Indonesian Journal of Electrical Engineering and Computer Science
Vol. 26, No. 1, April 2022, pp. 568~575
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v26.i1.pp568-575

An analysis on micronutrient deficiency in plant leaf and soil using digital image processing

Swetha Reddy Anthay[1], Arun Chokkalingam[1], Komathi B. Jeyashanker[1], Bharathiraja Natarajan[2]
[1]Department of Electronics and Communication Engineering, R.M.K. College of Engineering and Technology, Chennai, India
[4]Department of Biomedical Engineering, Vel Tech Multi Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Chennai, India

Article Info

Article history:

Received Aug 11, 2021
Revised Jan 28 2022
Accepted Feb 9, 2022

Keywords:

Healthy leaf
Image processing
Macronutrients
Micronutrients
RaspberryPi 3
Unhealthy leaf

ABSTRACT

The plant requires thirteen different nutrients. The two main types of nutrients are micronutrients and macronutrients. Diseases develop due to deficiency of vital nutrients, resulting in colored spots on the leaves. Plant development is affected by toxicity or lack of one or more of these nutrients, resulting in plant death. As a result, a continuous monitoring system is necessary to know the nutritional status of the plants to enhance production efficiency and output. Optical image recognition-based medical technology can identify indicators of inaccuracy faster than the human eye. Consequently, farmers are prepared to take prompt and effective remedial action. This article investigates the nutrient deficits in plants using image processing techniques.

Corresponding Author:

Arun Chokkalingam
Department of Electronics and Communication Engineering
R.M.K. College of Engineering and Technology
Chennai, India
Email: carunece@gmail.com

1. INTRODUCTION

Plants are multicellular, photosynthetic eukaryotes that belong to the kingdom Plantae. Most plants' energy comes from photosynthesis by primary chloroplasts produced through endosymbiosis with cyanobacteria. Green plants are the backbone of most ecosystems, particularly on land, and create a considerable percentage of the world's molecular oxygen. Plants have numerous cultural and other purposes, such as decorations, construction materials, writing materials, and a wide array of medications and psychotropic substances. Plants rely on soil for various reasons, including support and water, but they also get nitrogen, phosphorous, potassium, magnesium, and other essential minerals from it. Most plants require oxygen in the environment and around their roots for respiration to develop appropriately. Plants obtain energy from oxygen and glucose. Environmental variables like temperature, available water, available light, carbon dioxide, and available nutrients in the soil all influence growth [1]. There are seventeen essential nutrients for plants. Plants must obtain the following mineral nutrients from their growth medium: The macronutrients: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg), carbon (C), oxygen (O), hydrogen (H). 2 The micronutrients (or trace minerals): iron (Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni). These elements remain as salts under the soil surface, so plants take them as ions. Macronutrients are used in higher quantities; hydrogen, oxygen, nitrogen, and carbon account for around 95 percent of a plant's total biomass on a dry matter weight basis. Micronutrient levels in plant tissue are range from 0.1 to 200 parts per million (ppm), or less than 0.02 percent dry weight. A lack of one or more plant nutrients can result in poor development and a range of diseases, including leaf discoloration (chlorosis) [2], [3]. Plant nutrient shortages can be avoided or remedied utilizing various methods, including on-site consulting, soil and plant tissue testing, prescription-blend fertilizer treatment, and the application of fresh or well-decomposed organic matter. Plants suffer from chronic illness due to nutrient shortages [4].

Important molecules like chlorophyll, deoxyribonucleic acid (DNA), ribonucleic acid (RNA), proteins, and lipids cannot be produced when nutrients are in short supply. Enzymes may not perform critical chemical reactions. Plant growth generally slows, and disease susceptibility may arise [5]. Flowering potted plants may get undersized, exhibit chlorosis or necrosis, produce fewer blooms, or appear typically unsightly. Lower leaf chlorosis can develop in some situations. Overfertilization can cause plants to perish. Overfertilized plants' root systems are diminished, and they may appear to be afflicted with a root disease or parasite [6], [7]. A plant's nutrition is the study of the minerals, compounds, and essential elements that a plant requires to have healthy growth. It also includes water, soil, temperature, and sunlight; if the plant lacks these elements, it is deficient. Deficiency is mainly the elements [8], and such deficiency causes changes in the appearance of the plants, mainly in the leaves of plants. The deficiency in plants is of two types. The macronutrient deficiency in plants is due to air, water, and primary nutrients, and primary nutrient deficiency is due to sulphur, calcium, and magnesium.

Plants not only require macronutrients it also needs micronutrients for their efficient growth. The plants accumulate most trace of elements present in the soil for their development. Figure 1 shows the micronutrient deficiency in plants. The micronutrients that plants require for effective growth are of many types; some of them are iron, molybdenum, boron, copper, manganese, sodium, zinc, nickel, chlorine. i) iron deficiency: iron is necessary for photosynthesis and is present as an enzyme cofactor in plants. Plants require iron to produce chlorophyll, and iron deficiency in the plant is known as lime-induced chlorosis. In soil presence of iron is high even though the absorption of iron by the plants becomes impossible if the soil pH is above 6.5; ii) molybdenum deficiency: molybdenum is an essential cofactor for enzymes involved in forming amino acids and nitrogen metabolism, this occurs because the plants cannot absorb enough of the mineral, leading to limited growth of the plants. It also occurs due to the minimal presence of molybdenum in the soil, or it may be available in a form that the plants cannot absorb. molybdenum absorption is high in acid soils; iii) boron deficiency: boron is required to form and strengthen cell walls. Boron impacts blooming and fruiting, pollen germination, cell division, and active salt absorption in plants, among other things. boron deficiency causes short, thick cells, resulting in small fruiting bodies and roots. It is accessible to plants at pH levels ranging from 5.0 to 7.5; iv) copper deficiency: copper is essential for the photosynthesis of plants. Copper deficiency can be found by chlorosis, and it involves many enzymes process, and it is for optimal photosynthesis, cell wall formation, and grain production; v) manganese deficiency: manganese is required to build chloroplast and is necessary for photosynthesis. It occurs in poorly drained soils and soils where the pH is high. Its symptom is the yellowing of leaves. Brown patches on leaf surfaces may emerge, and badly afflicted leaves may become brown and wither; vi) sodium deficiency: in crassulacean acid metabolism, (CAM) photosynthesis, sodium aids in regenerating phosphoenolpyruvate. It stimulates growth, increases the leaf area, improves water balance, and improves crop quality; vii) zinc deficiency: zinc has a critical function in the DNA. transcription and is necessary for many enzymes. It is the most widespread micronutrient deficiency, and it results in yellowing of leaves, death of leaf tissue, and bronze; viii) nickel deficiency: nickel is required to energize ureases, necessary for nitrogen metabolism to produce urea. The absence of nickel leads to the causes of necrotic lesions to develop; ix) chlorine deficiency: chlorine is required mainly for osmosis, ionic balance, and photosynthesis. chlorine deficiency causes wilting, restricted, and highly branched root system with stubby tips. A method for automatically identifying nitrogen status in sugarcane leaf pictures [9]. A technique for automatically detecting nitrogen status in sugarcane leaf images [9]. This technique used an adaptive threshold of the mean for both greyscale and YCrCb color space images to eliminate the leaf edge in the background. In the previous procedure, the quality of the extracted edge included shadow on the backdrop. The latter's results were good, but it could not remove the midrib.

Consequently, both results were ANDed before being multiplied by the color image. This output was subjected to the Sobel algorithm, which resulted in leaf edges with spiky noise. A series of morphological open and close operations were used to reduce noise. Finally, an active contour model defined the Leaf's border, a technique for segmenting diseased portions in leaf images [10]. In this procedure, the RGB image is first converted to HSV, and just the hue component was used, with the saturation and value components being ignored. For texture feature extraction, the approach employs the color co-occurrence method. For the Hue content of the image, statistical texture features such as contrast, energy, local homogeneity, and correlation were extracted using spatial grey level dependence matrices (SGDM). By assigning zero to the R, G, and B components of green pixels, the healthy areas of the leaf are deleted, and the sick region is extracted. A technique for classifying nutrient shortage symptoms in plant photos using image processing [11]. They created this method as a preliminary way for determining whether an image should be communicated through a wireless multimedia sensor network, hence reducing network traffic.

Only the unhealthy area of the leaf image is saved for further processing; the green regions of the image are eliminated.

A method for assessing sugar beet leaf chlorophyll concentration [12] is crucial in determining nitrogen status. The chlorophyll content of the Leaf is measured using a chlorophyll meter in this article (SPAD-502). A multilayer perceptron neural network with backpropagation was created [13]. Three input neurons and one output neuron were employed to match three input components (R, G, and B) with one data (a measure of chlorophyll concentration) in the output layer. This model's output is compared to that of the artificial neural network (ANN) model. In the paper, Viraj *et al.* [14] suggested a cotton leaf diagnostic method as a whole. The anisotropic diffusion approach improves the input leaf picture in this algorithm. Then, the leaf color was recovered from the background using HIS color space, and the B component was taken from the L.A.B. color space. The generated color pixels were clustered using an unsupervised self-organizing feature map (SOFM) network. A backpropagation neural network identifies illness in a color leaf picture. This algorithm has an accuracy range of 85 to 91 percent depending on the image quality. An algorithm detects sick plant leaf regions and classifies plant leaf illnesses [15]. The RGB leaf picture is transformed to H.S.I. color space to see harmful parts, and green pixels (healthy regions) were masked using the hue component thresholding technique. The resulting leaf picture was divided into equal-sized patches with exclusively infected parts. The present method will examine leaf macronutrient insufficiency [16], [17]. The leaf area measurement, segmentation of the edge and vein of the Leaf, determining the shape of the Leaf, classification of the deficient mineral, determining the age of the Leaf, and extraction of color features of the Leaf are the techniques used to identify these diseases due to micronutrient deficiency [18]. Image histogram, binarization, RGB thresholding, and area projection are utilized for Leaf measuring [19]. Grey level co-occurrence matrix, Chaos and fractal dimension, regression model, color moments extraction, geometric moments, and hue saturation 2D histogram are some approaches used for color segmentation. Using similar techniques, many scientists have used image processing tools to analyze macronutrient deficit in leaves [20], [21]. Our suggested system is built on utilizing MATLAB to detect vitamin shortage in leaves and a Raspberry Pi 3 to construct a plant monitoring system.

2. METHOD

Our project setup consists of a Raspberry Pi 3 model B processor with 40 GPIO pins and runs on raspbian O.S. This rpi3 processor is interfaced with a pH sensor, soil moisture sensor, and temperature and humidity sensor (DHT11). The soil moisture sensor is used to find the moisture level content of the soil based on which the plant's growth is analyzed; the pH sensor consists of two electrodes. Based on the pH sensor value, a logarithm of hydrogen ion concentration of the soil is found. Temperature and humidity sensor is used for finding out the surrounding temperature and humidity. Based on micronutrient deficiency, leaves will have red, yellow, and white spots patched around. Using MATLAB software, the images of leaves are converted into greyscale images for analyzing the deficient areas in leaves. Thus, there will be a differentiation between healthy and diseased leaves [22]. This paper has proposed both concepts of embedded systems and digital image processing. An Embedded system is used for monitoring the soil moisture content, texture, and surrounding temperature; suppose if it is too hot, leaves may get dried quickly [23]. Using Digital Image Processing, healthy leaves and diseased leaves are analyzed and found [24], [25]. Thus, a complete health monitoring status of a plant is nutritional or not.

2.1. Interfacing of Raspberry Pi 3 with DHT11

The DHT11 has a distance between ground (GND) pin, a VCC pin, and a signal (SIG) pin. These pins are connected with the Raspberry Pi 3. GND pin is connected to the 6th pin of Raspberry Pi, the VCC pin is connected to the 2nd pin of the pi, and the SIG pin is connected to the 7th pin of the Raspberry Pi. The necessary coding is done in the Pi using Python; the DHT11 sensor takes the surrounding temperature and humidity value by making these connections and coding.

2.2. Interfacing of Raspberry Pi 3 with soil moisture sensor

The Soil moisture sensor has four VCC pins, a GND pin, an analog pin (A0), and a Digital pin (D0). VCC is given to the 4th pin of the Pi, GND pin is given to the 6th pin of the Pi, and Digital pin (D0) is given to the 40th pin of 31 Raspberry Pi. The necessary coding is done in the Pi using Python. When these connections and the coding are made, the sensor reads the soil moisture content.

2.3. Interfacing of Raspberry Pi 3 with Ph sensor

The pH sensor has four pins: VCC pin, GND pin, TX pin, and R.X. pin. The VCC pin is given to the 4th pin of the Raspberry Pi; the GND pin is given to the 6th pin of the Pi, the TX pin of pH sensor is given to the 10th UART RX pin of the Raspberry Pi, and the R.X. pi is connected with the 8th UART TX pin of the Raspberry Pi. The coding is done in the Pi, and when the connections are made, the sensor begins to measure the soil's pH level value.

2.4. Integrated connection of all the sensors and components

Figure 1 shows the sensors are interfaced with the processor and the workflow of the hardware components required for analyzing the 33-health condition of the plants. Let us see the functionality, role of each element, and overall working of a project; it also monitors the health of the plants. Figure 2 shows the overall connections of the sensor and the hardware components. All the sensors GND pins and the VCC pins are shorted, the shorted VCC pin is given to the output pin of the voltage regulator, and the shorted GND pin is given to the GND pin of the voltage regulator. The voltage regulator is used to convert the 230V power supply to 5V, and it is used to provide a separate power supply for the sensors. The GND pin and the VCC pin of the regulator are connected to the plug point for the power supply. SIG pin of DHT11 sensor is given to the 35th pin of Raspberry Pi, TX pin of the pH sensor is given to the 33rd pin of the Pi, and the D0 of the soil moisture sensor is connected to the 37th pin of the Raspberry Pi. The power supply for the Raspberry Pi is given separately. The Raspberry Pi is serially connected with the C.O.M. port of the laptop. The Raspberry Pi begins to 34 measure and displays the temperature and humidity, soil moisture, and pH sensor in the serial monitor by making these connections and the necessary coding.

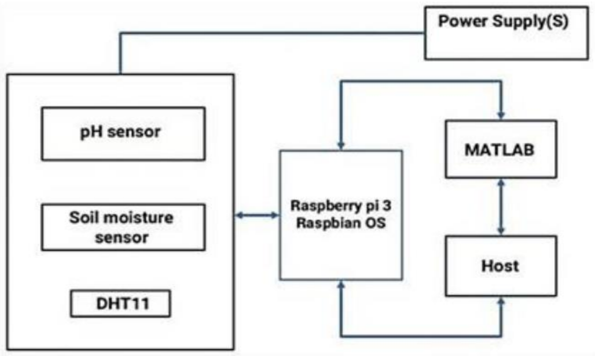


Figure 1. Proposed method of micronutrient deficiency detection system

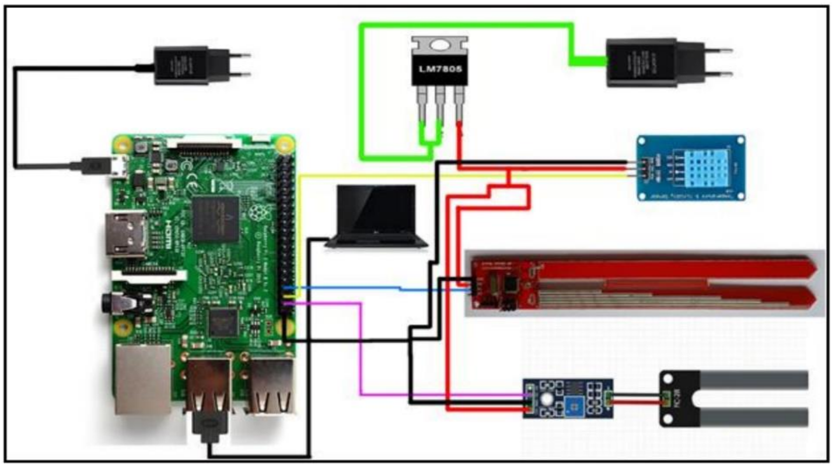


Figure 2. Hardware implementation of micronutrient deficiency detection system

2.5. Raspberry Pi terminal

After the connections are made, the Raspbian OS is turned ON, the coding in the Raspberry Pi is initiated. In the terminal, the command sudo su is entered to enter into the root user of the Raspberry Pi, then the command 'python *name of file*.py' is entered to run the program. The terminal waits for the next step.

2.6. Matlab processing

The Raspberry Pi terminal waits for the signal from MATLAB. MATLAB software is opened the programming is done in MATLAB using C. The code in MATLAB is initiated and made to run, as shown in Figure 3. A picture is selected, and the open button is pressed, and finally, we can find the output of the unhealthy and healthy Leaf using MATLAB, as shown in Figures 4 and 5.

Figure 3. Sample images input to the system

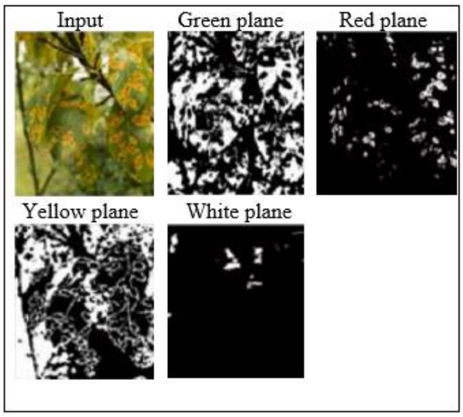


Figure 4. Simulation results of the unhealthy leafs

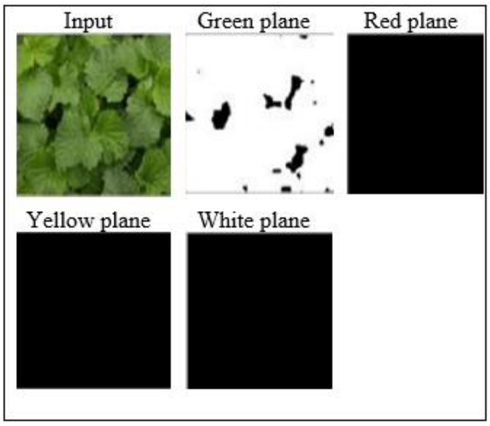
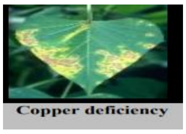


Figure 5. Simulation results of the healthy leafs

3. RESULTS AND DISCUSSION

The key to reducing losses in agricultural product output and quantity is the early detection of plant diseases. It takes a great deal of effort, knowledge of plant diseases, and an excessive length of processing time. As a result, image processing is utilized to identify plant illnesses. Image capture, picture pre-processing, image segmentation, feature extraction, and classification are all processes in the disease detection process. This study examined numerous strategies for segmenting the plant's diseased section. This research also examined feature extraction and classification strategies for extracting diseased leaf characteristics and plant disease categorization. The correct diagnosis and categorization of plant diseases are critical for efficient crop cultivation, and image processing is explained in Table 1. This study examined numerous strategies for segmenting the plant's diseased section.

Table 1. Experimental results and observations

SI.NO	Deficiency	Result of Observation	Picture of plant deficiency
	Iron	Yellowing happens between the veins of the young leaves.	
	Molybdenum	Older leaves (at the bottom of the plant) are yellowing, but the remaining part is still light green.	
	Boron	The creation of a witch's broom and the death of the terminal buds	
	Copper	Growth is reduced, the leaf tip dies back, the leaf tip breaks down, and the leaves are ragged.	
	Manganese	Stunted plants, yellow cast over deficient zones, and interveinal chlorosis of leaves	
	Sodium	It causes toxic levels that cause stunted growth and arrested cell development.	
	Zinc	White lines parallel to leaf blade, chlorotic leaves, poor development, diminished vitality	
	Nickel	Lower leaves turn dark, leaves abort, yellow leaves, stunted growth.	
	Chlorine	Nonsucculent tissue, stubby roots, interveinal chlorosis, and reduced growth (in leafy vegetables)	

4. CONCLUSION

This paper has implemented the concepts of Digital Image processing and Embedded systems for the health monitoring of the leaves. This process can monitor the fertility of the soil periodically, thus maintaining the pH level and moisture level of the ground. Mainly, the deficiency of plant leaf is affected using the image processing of the leaves; all the sensor values and health conditions are displayed in the monitor through the help of the processor. This paper implements the techniques for the effective and continuous monitoring of the plant leaf and soil using a processor and sensor using MATLAB. The kit is transformed into an A.I.-based IoT-controlled robot. Control is ultimately using the android application connected to the IoT platform. Image processing is done using the images captured by the Raspberry Pi. Processing of the image will be done in the android application. All the interfaced sensor values can be stored in the cloud for effective monitoring and evaluating the health condition of the entire field using the measured values.

REFERENCES

[1] J. C. Puno, E. Sybingco, E. Dadios, I. Valenzuela, and J. Cuello, "Determination of soil nutrients and pH level using image processing and artificial neural network," in *HNICEM 2017 - 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management*, Dec. 2017, vol. 2018-Janua, pp. 1–6, doi: 10.1109/HNICEM.2017.8269472.

[2] R. Kumar, "Feature extraction of diseased leaf images," vol. 3, no. 1, 2012, Accessed: Feb. 07, 2022. [Online]. Available: http://www.bioinfo.in/contents.php?id=48.

[3] S. B. Patil and S. K. Bodhe, "Betel leaf area measurement using image processing." *International Journal on Computer Science and Engineering*, vol. 3, no. 7, pp. 2656-2660, 2011.

[4] H. M. Asraf, M. T. Nooritawati, and M. S. B. S. Rizam, "A comparative study in kernel-based support vector machine of oil palm leaves nutrient disease," *Procedia Engineering*, vol. 41, pp. 1353–1359, 2012, doi: 10.1016/j.proeng.2012.07.321.

[5] K. Thangadurai and K. Padmavathi, "Computer visionimage enhancement for plant leaves disease detection," in *Proceedings - 2014 World Congress on Computing and Communication Technologies, WCCCT 2014*, Feb. 2014, pp. 173–175, doi: 10.1109/WCCCT.2014.39.

[6] J. K. Patil, R. Kumar, B. Vidyapeeth COE Kolhapur, and B. Vidyapeeth, "Color feature extraction of tomato leaf diseases," *International Journal of Engineering Trends and Technology*, 2011, Accessed: Feb. 07, 2022. [Online]. Available: http://www.internationaljournalssrg.org.

[7] V. B. Sunagar, P. A. Kattimani, V. A. Padasali, and N. V Hiremath, "Estimation of nitrogen content in leaves using image processing," *In Proceedings of the International Conference on Advances in Engineering & Technology*, Goa, India, vol. 20, 2014.

[8] A. Sridevi and S. Vijendran, "An Evolving expert system for maize plant nutrient deficiency using image processing technique," *International Journal of Science and Research (IJSR)*, vol. 5, no. 2, pp. 70–77, Feb. 2016, doi: 10.21275/v5i2.NOV152651.

[9] Piti Auearunyawat et al., "An automatic nitrogen estimation method in sugarcane leaves using image processing techniques," in *Proceedings of International Conference on Agricultural, Environment and Biological Sciences*, 2012, pp. 39–42.

[10] A. and S. Sanjana, Y and Sivasamy, "Plant disease detection using image processing techniques," *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 4, pp. 95–301, 2015.

[11] K. Dang *et al.*, "Wireless multimedia sensor network for plant disease detections," Accessed: Feb. 07, 2022. [Online]. Available: https://hal.archives-ouvertes.fr/hal-00876433.

[12] P. A. Moghaddam and M. H. Derafshi, "Estimation of single leaf chlorophyll content in sugar beet using machine vision," *Turk J Agric For*, vol. 35, pp. 563–568, 2011, doi: 10.3906/tar-0909-393.

[13] K. H. Jin, M. T. McCann, E. Froustey, and M. Unser, "Deep convolutional neural network for inverse problems in imaging," *IEEE Transactions on Image Processing*, vol. 26, no. 9, pp. 4509–4522, Sep. 2017, doi: 10.1109/TIP.2017.2713099.

[14] V. A. Gulhane and A. A. Gurjar, "Detection of diseases on cotton leaves and its possible diagnosis," *Gurjar International Journal of Image Processing (IJIP)*, no. 5, p. 590, 2011.

[15] S. Arivazhagan, R. N. Shebiah, S. Ananthi, and S. Vishnu Varthini, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features," *Agricultural Engineering International: CIGR Journal*, vol. 15, no. 1, pp. 211–217, 2013.

[16] S. Jeyalakshmi and R. Radha, "A review on diagnosis of nutrient deficiency symptoms in plant leaf image using digital image processing," *ICTACT Journal on Image and Video Processing*, vol. 7, no. 4, pp. 1515–1524, Jun. 2017, doi: 10.21917/ijivp.2017.0216.

[17] A. Ambatkar *et al.*, "Leaf disease detection using image processing," in *Proceedings of International Conference on Recent Trends in Engineering Science and Technology*, 2017, pp. 333–336.

[18] G. Xu, F. Zhang, S. G. Shah, Y. Ye, and H. Mao, "Use of leaf color images to identify nitrogen and potassium deficient tomatoes," *Pattern Recognition Letters*, vol. 32, no. 11, pp. 1584–1590, Aug. 2011, doi: 10.1016/j.patrec.2011.04.020.

[19] J. K. Park, E. J. Hwang, and Y. Nam, "Utilizing venation features for efficient leaf image retrieval," *Journal of Systems and Software*, vol. 81, no. 1, pp. 71–82, Jan. 2008, doi: 10.1016/j.jss.2007.05.001.

[20] M. E. Scholar, "A survey on disease and nutrient deficiency detection in cotton plant," *International Journal of Engineering Development and Research*, pp. 812–815, 2013.

[21] B. Tigadi and B. Sharma, "Banana plant disease detection and grading using image processing," *International Journal of Engineering Science and Computing*, vol. 6, no. 6, pp. 6512–6516, 2016, doi: 10.4010/2016.1565.

[22] J. Wang, J. He, Y. Han, C. Ouyang, and D. Li, "An adaptive thresholding algorithm of field leaf image," *Computers and Electronics in Agriculture*, vol. 96, pp. 23–39, Aug. 2013, doi: 10.1016/j.compag.2013.04.014.

[23] M. K. R. Gavhale and P. U. Gawande, "An overview of the research on plant leaves disease detection using image processing techniques," *IOSR Journal of Computer Engineering*, vol. 16, no. 1, pp. 10–16, 2014, doi: 10.9790/0661-16151016.

[24] P. Sanjay, B. Dhaygude, M. Nitin, and P. Kumbhar, "Agricultural plant leaf disease detection using image processing," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 2, no. 1, 2013, Accessed: Feb. 07, 2022. [Online]. Available: www.ijareeie.com.

[25] D. Shergill, A. Rana, and H. Singh, "Extraction of rice disease using image processing," *International Journal of Engineering Sciences*, vol. 4, no. 6, pp. 135–143, 2015, Accessed: Feb. 07, 2022. [Online]. Available: http://www.ijesrt.com.

BIOGRAPHIES OF AUTHORS

Swetha Reddy Anthay Assistant Professor, in the Department of Electronics and Communication Engineering in R.M.K. College of Engineering and Technology. She has graduated from Rajalakshmi Institute of Technology, Chennai, in Electronics and Communication Engineering. She has obtained her Master's degree in Applied Electronics from R.M.K. Engineering College, Chennai. Her area of interest is I.O.T., Digital Image Processing, Embedded Systems, Wireless Communication, Wireless networks, Artificial Intelligence, and Communication signal processing. She is a member of the International Association of Engineers (IAENG). She can be contacted at email: swethareddyece@rmkcet.ac.in.

Arun Chokkalingam received his Ph.D. degree with the specialization of VLSI design at Anna University in 2009. He is currently a Professor in the Department of Electronics and Communication Engineering at R.M.K. College of Engineering and Technology, Chennai. He has more than 17 years of teaching experience. His research interests include Chromosomal Image Processing, Wireless Networks, Image Denoising of Cardio Fibroblast Cells. He had published more than 143 papers in reputed journals. He is a recognized supervisor of four reputable universities and guided 14 Ph.D. scholars, and nine scholars are pursuing Ph.D. He had received a fund of Rs.12.98L from ISRO-SAC, and the project was completed. He can be contacted at email: carunece@gmail.com.

Komathi B. Jeyashanker Assistant Professor, in the Department of Electronics and Communication Engineering in R.M.K. College of Engineering and Technology. She has graduated from R.M.D. Engineering College, Chennai, in Electronics and Communication Engineering. She has obtained her Master's degree in Communication Systems from Sri Venkateswara College of Engineering, Chennai. Her area of interest is Wireless Communication, Wireless networks, Digital Image Processing, Communication Networks, Embedded. She can be contacted at email: komathiece@rmkcet.ac.in.

Bharathiraja Natarajan received his B.E. degree in Electronics and Communication Engineering (E.C.E.) from Priyadarshini Engineering College, India, and his MTech degree from Annamalai University, India, in 2000 and 2004, respectively. He received Ph.D. in 2018. He is currently working as an Associate professor in the Biomedical Engineering Department in Vel Tech Multi tech Dr. Rangarajan Dr. Sakunthala Engineering college. His research interests are wireless communication systems, signal processing, 5G communications. He can be contacted at email: bharathinatarajan78@gmail.com