Detection of Fungal Disease in Cabbage Images Using Adaptive Thresholding Technique Compared with Threshold Technique

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Abstract

*Aim: To improve the detection rate of fungal disease in cabbage leaf images using the adaptive thresholding algorithm in terms of accuracy and sensitivity. **Materials and methods:** The accuracy and sensitivity of adaptive thresholding algorithm (n=272) was compared with thresholding algorithm (n=272) with p-value 0.8 and appears to be improved the detection rate of fungal disease in cabbage in terms of accuracy and sensitivity in the MATLAB simulation tool. **Result:** The adaptive thresholding algorithm has appeared to be accuracy (80.5%) and sensitivity (93.5%) than the thresholding algorithm accuracy(62.7%) and sensitivity(43.1%). Adaptive thresholding algorithm has appeared to be accuracy (p=0.26) and sensitivity (p=0.614) compared with the thresholding algorithm. **Conclusion:** It appears to be that the detection rate is better using adaptive thresholding algorithm compared with thresholding algorithm in terms of accuracy and sensitivity.*

Key-words: Fungal Disease, Thresholding, Novel Adaptive Thresholding Algorithm, Image Processing.

1. introduction

India is an agriculture based country and we all know that agriculture is the backbone of our country. The agriculture field plays an important role in the economic development of the country. The need for monitoring agriculture is increasing as diseases occur in the plants is increasing. In this study fungal disease in cabbage is detected using adaptive thresholding compared with thresholding algorithms (Singh and Misra 2017). The most common types of diseases that infects the plants are bacterial, fungal, and viral infections. Cabbage plants are affected by various fungal diseases. In this

we will mainly concentrate on spotting the fungal diseases in cabbage plants and prevent the plant from being infected and spoiled (Fang and Ramasamy 2015). Detecting diseases by human experts observation is possible to only some extent. By using the proposed technique, we can detect the disease at an early stage which results in increase in the productivity of the crop. Decrease the loss that occurs in the agriculture sector. Increase in the quality of the crop and increase the country's economy (Chen et al. 2013). Detecting fungal disease in cabbage would assist the farmers in keeping the plants healthy and clean, thus ensuring the health of both plants and humans. (Bharate and Shirdhonkar 2017).

There have been 20 research papers written in the last five years on fungal disease detection in plants. Fungal disease in cabbage is detected using an adaptive thresholding algorithm. The heavy metals have adverse effects on plant diseases. These heavy metals are one of the reasons for plant stress (Morkunas et al. 2018). Different types of imaging techniques are used for plant disease detection (Pathmanaban, Gnanavel, and Anandan 2019). sclerotina sclerotiorum and botrytis cineria are the two types of fungus which can infect the plant. But, the exogenous DSRNA can protect the plant effectively from those fungus (McLoughlin et al. 2018). Hormetic dose responses are induced by grand level ozone in plants. Ozones impact on vegetation based on linear non-threshold is minimum (Agathokleous et al. 2019). Recent applications of imaging techniques is the best study and the motivation behind doing the research is disease detection in plants prevents the loss in the agriculture field (Pathmanaban, Gnanavel, and Anandan 2019).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S. R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Parvarish Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

The main aim of this research is to detect the fungal disease in cabbage image with high accuracy using adaptive thresholding algorithm. Because, the detection rate of fungal disease in cabbage images using thresholding algorithm is poor.

2. Materials and Methods

The study setting of the proposed work is done in our university. The number of groups identified for the study is 2. One group refers to an adaptive thresholding algorithm and the other

group refers to thresholding algorithm. For each group the sample size is 272 (Kane, Phar, and BCPS n.d.). The total sample size of this research work is 544. The pre-test analysis is found to be 80%.

In sample preparation group 1, fungal disease in cabbage leaf image is detected using adaptive thresholding algorithm. It is a Novel Algorithm in which k-means clustering is used to detect the fungal disease in Cabbage leaf images. It is a method used for determining the value for smaller regions resulting in varying threshold values for different regions. A grayscale or colour image is usually used as an input for adaptive thresholding and output is displayed as a binary image. Based on the pixel intensities of each area, adaptive thresholding is used to distinguish suitable foreground image objects from the background. Over the course of the picture adaptive thresholding adjusts the threshold dynamically. In adaptive thresholding there are different threshold values for different regions of the image. Whereas in other types the threshold value will be a global value. In this approach we will analyse the strength values of each pixel's local neighbourhood statistically. The measurement which is more suitable relies to a great extent upon the information of the picture. The value of the adaptive threshold technique is determined automatically. And we select the area of interest of an image and will ignore the parts that we are not concerned with in this algorithm.
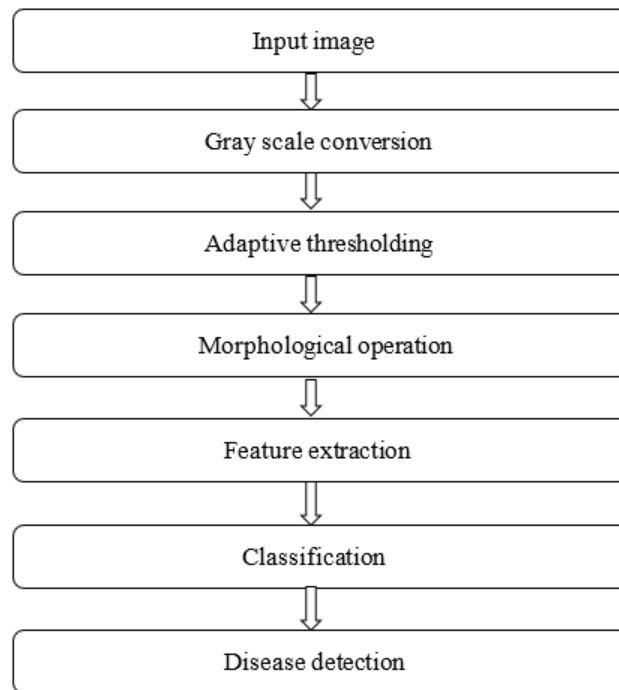
In sample preparation group 2, the fungal disease in cabbage leaf image is detected using thresholding algorithm. It is the basic method of image segmentation and it is used to construct the binary image (Mapayi, Viriri, and Tapamo 2014; Tete and Kamlu 2017a). Each pixel in an image is converted into black pixel in a thresholding method if the image intensity is lower than the predetermined value (Meunkaewjinda et al. 2008). Thresholding involves replacing each pixel in an image with black pixel if the intensity is less than any fixed constant or the white pixel if image intensity is greater than the constant (Kim and Fessler 2018). There are many types of thresholding techniques(Dhal et al. 2020). They are histogram based, Entropy based, Spatial method.

Matlab toolkit (2016) is used for simulation with required add ons installed. Write the code for fungal disease detection in cabbage using adaptive threshold algorithm in matlab's new script.

As shown in **Fig. 1**, the first step is digital images of plant leaves are collected from a data set to give input. Cabbage image is given as an input image and the image is converted into grayscale. After that adaptive thresholding is applied. To remove the unwanted area from the image and decrease the noise in the image morphological operation will be performed. It highlights the diseased portion of the leaf So that it will be easier for the detection of fungal disease. After performing the morphological operation the features are extracted from the image. Then the feature vector is compared with the features of the database. Based on the matching status classification of the disease will be done. Finally the detected disease will be displayed as a result. In this research work Image

with fungal disease is taken as independent variables in this study, and based on this output images will be shown in the command window with dependent variables accuracy and sensitivity. Detection rate will be calculated with the help of output variables.

Fig. 1 - Flow Chart for Disease Detection in Cabbage Image

Input image

Gray scale conversion

Adaptive thresholding

Morphological operation

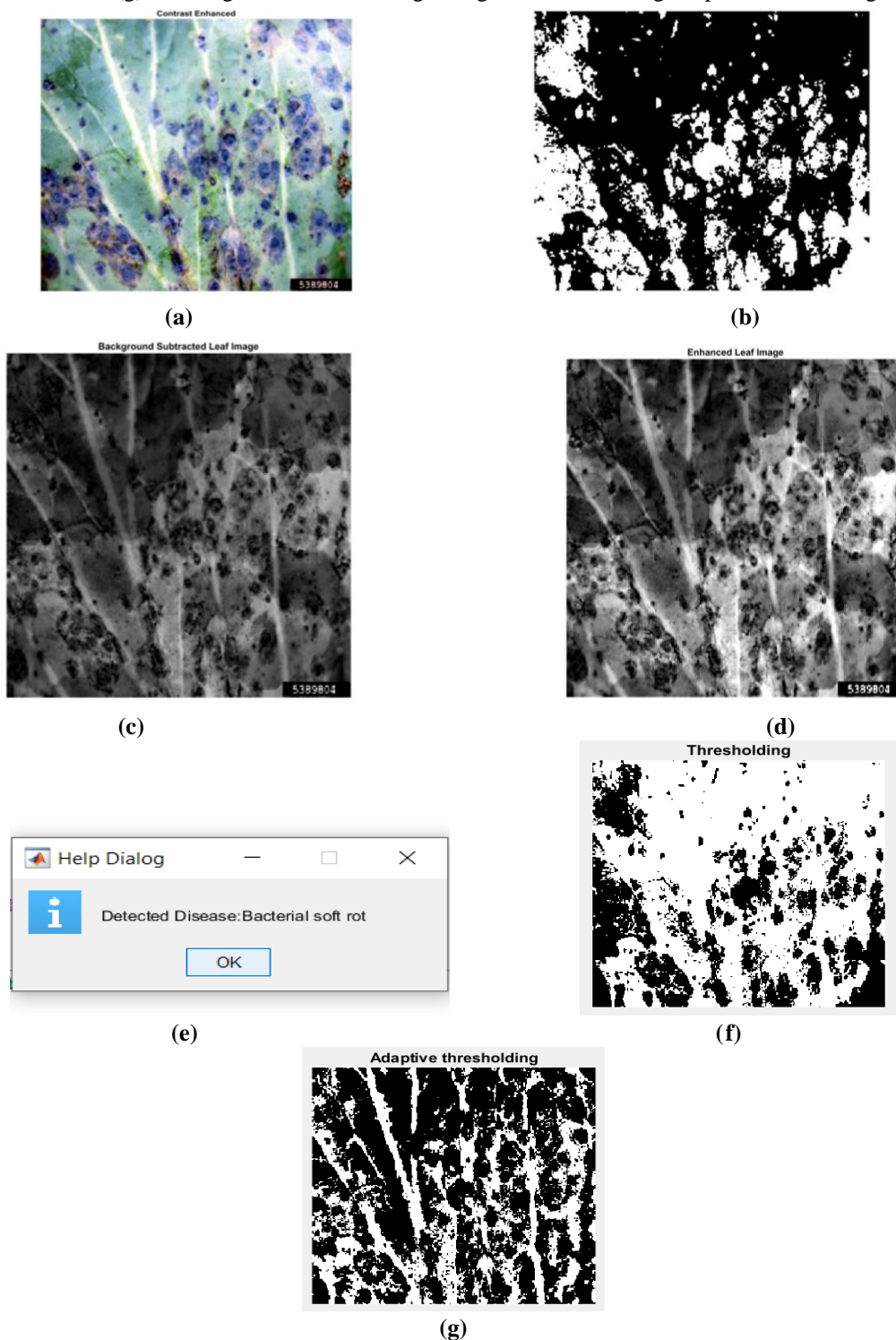Feature extraction

Classification

Disease detection

3. Results

Figure 2 Represents The input is the cabbage image in rgb form in which the contrast of the image is enhanced. The contrast is enhanced because it improves the quality of the image as shown in (a). After the image contrast is enhanced it is converted into a grayscale image for better understanding of the image and it will be easier for the detection of the disease as shown in (b). After the grayscale conversion of the image, the background subtraction is done. This process is done to remove background data as shown in (c). Because background data sometimes leads to the ambiguous results. After the background subtraction, the total image will be enhanced. The image is enhanced to highlight the disease portions of the leaf. So that we can detect the disease clearly as shown in (d). As shown in (e) the detected fungal disease type in cabbage image is displayed on the screen as a result. As shown in (f), the fungal disease in cabbage image is detected using thresholding. As shown in (g), the fungal disease in cabbage image is detected using adaptive thresholding. But, the adaptive thresholding algorithm appears to be improved in terms of accuracy and sensitivity when compared to the thresholding algorithm.

Fig. 2 - The input is the cabbage image in rgb form in which the contrast of the image is enhanced. The contrast is enhanced because it improves the quality of the image as shown in (a). After the image contrast is enhanced it is converted into a grayscale image for better understanding of the image and it will be easier for the detection of the disease as shown in (b). After the grayscale conversion of the image, the background subtraction is done. This process is done to remove background data as shown in (c). Because background data sometimes leads to the ambiguous results. After the background subtraction, the total image will be enhanced. The image is enhanced to highlight the disease portions of the leaf. So that we can detect the disease clearly as shown in (d). As shown in (e) the detected fungal disease type in cabbage image is displayed on the screen as a result. As shown in (f), the fungal disease in cabbage image is detected using thresholding. As shown in (g), the fungal disease in cabbage image is detected using adaptive thresholding.

(a)

(b)

(c)

(d)

(e)

(f)

(g)

Accuracy and sensitivity are taken for 20 sample images in table 1. These were used in the spss software to get the group statistics which contains the mean values of accuracy and sensitivity and standard deviation has been calculated in table 2 which is obtained from the outputs of spss. Table 3 shows the testing of independent variables in which significance, mean difference and standard error deviation has been given for the adaptive thresholding algorithm and thresholding algorithm. **Fig. 3** and **Fig. 4** shows the graph comparison between adaptive thresholding and thresholding algorithms. **Fig. 5** shows the comparison graph for adaptive thresholding algorithm and thresholding algorithm in which accuracy and sensitivity of both the algorithms are compared and to find the effective algorithm for the detection of fungal disease in cabbage.

Table 1 - Accuracy and sensitivity values for adaptive thresholding algorithm and thresholding algorithm. These were obtained by simulating the images in matlab tool.

S.NO	Adaptive thresholding algorithm		Thresholding algorithm	
	accuracy	sensitivity	accuracy	sensitivity
1	.85	1	.60	.38
2	.73	1	.69	.44
3	.75	.54	.66	.42
4	.71	1	.71	.72
5	.80	1	.68	.46
6	.86	1	.45	.33
7	.79	1	.62	.43
8	.75	1	.72	.53
9	.74	1	.71	.53
10	.82	1	.63	.46
11	.83	.70	.77	.64
12	.95	1	.37	.23
13	.81	.48	.79	.88
14	.84	1	.64	.39
15	.82	1	.47	.14
16	.88	1	.63	.36
17	.76	1	.69	.47
18	.79	1	.68	.42
19	.80	1	.48	.36
20	.84	1	.56	.36

Table 2 - Group statistics T-test: comparison of accuracy and sensitivity of adaptive thresholding and thresholding algorithms. There is a statistically significant difference in accuracy and sensitivity of adaptive thresholding algorithm and thresholding algorithm. Accuracy of adaptive thresholding has the highest mean (.8054) over thresholding algorithm (.6276). sensitivity of adaptive thresholding algorithm has a mean of .9359 which is higher and thresholding algorithm has the lowest mean of .4319

Group		No of samples	mean	Std. deviation	Std. mean error
Accuracy	Adaptive thresholding	272	.8054	.05728	.01281
	thresholding	272	.6276	.11107	.02483
Sensitivity	Adaptive thresholding	272	.9359	.16062	.03592
	Sensitivity	272	.4319	.12780	.02858

Table 3 - independent sample test The mean, standard deviation and significance difference of accuracy and sensitivity for adaptive thresholding algorithm and thresholding algorithm. There is a significant difference between the two groups since p<0.05 (independent sample test)

Levene's test for equality of variances		F	Sig	T- test for equality of means					95% confidence interval of the difference	
				t	df	sig(2-tailed)	Mean difference	Std. error diff	lower	upper
accuracy	Equal variances assumed	5.390	0.26	6.363	38	<.001	.17782	.02794	.12125	.23438
	Equal variances not assumed			6.363	28.440	<.001	.17782	.02794	.12062	.23501
Sensitivity	Equal variances assumed	.259	.614	10.983	38	<.001	.50408	.04590	.41116	.59699
	Equal variances not assumed			10.983	36.173	<.001	.50408	.04590	.41101	.59714

Using matlab toolkit, simulation has been done and the results have been obtained. In this study using IBM SPSS software analysis was done. The Accuracy and sensitivity of the adaptive thresholding and thresholding algorithms are analysed using SPSS. The mean accuracy has been calculated by iterating 20 samples and group statistics and an independent sample test has been done and results were analysed using SPSS and obtained graphs.

Fig. 3 - Accuracy graph which shows the difference between adaptive thresholding algorithm and thresholding algorithm and there is a significant difference between two algorithms.
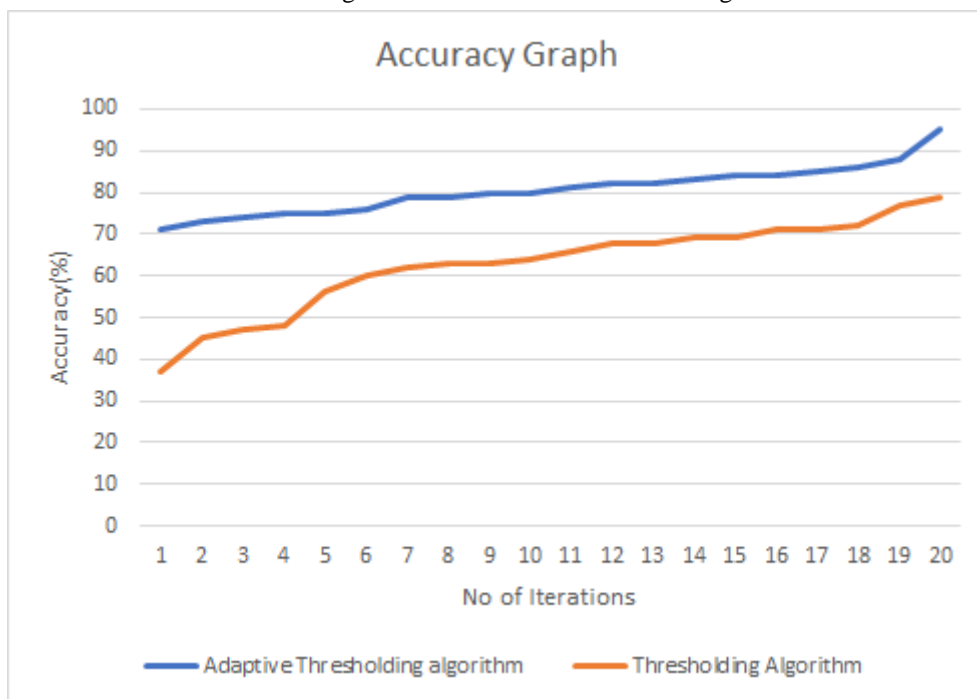
Fig. 4 - Sensitivity graph which shows the difference between adaptive thresholding algorithm and thresholding algorithm and there is a significant difference between two algorithms
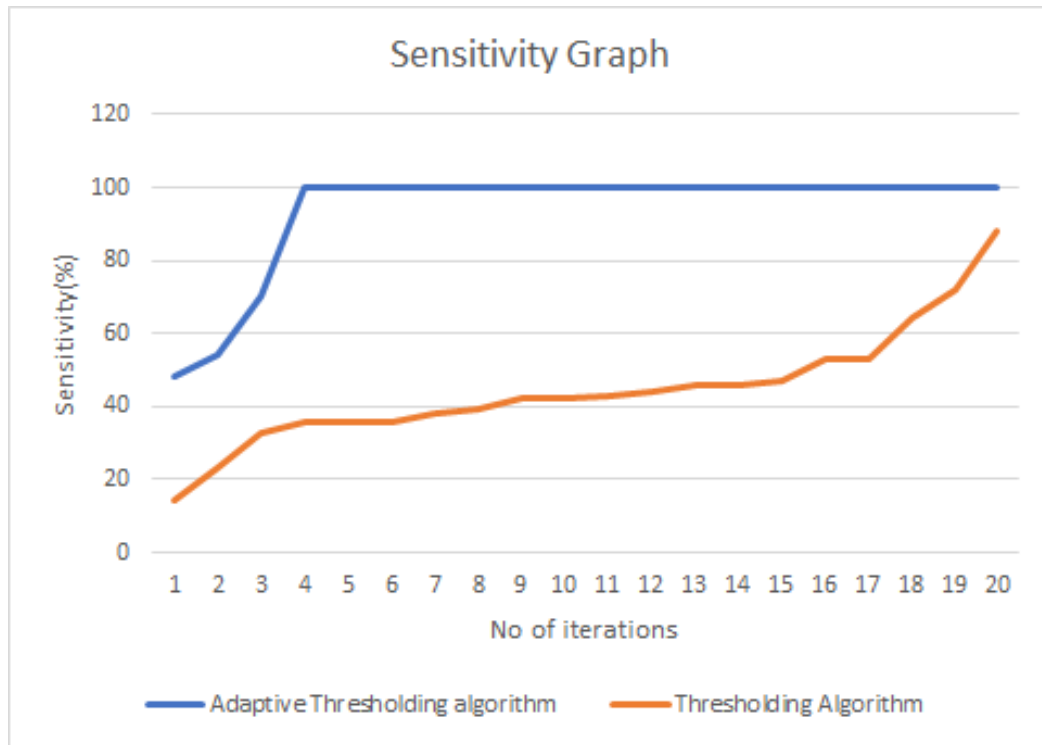

Fig. 5 - Graph obtained using SPSS that compares sensitivity and accuracy of adaptive thresholding algorithm and thresholding algorithm. and it shows that adaptive thresholding algorithm appears to be better at Accuracy and Sensitivity compared with thresholding algorithm. In the graph adaptive thresholding algorithm and thresholding algorithm are compared in x-axis and Mean of Accuracy and Sensitivity with +/- 1 SD.
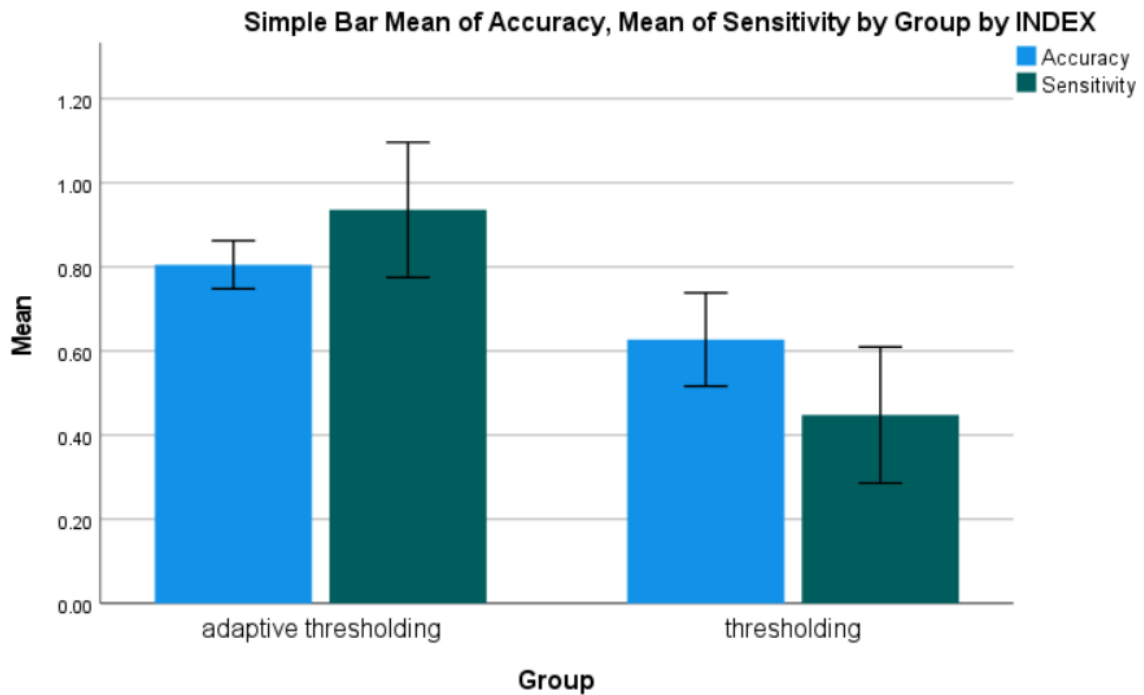
4. Discussion

Adaptive thresholding algorithm have accuracy (80.5%) and sensitivity (93.5%) compared with the Accuracy (62.7%) and Sensitivity (43.1%) of thresholding algorithm. It appears to be a better detection rate in terms of accuracy and sensitivity using adaptive thresholding algorithm compared with thresholding algorithm. The pre-test analysis is found to be 80% and (p=0.26).

Adaptive thresholding algorithm is able to detect the fungal disease in cabbage leaf images more clearly. Whereas the thresholding algorithm is unable to detect the disease in cabbage leaf images such effectively (Ray et al. 2017). In plant disease detection, feature extraction and classification plays a major role. Hence we use svm classifier (Gupta 2019). In plant disease detection major image processing steps which includes image acquisition, pre-processing, and image segmentation has been explained briefly and uses features of image like colour, shape, size, texture for the successful detection of diseases in plants. So, we use an adaptive thresholding algorithm which is the advanced technique for the detection of fungal disease in cabbage leaf images using image processing and classifiers (Khajuria and Khajuria 2019). plant diseases can be detected using ANN and its families. The ANN is also a computing system which is used to detect the disease in plants. The fungal disease detection in adaptive thresholding algorithm has more detection rate when compared to thresholding algorithm (Parul Sharma, Berwal, and Ghai 2020). Different image processing based methods have been used to identify and classify leaf diseases on various agriculture plants. Early identification of fungal disease in cabbage leaves has become more difficult in recent years.(Tete and Kamlu 2017b). Since the plants are mostly exposed to the outside world they are highly susceptible to fungal diseases.(Sun, Jia, and Geng 2018) Therefore the prevention and control of plant diseases have become a tough task. Picture segmentation and recognition systems have seen a variety of advancements. Among them histogram segmentation approach will give good results.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

Disease detection is not possible in any other plants. detection of fungal disease in dry diseased cabbage leaves is low. can improve the accuracy by using some other algorithms and techniques. The sensitivity value in adaptive thresholding algorithm can be less than the value in thresholding algorithm in very rare cases. The future scope is different image processing techniques

can be used for the detection of fungal disease in plants with improved accuracy and sensitivity. Advanced algorithms along with filters for the detection of fungal disease can be used.

5. Conclusion

Based on the result, the detection rate of fungal disease in cabbage leaf images appears to be better in terms of accuracy (80.5%) and sensitivity (93.5%) using adaptive thresholding algorithm compared with the accuracy (62.7%) and sensitivity (43.1%) of thresholding algorithm.

Declarations

Conflict of Interests

No conflict of interests in this manuscript.

Author Contribution

Author SA was involved in image collection, analysis of image and manuscript writing. Author SP was involved in conceptualization, image validation, and critical review of manuscript.

References

Agathokleous, Evgenios, Regina G. Belz, Vicent Calatayud, Alessandra De Marco, Yasutomo Hoshika, Mitsutoshi Kitao, Costas J. Saitanis, Pierre Sicard, Elena Paoletti, and Edward J. Calabrese.

2019. "Predicting the Effect of Ozone on Vegetation via Linear Non-Threshold (LNT), Threshold and Hormetic Dose-Response Models." *Science of The Total Environment*. https://doi.org/10.1016/j.scitotenv.2018.08.264.

Bharate, Anil A., and M. S. Shirdhonkar. 2017. "A Review on Plant Disease Detection Using Image Processing." *2017 International Conference on Intelligent Sustainable Systems (ICISS)*. https://doi.org/10.1109/iss1.2017.8389326.

Chen, Quansheng, Chaojie Zhang, Jiewen Zhao, and Qin Ouyang. 2013. "Recent Advances in Emerging Imaging Techniques for Non-Destructive Detection of Food Quality and Safety." *TrAC Trends in Analytical Chemistry*. https://doi.org/10.1016/j.trac.2013.09.007.

Dhal, Krishna Gopal, Arunita Das, Swarnajit Ray, Jorge Gálvez, and Sanjoy Das. 2020. "Nature-Inspired Optimization Algorithms and Their Application in Multi-Thresholding Image Segmentation." *Archives of Computational Methods in Engineering*. https://doi.org/10.1007/s11831-019-09334-y.

Ezhilarasan, Devaraj, Velluru S. Apoorva, and Nandhigam Ashok Vardhan. 2019. "Syzygium Cumini Extract Induced Reactive Oxygen Species-Mediated Apoptosis in Human Oral Squamous Carcinoma Cells." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (2): 115–21.

Fang, Yi, and Ramaraja P. Ramasamy. 2015. "Current and Prospective Methods for Plant Disease Detection." *Biosensors* 5 (3): 537–61.

Gheena, S., and D. Ezhilarasan. 2019. "Syringic Acid Triggers Reactive Oxygen Species-Mediated Cytotoxicity in HepG2 Cells." *Human & Experimental Toxicology* 38 (6): 694–702.

Gupta, Deepti. 2019. "A Survey on Disease Detection in Plant Using Image Processing Techniques." *International Journal for Research in Applied Science and Engineering Technology*. https://doi.org/10.22214/ijraset.2019.6079.

Jose, Jerry, Ajitha, and Haripriya Subbaiyan. 2020. "Different Treatment Modalities Followed by Dental Practitioners for Ellis Class 2 Fracture – A Questionnaire-Based Survey." *The Open Dentistry Journal* 14 (1): 59–65.

Kane, Sean P., Phar, and BCPS. n.d. "Sample Size Calculator." Accessed March 23, 2021. https://clincalc.com/stats/samplesize.aspx.

Ke, Yang, Mohammed Saleh Al Aboody, Wael Alturaiki, Suliman A. Alsagaby, Faiz Abdulaziz Alfaiz, Vishnu Priya Veeraraghavan, and Suresh Mickymaray. 2019. "Photosynthesized Gold Nanoparticles from Catharanthus Roseus Induces Caspase-Mediated Apoptosis in Cervical Cancer Cells (HeLa)." *Artificial Cells, Nanomedicine, and Biotechnology* 47 (1): 1938–46.

Khajuria, Rakshit, and Himani Khajuria. 2019. "Leaf Disease Detection Using Artificial Neural Network." *International Journal of Computer Trends and Technology*. https://doi.org/10.14445/22312803/ijctt-v67i8p108.

Kim, Donghwan, and Jeffrey A. Fessler. 2018. "Another Look at the Fast Iterative Shrinkage/Thresholding Algorithm (FISTA)." *SIAM Journal on Optimization*. https://doi.org/10.1137/16m108940x.

Krishnaswamy, Haribabu, Sivaprakash Muthukrishnan, Sathish Thanikodi, Godwin Arockiaraj Antony, and Vijayan Venkatraman. 2020. "Investigation of Air Conditioning Temperature Variation by Modifying the Structure of Passenger Car Using Computational Fluid Dynamics." *Thermal Science* 24 (1 Part B): 495–98.

Malli Sureshbabu, Nivedhitha, Kathiravan Selvarasu, Jayanth Kumar V, Mahalakshmi Nandakumar, and Deepak Selvam. 2019. "Concentrated Growth Factors as an Ingenious Biomaterial in Regeneration of Bony Defects after Periapical Surgery: A Report of Two Cases." *Case Reports in Dentistry* 2019 (January): 7046203.

Mapayi, Temitope, Serestina Viriri, and Jules-Raymond Tapamo. 2014. "A New Adaptive Thresholding Technique for Retinal Vessel Segmentation Based on Local Homogeneity Information." *Lecture Notes in Computer Science*. https://doi.org/10.1007/978-3-319-07998-1_64.

Mathew, M. G., S. R. Samuel, A. J. Soni, and K. B. Roopa. 2020. "Evaluation of Adhesion of Streptococcus Mutans, Plaque Accumulation on Zirconia and Stainless Steel Crowns, and Surrounding Gingival Inflammation in Primary …." *Clinical Oral Investigations*. https://link.springer.com/article/10.1007/s00784-020-03204-9.

McLoughlin, Austein G., Nick Wytinck, Philip L. Walker, Ian J. Girard, Khalid Y. Rashid, Teresa de Kievit, W. G. Dilantha Fernando, Steve Whyard, and Mark F. Belmonte. 2018. "Identification and Application of Exogenous dsRNA Confers Plant Protection against Sclerotinia Sclerotiorum and Botrytis Cinerea." *Scientific Reports* 8 (1): 7320.

Mehta, Meenu, Deeksha, Devesh Tewari, Gaurav Gupta, Rajendra Awasthi, Harjeet Singh, Parijat Pandey, et al. 2019. "Oligonucleotide Therapy: An Emerging Focus Area for Drug Delivery in Chronic Inflammatory Respiratory Diseases." *Chemico-Biological Interactions* 308 (August): 206–15.

Meunkaewjinda, A., P. Kumsawat, K. Attakitmongcol, and A. Srikaew. 2008. "Grape Leaf Disease Detection from Color Imagery Using Hybrid Intelligent System." *2008 5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*. https://doi.org/10.1109/ecticon.2008.4600483.

Morkunas, Iwona, Agnieszka Woźniak, Van Mai, Renata Rucińska-Sobkowiak, and Philippe Jeandet. 2018. "The Role of Heavy Metals in Plant Response to Biotic Stress." *Molecules*. https://doi.org/10.3390/molecules23092320.

Muthukrishnan, Sivaprakash, Haribabu Krishnaswamy, Sathish Thanikodi, Dinesh Sundaresan, and Vijayan Venkatraman. 2020. "Support Vector Machine for Modelling and Simulation of Heat Exchangers." *Thermal Science* 24 (1 Part B): 499–503.

Pathmanaban, P., B.K. Gnanavel, and Shanmuga Sundaram Anandan. 2019. "Recent Application of Imaging Techniques for Fruit Quality Assessment." *Trends in Food Science & Technology*. https://doi.org/10.1016/j.tifs.2019.10.004.

Pc, J., T. Marimuthu, and P. Devadoss. 2018. "Prevalence and Measurement of Anterior Loop of the Mandibular Canal Using CBCT: A Cross Sectional Study." *Clinical Implant Dentistry and Related Research*. https://europepmc.org/article/med/29624863.

Ramadurai, Neeraja, Deepa Gurunathan, A. Victor Samuel, Emg Subramanian, and Steven J.L. Rodrigues. 2019. "Effectiveness of 2% Articaine as an Anesthetic Agent in Children: Randomized Controlled Trial." *Clinical Oral Investigations* 23 (9): 3543–50.

Ramesh, Asha, Sheeja Varghese, Nadathur D. Jayakumar, and Sankari Malaiappan. 2018. "Comparative Estimation of Sulfiredoxin Levels between Chronic Periodontitis and Healthy Patients - A Case-Control Study." *Journal of Periodontology* 89 (10): 1241–48.

Ray, Monalisa, Asit Ray, Swagatika Dash, Abtar Mishra, K. Gopinath Achary, Sanghamitra Nayak, and Shikha Singh. 2017. "Fungal Disease Detection in Plants: Traditional Assays, Novel Diagnostic Techniques and Biosensors." *Biosensors and Bioelectronics*. https://doi.org/10.1016/j.bios.2016.09.032.

Samuel, Melvin S., Jayanta Bhattacharya, Sankalp Raj, Needhidasan Santhanam, Hemant Singh, and N. D. Pradeep Singh. 2019. "Efficient Removal of Chromium (VI) from Aqueous Solution Using Chitosan Grafted Graphene Oxide (CS-GO) Nanocomposite." *International Journal of Biological Macromolecules* 121 (January): 285–92.

Samuel, Srinivasan Raj, Shashidhar Acharya, and Jeevika Chandrasekar Rao. 2020. "School Interventions-Based Prevention of Early-Childhood Caries among 3-5-Year-Old Children from Very Low Socioeconomic Status: Two-Year Randomized Trial." *Journal of Public Health Dentistry* 80 (1): 51–60.

Sathish, T., and S. Karthick. 2020. "Wear Behaviour Analysis on Aluminium Alloy 7050 with Reinforced SiC through Taguchi Approach." *Journal of Japan Research Institute for Advanced Copper-Base Materials and Technologies* 9 (3): 3481–87.

Sharma, Parul, Yash Paul Singh Berwal, and Wiqas Ghai. 2020. "Performance Analysis of Deep Learning CNN Models for Disease Detection in Plants Using Image Segmentation." *Information Processing in Agriculture*. https://doi.org/10.1016/j.inpa.2019.11.001.

Sharma, Parvarish, Meenu Mehta, Daljeet Singh Dhanjal, Simran Kaur, Gaurav Gupta, Harjeet Singh, Lakshmi Thangavelu, et al. 2019. "Emerging Trends in the Novel Drug Delivery Approaches for the Treatment of Lung Cancer." *Chemico-Biological Interactions* 309 (August): 108720.

Singh, Vijai, and A. K. Misra. 2017. "Detection of Plant Leaf Diseases Using Image Segmentation and Soft Computing Techniques." *Information Processing in Agriculture*. https://doi.org/10.1016/j.inpa.2016.10.005.

Sridharan, Gokul, Pratibha Ramani, Sangeeta Patankar, and Rajagopalan Vijayaraghavan. 2019. "Evaluation of Salivary Metabolomics in Oral Leukoplakia and Oral Squamous Cell Carcinoma." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (4): 299–306.

Sun, Guiling, Xinglong Jia, and Tianyu Geng. 2018. "Plant Diseases Recognition Based on Image Processing Technology." *Journal of Electrical and Computer Engineering*. https://doi.org/10.1155/2018/6070129.

Tete, Trimi Neha, and Sushma Kamlu. 2017a. "Detection of Plant Disease Using Threshold, K-Mean Cluster and Ann Algorithm." *2017 2nd International Conference for Convergence in Technology (I2CT)*. https://doi.org/10.1109/i2ct.2017.8226184.

Trimi Neha Tete, 2017b. "Plant Disease Detection Using Different Algorithms." *Proceedings of the Second International Conference on Research in Intelligent and Computing in Engineering*. https://doi.org/10.15439/2017r24

Varghese, Sheeja Saji, Asha Ramesh, and Deepak Nallaswamy Veeraiyan. 2019. "Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students." *Journal of Dental Education* 83 (4): 445–50.

Venu, Harish, V. Dhana Raju, and Lingesan Subramani. 2019. "Combined Effect of Influence of Nano Additives, Combustion Chamber Geometry and Injection Timing in a DI Diesel Engine Fuelled with Ternary (diesel-Biodiesel-Ethanol) Blends." *Energy* 174 (May): 386–406.

Venu, Harish, Lingesan Subramani, and V. Dhana Raju. 2019. "Emission Reduction in a DI Diesel Engine Using Exhaust Gas Recirculation (EGR) of Palm Biodiesel Blended with TiO2 Nano Additives." *Renewable Energy* 140 (September): 245–63.

Vignesh, R., Ditto Sharmin, C. Vishnu Rekha, Sankar Annamalai, and Parisa Norouzi Baghkomeh. 2019. "Management of Complicated Crown-Root Fracture by Extra-Oral Fragment Reattachment and Intentional Reimplantation with 2 Years Review." *Contemporary Clinical Dentistry* 10 (2): 397–401.

Vijayakumar Jain, S., M.R. Muthusekhar, M.F. Baig, P. Senthilnathan, S. Loganathan, P. U. Abdul Wahab, M. Madhulakshmi, and Yogaen Vohra. 2019. "Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Lefort One Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study." *Journal of Maxillofacial and Oral Surgery* 18 (1): 139–46.

Vijayashree Priyadharsini, Jayaseelan. 2019. "In Silico Validation of the Non-Antibiotic Drugs Acetaminophen and Ibuprofen as Antibacterial Agents against Red Complex Pathogens." *Journal of Periodontology* 90 (12): 1441–48.