novel lesion area segmentation algorithm to support the classification of tobacco seedling diseases.
- Exploitation of first order and second order statistical texture features to diagnose the type of disease on lesion areas and the corresponding classification models based on K-NN classifier and PNN classifier.
- A novel maturity spots detection algorithm to evaluate the ripeness of a tobacco leaf for harvesting and a novel model for classification of leaves.
- Proposal of fusion of various texture features and application of wrapper feature selection methods for classification of tobacco leaves for harvesting.
- A novel symbolic representation of cured tobacco leaves for grading and the corresponding symbolic classifier.

### 6.4 Scope for Future Work

The work presented in this thesis could be extended in many folds. Indeed to the best of our knowledge, this is the first attempt towards the development of computer vision based algorithmic models for the precision agricultural stages of a tobacco crop. Therefore, the presented research work is expected to open up a new avenue for exploiting the applicability of computer vision based algorithmic models for other commercial crops towards improving the performance of a precision agricultural system.

For addressing the problem of disease mapping at seedling stage of tobacco crop, we have presented novel lesion area segmentation algorithm. We can extend the proposed segmentation algorithm to tackle the problem of disease mapping for other commercial crops by tuning the parameters of an algorithm. We can also extend the proposed segmentation algorithm for disease mapping at plant level.
We have explored the textural features and wrapper feature selection methods for classification of tobacco leaves for the purpose of harvesting. Exploration of other feature selection methods to select the best discriminating features to enhance the performance of classification of tobacco leaves shall be an interesting future work.

In the present work, we proposed the ripeness evaluation algorithm to compute degree of ripeness of a tobacco leaf for the purpose of harvesting. In future, considering humidity factor in addition to maturity spot density and yellowness of leaf to define ripeness of a leaf may improve the performance of harvesting system.

In the current work, symbolic interval valued representation of cured tobacco leaves is proposed for the purpose of grading of cured tobacco leaves. In future, exploration of other symbolic representation schemes can improve the performance of a grading system. In future, fusion of color features of different color models may by tried to improve the accuracy of the grading system. In present work, we have designed the grading system for 12 grades of cured tobacco leaves. In future we can extend the proposed grading system for all 63 grades of cured tobacco leaves.