Comparative Analysis of Coconut Tree Disease Segmentation Using Fuzzy Rough C-Means and YOLO v8

[1]R.Mamallan and [2]S.Prabakaran[3]S.Menaka and [4]A.Sujitha

[1]Assistant Professor, Department of Electronics and Communication Engg., P.T.Lee Chengalvaraya Naicker College of Engineering and Technology, Kancheepuram, Tamilnadu, India.
[2]Assistant Professor, Department of Electronics and Communication Engg., P.T.Lee Chengalvaraya Naicker College of Engineering and Technology, Kancheepuram, Tamilnadu, India.
[3]Assistant Professor, Department of Electronics and Communication Engg., P.T.Lee Chengalvaraya Naicker College of Engineering and Technology, Kancheepuram, Tamilnadu, India.
[4]Assistant Professor, Department of Electronics and Communication Engg., P.T.Lee Chengalvaraya Naicker College of Engineering and Technology, Kancheepuram, Tamilnadu, India.

ABSTRACT

Early detection of plant diseases is crucial for preventing significant agricultural losses. Coconut palms are vulnerable to various pathogens, including fungi, bacteria, viruses, and nematodes, which impact yield quality and quantity. This paper presents a Fuzzy Rough C-Means (FRCM) segmentation algorithm for detecting coconut tree diseases. The proposed method is evaluated against OTSU segmentation and the YOLO v8 algorithm. Experimental results demonstrate the effectiveness of FRCM in disease identification. Accurate segmentation aids in timely disease management, improving decision-making in agriculture. The study highlights the importance of advanced detection techniques.

Key words: Segmentation, image processing, Fuzzy, Rough C Means , YOLO v8 and Disease.

INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Image pre-processing techniques are used to improve the quality of an image before processing into an application [1]. This uses a small neighborhood of a pixel in an input image to get a new brightness value in the output image. These pre-processing techniques are also called filtration and resolution enhancement. Most of the imaging techniques are degraded by noise. In order to preserve the edges and contour information of the Agricultural plant images, the efficient denoising and an improved enhancement technique is required. Gaussian, Median and Wiener filters are used for image de -noising.

Image segmentation is a daunting task in automatic image processing analysis [2]. It occupies vital position in many image processing applications, and it consists of sub-dividing the image into its constituent parts. Also, it extracts the Region of Interest (ROI) that should be homogeneous as for a few attributes. Image segmentation algorithms are developed based on two basic properties of intensity values: a)Similarity –Based b)Discontinuity-Based. In similarity-based approach, segmentation is done based on grouping of pixels based on some features. In discontinuity-based approach the partition is done based on some abrupt changes in gray level intensity of the image. a)Detection of Isolated Points b)Detection of Lines c)Edge Detection [3]. The agriculture sector can be considered as the backbone for any developing economy. To obtain the maximum yield from the crops, it is required that farmers should be provided with the best technologies and methodologies.

Coconut is a palm plantation vital for its various uses from its fruit to trunk. India is the third-largest producer of coconut and its by-products in the world [4]. The southern states of India contribute a majority of the production in the country. Any disease affecting the yield of the coconut plantation eventually affects the related industries and the livelihood of the families who depend on the coconut economy [5].

P. Balamurugan and R. Rajesh (2012) [6] deals with the classification of coconut tree leaves which are affected by one of the diseases named as 'leaf rot'. They used Neural Network Based System for the Classification of Leaf Rot Disease in Cocos Nucifera Tree Leaves. Abraham Chandy (2019) [7] proposed a precision agriculture technique to detect various pests in coconut trees with the help of NVIDIA Tegra System on Chip (SoC) along with a camera interfaced drone. The drone flies across the coconut farm and captures the images and processes the data using deep learning algorithm to identify the unhealthy and pest affected trees. The deep learning algorithm uses a set of sample pest database.

Dirami, Ahmed, et al (2013) [8] employed the Thresholding segmentation (THS), techniques to segment the images before going for the classification process. R. Mamallan, A.Sunitha (2025) [9] employed the proposed segmentation algorithm is YOLO v8 algorithm. Alshawwa et.al., (2019) [10] proposed the expert System which was produced to help farmers in diagnosing many of the coconut diseases such as: Bud Rot, Leaf Rot, Stem Bleeding, Tanjore wilt and Root (wilt). In this paper, section 1 discusses about the introduction of the proposed work. The major diseases and pests which are affecting coconut tree are discussed in section 2 and 3 respectively. Section 4 elaborates the implementation of Fuzzy rough C Means algorithm (FRCM) and YOLO v8 algorithm for segmentation of coconut tree images. The results and discussion of the proposed work is discussed in section 5. Section 6 gives the conclusion of the proposed work.

2. MAJOR DISEASES AFFECTING COCONUT TREES

a) Ganoderma – basal stem rot (BSR)

Basal stem rot (BSR) caused by the species of Ganoderma is one of the most devastating diseases of numerous perennial, coniferous and palmaceous hosts. The disease is also referred to as Thanjavur wilt, bole rot, Ganoderma disease and Anabe.

Fig.1. Ganoderma – basal stem rot

Fig.2. Root Wilt Disease

b) Root Wilt Disease (RWD)

Root (wilt) disease (RWD) caused by phytoplasma is one of the most devasting diseases of coconut palms. The major symptoms of the disease in leaves are wilting and drooping and flaccidity; ribbing, paling/yellowing and necrosis of leaflets are typical symptoms of foliar diseases.

c) Bud rot

Bud rot is a fatal disease of coconut palm, characterized by the rotting of the terminal bud and surrounding tissues. Even though it affects the palms of all ages, young palms in low lying and moist situations are more susceptible to the disease. Fungus perpetuates on the host debris, in crevices and natural openings of the dead tissue.

Fig.3. Bud rot

Fig.4.Leaf Blight

d) Leaf Blight

Bacterial leaf blight is a serious disease of coconuts during wet seasons. The drying up of the leaves from the tip downwards, the progress of infection being from the older leaves to the younger. The worst affected palms present the appearance of severe drought-affected trees.

e) Stem bleeding disease

A reddish-brown liquid oozes from cracks and holes in the stem. It seeps out and runs down the stem, turning black and staining the stem as it dries. The disease is caused by Chalara paradoxa, a mainly soil borne plant-pathogenic fungus that infects wounds and openings in the coconut stem.

Fig.5. Stem bleeding disease

Fig.6. Leaf rot

f) Leaf rot

The first symptom is the appearance of water-soaked brown lesions in the spear leaves of root-wilt affected palms. Gradually these spots enlarge and coalesce resulting in extensive rotting.

3. PESTS AFFECTING COCONUT TREES

a) Rhinoceros beetle

Pest population occurs round the year but population maximum during June – September coinciding with the onset of monsoon

b) Red palm weevil

It is the most destructive pest of young coconut palms. Unlike the Rhinoceros beetle, the adult weevil is incapable of causing any direct damage to the tree; on the other hand, the early stages of the weevil are passed on the palm and the damage caused to the tree by the weevil larvae is often fatal.

Fig.7.Rhinoceros beetle

Fig.8. Red palm weevil

c) Black-headed caterpillar

The leaf eating black headed caterpillar, Opisina arenosella is a serious pest of coconut palm causing significant yield loss in all the coconut growing tracts of India. It infests coconut of all age groups and is a prolific feeder of coconut leaves.

d) Coconut Eriophyid Mite and Termite

Termites are likely to cause damage to transplanted seedlings particularly in the earlier stage (wilting of seedlings).

Fig.9.Black-headed caterpillar Fig,10,Coconut Eriophyid Mite and Termite

In this paper, required data set is collected to detect the symptoms of the coconut plant diseases and pest infections. To remove the unwanted noise present in the captured image, wiener filter is used. Fuzzy rough C-means clustering technique is used to segment the infected region in the image.

4. SEGMENTATION METHODS

4.1 FUZZY ROUGH C-MEANS (FRCM) CLUSTERING ALGORITHM

Fuzzy Rough C-Means (FRCM) clustering algorithm is a hybrid clustering algorithm, termed as the FRCM It is developed by integrating the merits of both rough sets and fuzzy sets. The RFCM adds the concept of fuzzy membership of fuzzy sets, and lower and upper approximations of rough sets into *c*-means algorithm. While the membership of fuzzy sets enables efficient handling of overlapping partitions, the rough sets deal with uncertainty, vagueness, and incompleteness in class definition. The RFCM algorithm partitions a set $X = (x_1 \ldots, x_i \ldots \ldots, x_n)$ of *n* objects into *c* clusters by minimizing the following objective function

$$J = \sum_{i=1}^{c} J_i$$

Step (1): Compute the cluster prototypes (means):

$$V_i^{(j)} = \frac{\sum_{k=1}^{N} (\mu_{ik}^{(j-1)})^m X_k}{\sum_{k=1}^{N} (\mu_{ik}^{(j-1)})^m}, 1 \le i \le c \tag{1}$$

Step (2): Compute the distances:

$$D_{ikA}^2 = (X_k - V_i^{(j)})^T A (X_k - V_i^{(j)}), \quad 1 \le i \le c,\ 1 \le k \le N \tag{2}$$

Step (3): Update the partition matrix:

If $D_{ikA} > 0$ for $1 \le i \le c, 1 \le k \le N,$

$$\mu_{ik}^{(j)} = \frac{1}{\sum_{n=1}^{c} (D_{ikA}/D_{nkA})^{2/(m-1)}}$$

Otherwise

$$\mu_{ik}^{(j)} = 0 \text{ if } D_{ikA} > 0, \text{ and } \mu_{ik}^{(j)} \in [0,1] \quad \text{with } \sum_{i=1}^{c} \mu_{ik}^{(j)} = 1 \tag{3}$$

Until $\| U^{(j)} - U^{(j-1)} \| < \varepsilon$.

In the FRCM, each cluster is represented by a centroid, a crisp lower approximation and a fuzzy boundary. The lower approximation influences the fuzziness of final partition.

4.2 YOLO V8 ALGORITHM (YOU ONLY LOOK ONCE VERSION 8.

YOLO v8 algorithm (You Only Look Once version 8) is a state-of-the-art deep learning model designed for real-time object detection and segmentation tasks. While YOLO traditionally excels at detecting bounding boxes around objects, YOLO v8 algorithm introduces the capability of performing pixel-level segmentation. Segmentation is the process of partitioning an image into multiple segments or regions, which makes it more useful for detailed tasks like object delineation. With the ability to generate masks for each detected object, YOLOv8 combines both detection and segmentation tasks within a single, unified model, thus facilitating more accurate and granular recognition.

YOLO v8' architecture provides several advantages for segmentation tasks. The key benefit lies in its ability to process both detection and segmentation simultaneously, significantly improving the efficiency of the model. This is accomplished through a hybrid approach where the model not only predicts bounding boxes but also generates segmentation masks. With YOLO v8, object boundaries are delineated more precisely, making it ideal for tasks such as instance segmentation, where each object in a scene needs to be uniquely identified and segmented. YOLOv8's high-speed inference allows it to operate in real-time, making it suitable for applications in autonomous driving, robotics, and medical image analysis.

YOLOv8 performs segmentation by integrating a segmentation head with the standard detection architecture. This segmentation head produces pixel-level masks for each detected object in the image. The model uses a convolutional neural network (CNN) backbone, typically a variant of Efficient Net or CSPDarkNet, to extract high-level features from the input image. These features are then passed through the segmentation head, which utilizes specialized layers like the DeepLabV3+ module to generate the final segmentation map. This allows YOLOv8 to output both the bounding boxes and the detailed masks of each object, offering more precise segmentation results compared to traditional detection models.

The ability to perform segmentation with YOLO v8 opens up numerous applications across various industries. In the field of autonomous driving, YOLO v8 can be used for semantic segmentation, identifying road lanes, vehicles, pedestrians, and other obstacles. In medical imaging, it can assist in segmenting organs, tumors, or other structures in radiological scans. Furthermore, in agriculture, YOLO v8 can help segment crops and detect diseases, enabling precision farming. The versatility of YOLO v8 for segmentation ensures that it can be applied in numerous domains where pixel-perfect detection of objects is crucial, and it continues to be refined for even better accuracy and performance in future iterations.

5 RESULTS AND DISCUSSION

The sample images shown in Figs 11(a), 12(a), 13(a) and 14(a) namely leaf blight, stem bleeding and healthy images are given as input to wiener filter. The pre processed outputs are presented in Figs. 11(b),12(b),13(b) and 14(b). The pre processed outputs are given as input to the segmentation algorithms like FRCM and OTSU**.** The segmentation results of the image processing algorithm are shown in Fig.11(c,d), 12 (c,d), 13(c,d) and 14(c,d). The segmentation results of the image processing YOLO v8 algorithm are shown in Fig.11(e), 12 (e), 13(e) and 14(e). The results indicate that the FRCM segmentation algorithm performed better than OTSU method for segmenting the regions. OTSU does a good job in segmenting the portion of the leaf blight; however, in other categories, it did not perform very well. Furthermore, OTSU fails to segment the portion of the stem bleeding. On the other hand, FRCM segmentation carries out its function to segment relevant regions in every category without problems. The results indicate that the YOLO v8 segmentation algorithm performed better than FRCM and OTSU method for segmenting the regions. For example, stem bled, Root Wilt Disease and Bud rot regions and sections with holes are properly segmented.

Table 1. Comparison of Classification Accuracy between FRCM and YOLOv8 Segmentation Methods Classification

S.No	Disease	Samples taken	FRCM	YOLO v8 Rightly detected
1	Leaf blight	100	95	95
2	Stem bleeding	100	96	96
3	Root Wilt Disease	100	94	96
4	Bud rot	100	95	96
	Total	400	380	383

Fig.11(a) Sample Image 1 (Leaf Blight)

Fig.11(b) Pre processed output

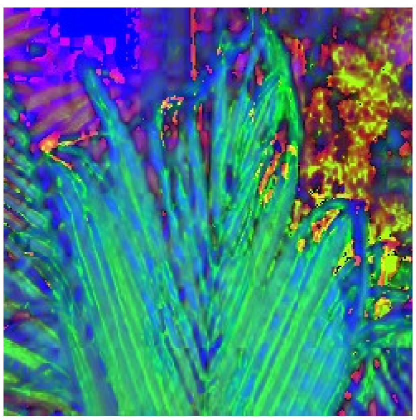

Fig.11(C) Segmented output using FRCM

Fig.11(d) Segmented output using OTSU

Fig.11(e) Segmented output using YOLO V8

Fig.12 (a) Sample Image 2 (Leaf Blight)

Fig.12(b) Pre processed output

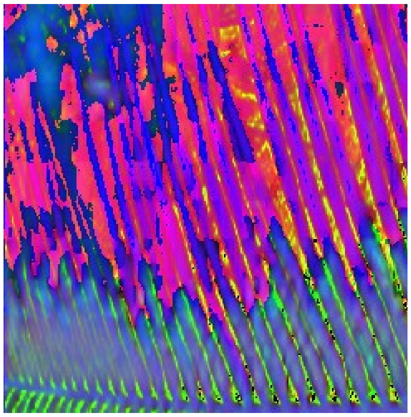

Fig.12(c) Segmented output using FRCM

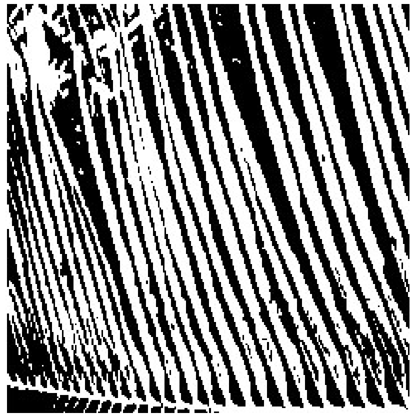

Fig.12(d) Segmented output using OTSU

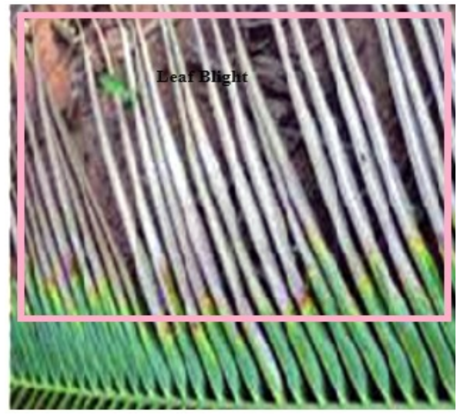

Fig.12(e) Segmented output using YOLO V8

Fig.13(a) Sample Image 3 (Stem Bleeding)

Fig.13(b) Pre processed output

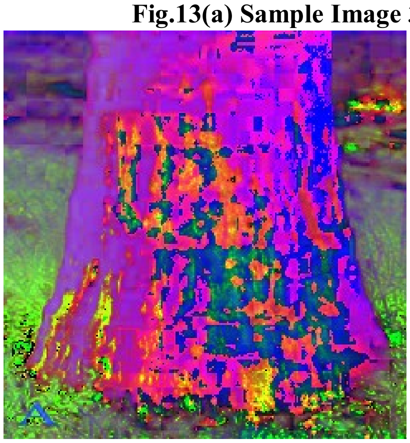

Fig.13(c) Segmented output using FRCM

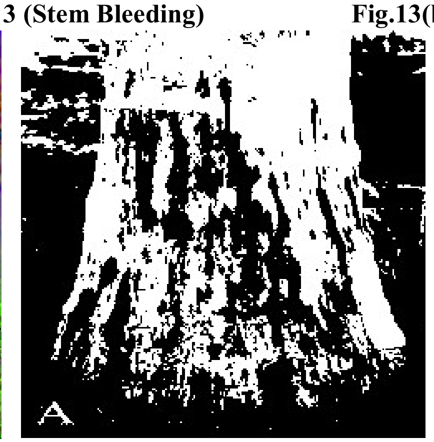

Fig.13(d) Segmented output using OTSU

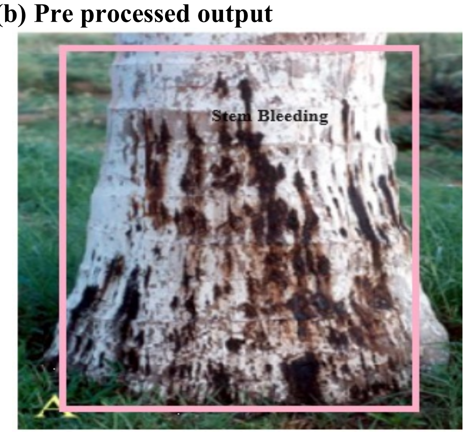

Fig.13(e) Segmented output using YOLO V8

Fig.14(a) Sample Image 4 (Healthy image)

Fig.14(b) Pre processed output

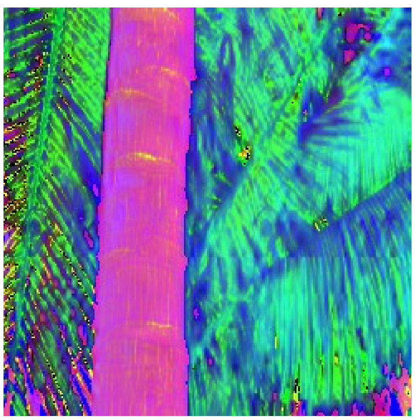

Fig.14(c) Segmented output using FRCM

Fig.14(d) Segmented output using OTSU

Fig.14(e) Segmented output using YOLO V8

6 CONCLUSION

In this study, coconut tree diseases and pests affecting coconut trees were analyzed using different segmentation techniques. The dataset was collected, pre-processed using the Wiener filter, and segmented using Fuzzy Rough C-Means (FRCM), OTSU thresholding, and YOLOv8 segmentation algorithms. The performance of these methods was evaluated to determine their effectiveness in segmenting diseased regions.

The results indicate that the FRCM algorithm outperformed the OTSU method in segmenting affected regions, as OTSU struggled with certain disease categories, particularly stem bleeding. While OTSU performed well in segmenting leaf blight, its overall segmentation accuracy was lower than that of FRCM. In contrast, the YOLOv8 segmentation algorithm demonstrated superior performance compared to both FRCM and OTSU, effectively segmenting relevant regions across all disease categories with higher accuracy and robustness.

Overall, the findings suggest that YOLOv8 is a more efficient and reliable method for coconut tree disease segmentation, offering improved precision and consistency over traditional segmentation approaches. Future work could focus on enhancing segmentation accuracy further by integrating deep learning-based refinements and exploring hybrid models for improved disease detection and classification.

REFERENCE PAPER

1. Sann, Si Si, Swe Swe Win, and Zin Minn Thant. "An analysis of various Image Pre-Processing techniques in Butterfly Image." *International Journal for Advance Research and Development* 6.1 (2021): 1-4.
2. Song, Yu, et al. "Deep learning-based automated image segmentation for concrete petrographic analysis." *Cement and Concrete Research* 135 (2020): 106118.
3. Kumar, Rajiv, M. Arthanari, and M. Sivakumar. "Image segmentation using discontinuity-based approach." *Int. J. Multimedia Image Process* 1 (2011): 72-78.
4. Singh, Piyush, Abhishek Verma, and John Sahaya Rani Alex. "Disease and pest infection detection in coconut tree through deep learning techniques." *Computers and electronics in agriculture* 182 (2021): 105986.
5. Yamuna, S. M. "A study of coconut cultivation and marketing in Pollachi Taluk." *International Journal of Innovative Research in Management Studies* 1.2 (2016): 77-98.
6. Balamurugan, P., and Reghunadhan Rajesh. "Neural network based system for the classification of leaf rot disease in cocos nucifera tree leaves." *European Journal of Scientific Research* 88.1 (2012): 137-145.
7. Chandy, Abraham. "Pest infestation identification in coconut trees using deep learning." *Journal of Artificial Intelligence* 1.01 (2019): 10-18.
8. Dirami, Ahmed, et al. "Fast multilevel thresholding for image segmentation through a multiphase level set method." *Signal processing* 93.1 (2013): 139-153.
9. Alshawwa, Izzeddin A., Abeer A. Elsharif, and Samy S. Abu-Naser. "An Expert System for Coconut Diseases Diagnosis." *International Journal of Academic Engineering Research (IJAER)* 3.4 (2019).
10. Ershadul Haque , Manoranjan Paul , Ashikur Rahman , Faranak Tohid , Md. Jahirul Islam, ,“ rice leaf disease detection and classification using shallow trained yolov7 active deep learning approach (2023): 516-522
11. R. Mamallan and E. Sivaraman “Coconut tree disease segmentation using Fuzzy Rough C-Means clustering algorithm” *Journal of Xidian University,* VOLUME 16, ISSUE 5, 2022
12. R. Mamallan and A.Sujitha “Coconut tree disease segmentation using YOLOv8 (You Only Look Once version 8)” *Journal of Xidian University,* VOLUME 19 – ISSUE 2 – February 25,Page No: 55 – 62