Revolutionizing Precision Agriculture with Drone-Based Imaging and Fuzzy Intelligent Algorithms

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Abstract

This paper proposes a clear understanding of drone based agricultural image processing techniques using fuzzy intelligent algorithm. This procedure is used for drone-based agricultural monitoring through intelligent calculations by various images acquired and trained from the field. The objective is to upgrade the exactness and proficiency of crop yield and the accuracy in agriculture. The proposed methods use high quality images caught by drones to remove crop-related infections and evaluate their wellbeing status. The fuzzy based calculation is applied to characterize the harvest wellbeing status and produce a choice to guide and assist the farmers of various regions to concentrate the area of infection based on the images captured from drones. The projected approach is assessed utilizing the information and the consideration and appropriate recommendation can be made after careful evaluation of infected region in the field. Graphical User Interface (GUI) is developed using fuzzy based algorithm which can segment the infectious leaves and classify the type of diseases and check the healthiness of the leaves. Results show that the proposed approach accomplishes higher exactness and improved effectiveness in distinguishing crop wellbeing status in comparable with existing the procedures. This study shows the capability of integrating drone-based agriculture with fuzzy intelligent image processing tool which makes efficient for farmers to improve the quality of crops, attain greater yield and to develop the nation with drone-based agribusiness.

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1. Introduction

Drones are used for various purposes. It plays a vital role in a different industries. Even though it is a light rain, drones could reduce the speed of the vehicles 1 - 10 Km/h, while heavy rain the speed might reduce to 15 - 45 Km/h. By wind and snowfall, the speed might be reduced by 10 - 40 % [1]. According to the Ministry of Transport and Highway department of India, 4,12,432 of accidents in 2021 had been identified as weather related [2]. We can cut down the additional cost due to the bad weather by determining more accurate, local weather. But existing weather information services have some drawbacks: that is, they cannot produce local short term weather information, which is known as nowcasting, with the required accuracy. The applied weather monitoring and forecasting models and systems have relatively low resolution and it needs more intensive computational resources and processing time. On top of this, there is an information gap relating to low-altitude data.

The lowest zone of the atmosphere is known as the atmospheric boundary layer (ABL), ranging 100 m - 3 km altitudes, depending on location and time of the year. The behavior of the ABL has a significant effect on local weather, while real-time monitoring and very short time forecasts also show a strong dependence on the internal atmospheric dynamics [3][4][5]. There are several improvements in operational weather models with these modern technologies[6]. Ground based remote sensing instruments require a lot of money to perform operations. The use of these instruments is limited in few areas. But satellite based remote sensing provides global coverage and it has significant impact in NWP [7]. Unmanned aerial vehicles (UAVs) allow us to operate in various fields such as monitoring, package delivery, surveillance, defence, research, etc,. Also Emerging technologies like 4G/5G networks, cameras, GPS receivers, sensors, etc. empower these UAVs to the next generation which makes our work easier [8]. UAVs have more potential that enabling new applications [9]. The advanced electronic devices and sensors made a bridge between science and the virtual world. And its applications like smartphones, [10]. Weather has a large impact on road transport. In moderate weather conditions it affects 40% of the vehicle speed, while in extreme conditions it affects 100%. The technologies have improved and it introduces the drone-based weather station [11]. Drones are applied in agriculture to make it as profitable.

2. Literature Review

Even Though the technology has developed and the remote sensing technology is also at its peak, we are lacking data gaps above the ocean and in the polar region. In order to get the lacking data, we can use drones, which provide significant data in an eco-friendly way [12]. Quadcopters in particular are popular due to their availability, cost, and ease of use [13][14][15][16][17]. Quadcopters cannot carry heavy payloads or fly for extended periods of time[18][19][20]. Because of this reason, quadcopters cannot be flown reliably for important missions such as defense, search, rescue and agricultural management [21][22][23]. These small drones can be used in the agricultural sector and its applications like fertilizing, pesticide spraying, real-time aerial imagery, farm surveillance and sensor data collection etc. Drones save time and are also efficient in resource utilization with substantial water savings. Also flying drones for agriculture is a good opportunity for rural youth. There is a good chance that their use can also be expanded to other advanced use cases. It is beneficial for Indian farmers. [24]. UAVs help agriculture in developing countries economically. It also reduces the health-related issues in human beings, which is way better than the traditional manual spraying method. Even farmers can use UAVs in agriculture for spraying, pest control, aerial mapping, irrigation. In general, fixed wings aircrafts are used in aerial mapping and multirotor are used for pesticide spraying. Because of its excellent aeronautics, the quadcopter is the most fitting type for agriculture. In a nutshell, UAVs are the reducing the amount of pesticide and fertilizer wastage. It keeps the laborer's aside from the chemical side-effects an make their job fast. Fig. 1 shows the drone application on agriculture. Even though it plays important role in agriculture, it also has some limitations such as accurate data interpretation, privacy risk, complex spraying environment and long-distanced positioning are some prime examples of their disadvantages [25].

Paddy leaves can become unhealthy due to a variety of factors, including nutrient deficiencies, diseases, pests, and environmental stress. This can lead to reduced crop yields and quality. However, there are a number of ways to improve the health of paddy leaves and increase productivity.

One of the most important steps in correcting unhealthy paddy leaves is to identify the cause. Nutrient deficiencies can be addressed by applying the appropriate fertilizers to the soil, while diseases and pests may require the use of fungicides or insecticides. Paddy plants also require a significant amount of water, and insufficient watering can lead to unhealthy leaves. Therefore, it is important to provide the plant with adequate water to prevent the leaves from becoming dry and weak.

Weeds can compete with paddy plants for nutrients and water, which can also lead to unhealthy leaves. As such, it is important to control weeds in and around the paddy field. Paddy plants also require a significant amount of nutrients to produce healthy leaves, and compost can help to provide these essential nutrients. However, it is important to apply the right amount and type of compost to avoid over-fertilization, which can lead to leaf scorching.

In addition to the above measures, farmers can also use drone-based agriculture farming practices to improve the health of paddy leaves and increase yields. Drones can be equipped with cameras and sensors that can provide farmers with high-resolution aerial imagery of their fields. This imagery can be used to identify problem areas such as pest infestations, disease outbreaks, or nutrient deficiencies. Farmers can then use this information to treat these problems in a targeted and precise manner, which can ultimately lead to increased crop yields and improved crop quality.

Drones can also be used to monitor climatic conditions such as soil moisture, humidity, and temperature that affect crop growth. Farmers can use this information to determine when to sow and harvest their crops, as well as how best to use irrigation and other resource management techniques.

Overall, drone-based agriculture farming practices can provide a number of benefits for farmers, including:

Increased crop yields and improved crop quality: Drones can help farmers to identify and treat problems such as pest infestations, disease outbreaks, and nutrient deficiencies in a timely and precise manner. This can lead to healthier crops and greater yields.

Improved resource management: Drones can help farmers to monitor climatic conditions and crop health, which can lead to more efficient use of irrigation and other resources.

Reduced labor costs: Drones can automate many tasks that are currently performed manually by farmers, such as field mapping and crop monitoring. This can save farmers time and money.

As drone technology continues to develop, it is likely that drone-based agriculture farming practices will become even more widely adopted and sophisticated. This could lead to significant improvements in agricultural productivity and efficiency in the years to come.

3. Methodology

Fuzzy Intelligent algorithm computation

Fig. 2 represents the algorithm description. The following layers are the steps involved in algorithm implementation.

Layer 1

Serves to raise the degree of membership and the membership used here is Gaussian membership function.

$$O_{1,i} = \mu_A(x), i = 1, 2$$

and

$$O_{1,i} = \mu B(y), i = 1, 2,$$

$$f(x, \sigma; c) = e^{\frac{-(x-c)^2}{2\sigma^2}}$$

by { σ and c} are the parameters of membership function or called as a parameter premise. σ signifies the cluster bandwidth, and c represents the cluster center.

Layer 2

Serves to evoke *firing-strength* by multiplying each input signal.

$$O_{2,i} = w_i = \mu_A(x) x \mu_B(y), \quad i = 1, 2,$$

Layer 3

Normalizes the *firing strength*

$$O_{3,i} = \bar{w}_i = \frac{w_i}{w_1 + w_2}, \quad i = 1, 2,$$

Layer 4

Calculates the output based on the parameters of the rule*consequent* $\{p_i , q_i \text{ and } r_i\}$

$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i (p_i x + q_i y + r_i),$$

Layer 5

Counts the ANFIS output signal by summing all incoming signals will produce

$$\sum_i \bar{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i},$$

ANFIS uses the input data scaling by xbounds= [min max] command used in MATLAB software which represents the scaling parameter of the input function varies between minimum to maximum value of the data point. Each data point is scaled for pre-processing of training initially by normalizing it.

4. Model Development and Application

Step 1:

Initially, data has been given to the system for training ANFIS. User input required in csv or excel format

Step 2:

After selecting the data, the user has to give his/her preference to number of iterations, performance measure and error percent.

Step 3:

After collecting all information from user, ANFIS start generating its own training data set by varying the random permutations with upper and lower bound.

Step 4:

After generating a particular amount of data required for training, the system moves on to the next step which is to test the data.

Step 5:

During this testing process, image classification and segmentation has been given as input and output respectively.

Step 6:

Finally, the tested data will be plotted in MATLAB.

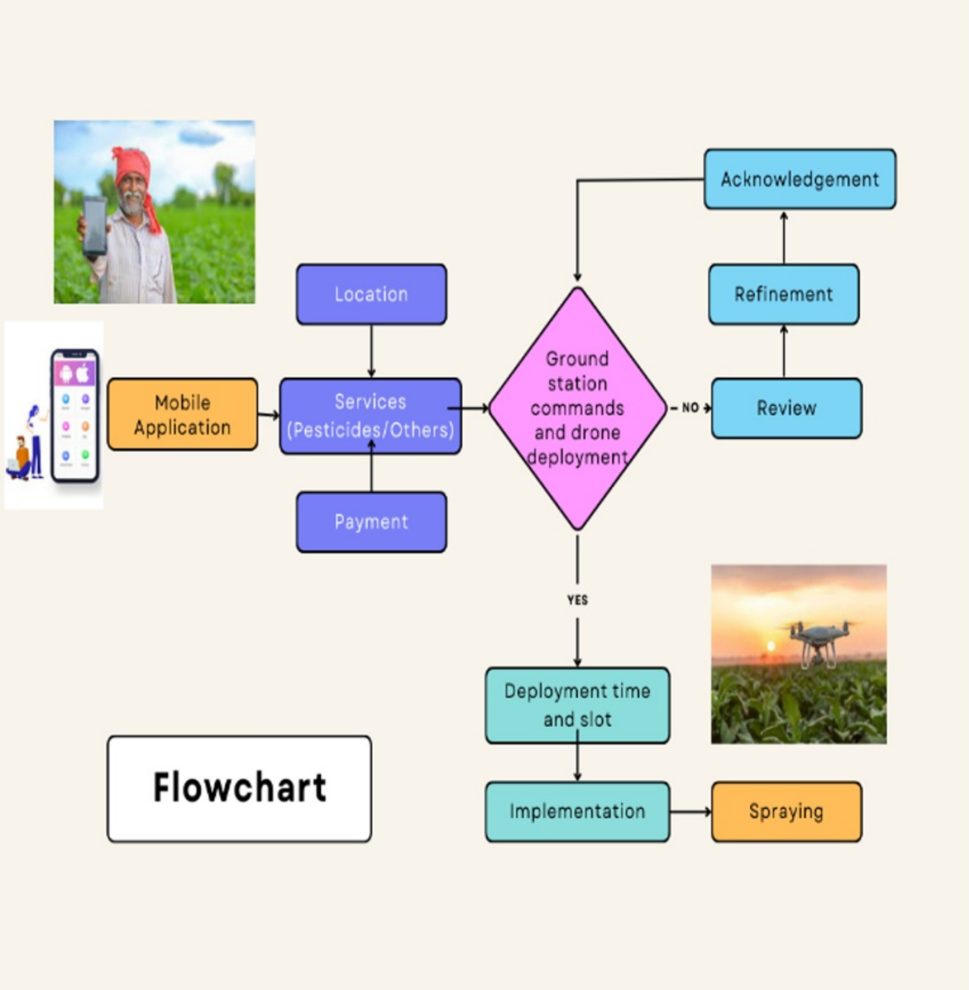

Figure 1. Drone based agricultural spraying unit and services

5. Uavs and Its Application

The applications of UAVs are diverse and the areas including civil, military, commercial and government sectors [26][27][28][29][30]. The application of UAVs in military and government were mostly used for surveillance and delivery aiming to acquire information and in commercial applications are focused in product delivery in both urban and rural areas [31]. The Internet of Things (IoT) constitutes a major role in such a way that it enables us to utilise and operate globally either indirectly by the user or by special software that captures their behavior and objective. These IoT applications enable objects to become active participants, with numerous applications such as smart city [32]. There are different types of UAVs with specific characteristics such as altitude, speed, energy autonomy that are suitable for different applications. In general, UAVs are classified according to their supported altitudes into Low-Altitude Platforms (LAP) and High-Altitude Platforms [33].

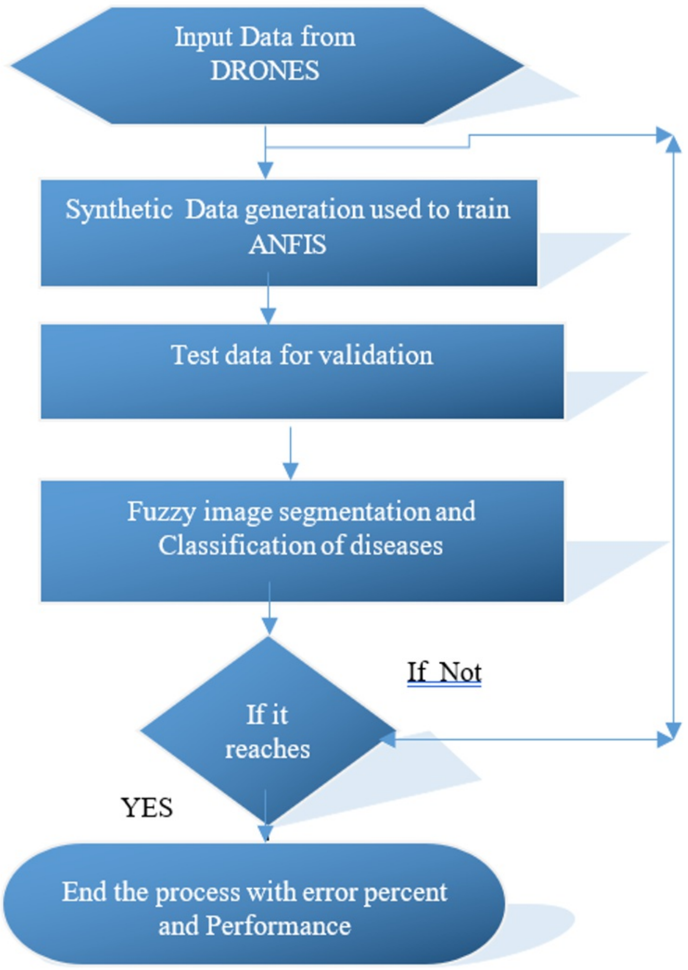

Figure 2. Represents the flow chart of the algorithm

Drones can identify different plan diseases and can check the health conditions of the crops and plants.

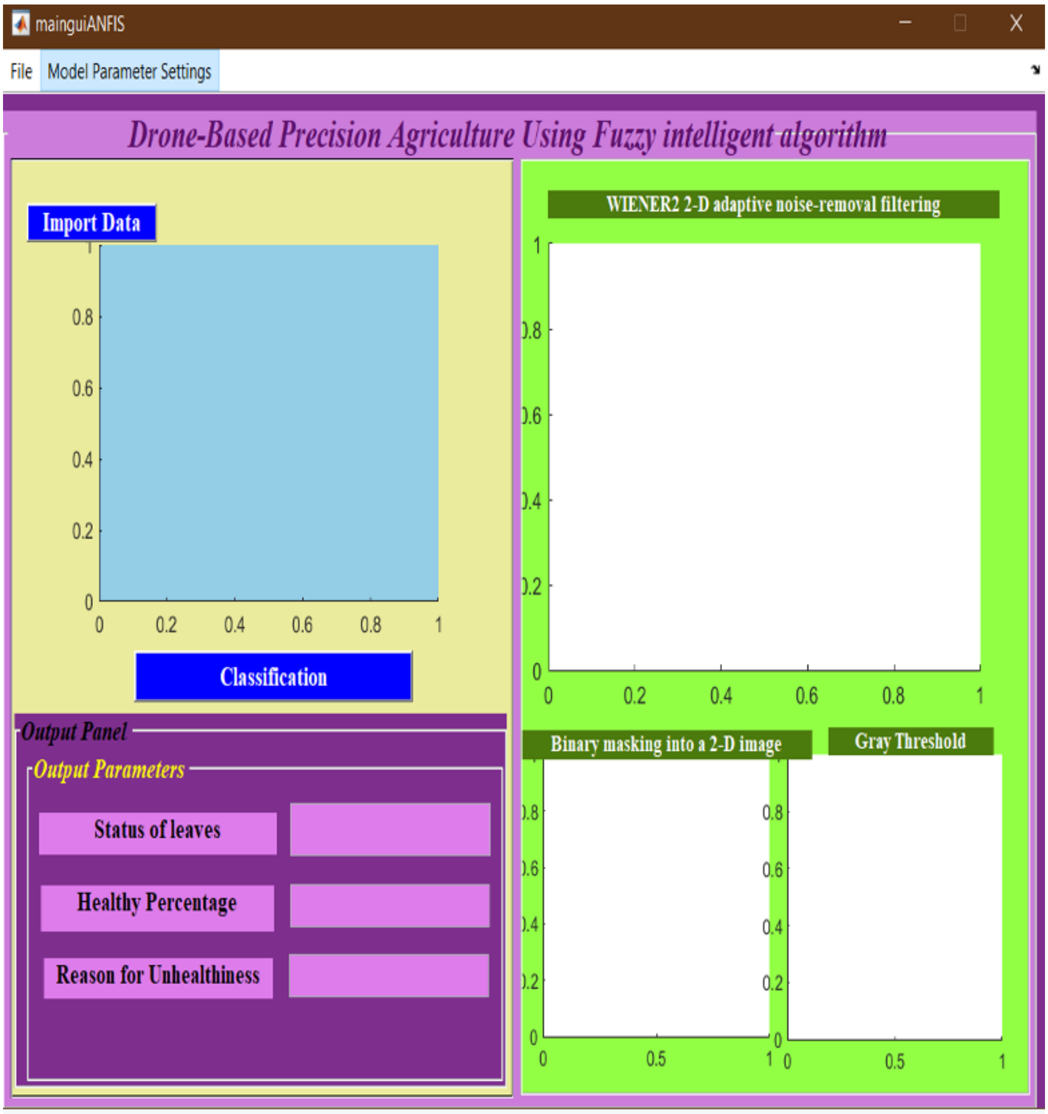

Figure 3. Main GUI panel used for classify plant diseases

6. Different Kinds of Infection in Plants and their Remedies

The dark spot is a contagious issue that structures dark, dim, or simple colored spots on rose leaves, making them drop. To keep it from framing once more, eliminate and obliterate tainted leaves and farmers utilize a rose fungicide splash.

Wool mould assaults over the ground portions of plants, especially youthful and undesirable ones. It can cause yellowing or forestall blooming, and fungicides won't work for this infection. Eliminate and annihilate tainted plants when side effects are seen is the only solution by the farmers.

Fine buildup flourishes in dry soil conditions and can taint roses and clematis, shaping white fine growth on the upper surface of leaves. Eliminate and obliterate tainted pieces of the plant, keep up with soil dampness, and utilize a fungicide arrangement all through the season.

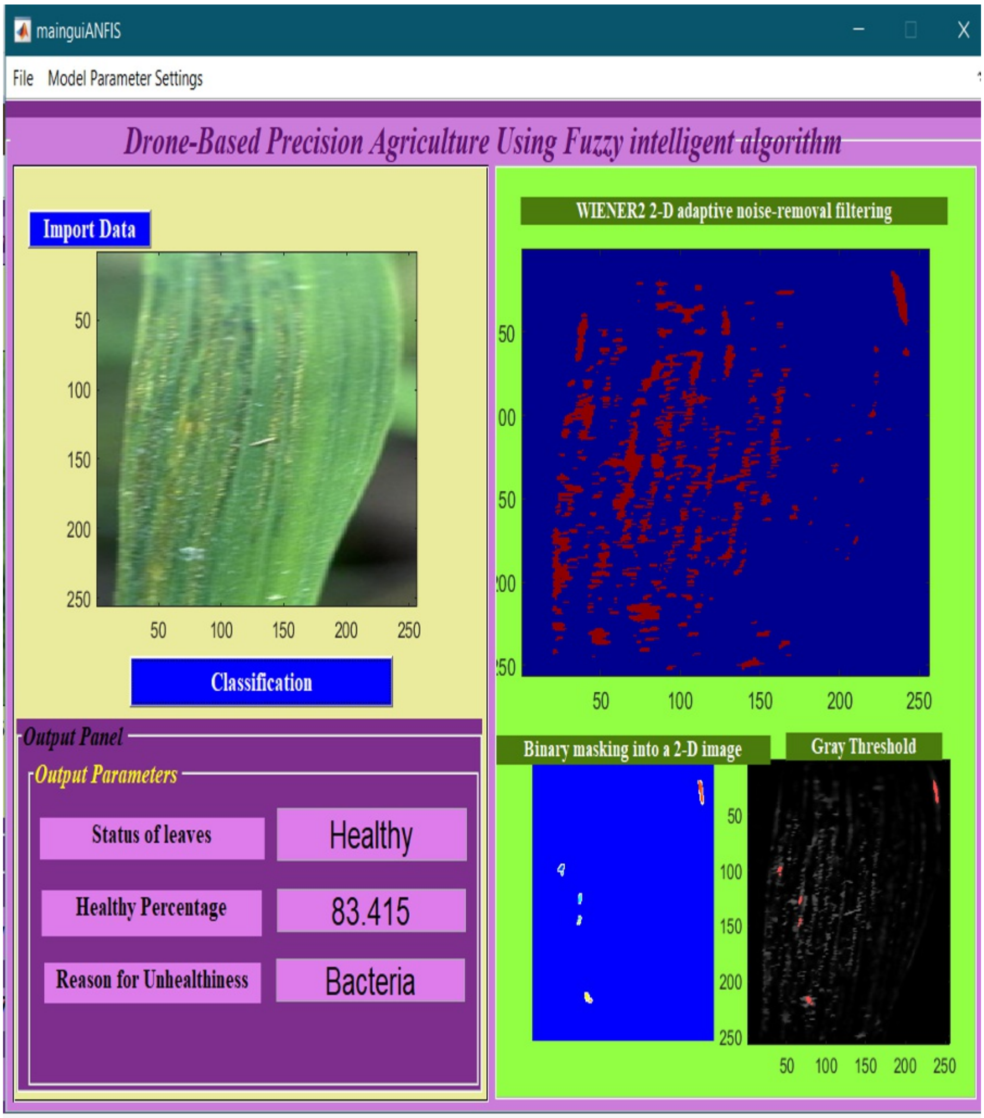

Figure 4. Shows the healthy paddy leaves after investigation with fuzzy algorithm

Late blight is a serious sickness that contaminates tomatoes and potatoes, causing brown, stained leaves that dry and twist internal, joined by white contagious development in sodden circumstances. Eliminate and obliterate contaminated regions and keep plants solid with foods grown from the ground feed and natural soil conditioner.

Rust seems to be rust shaping on plants and is well defined for one kind of plant, so it won't spread across the nursery. Eliminate and obliterate tainted parts, limit high nitrogen takes care of, purpose high potash feeds, and utilize a fungicide answer for keep rust from framing or returning.

Wither influences different plants and vegetables, causing shrinking leaves that become yellow or brown. Stay away from it by utilizing a fluid plant food to advance solid and solid plants and keeping away from high-nitrogen manures.

Clubroot is a parasitic disease that influences brassicas roots and elaborate family members, causing enlarged and mutilated roots and hindered development with purplish, shrinking foliage. Treat it by raising the dirt pH and further developing seepage, and utilize a fluid plant food during the developing season.

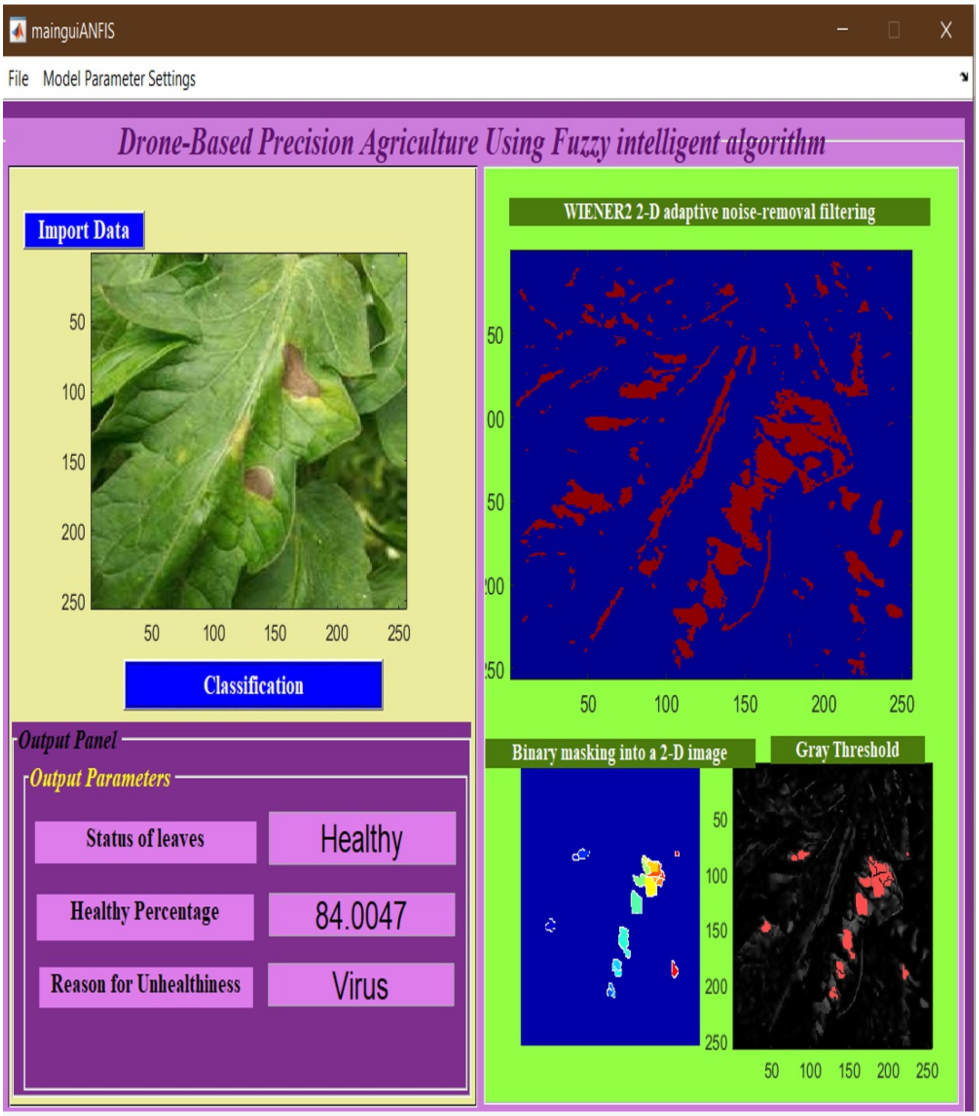

Figure 5. Shows the Cercospora Leaf Spot

Cercospora Leaf Spot can be treated using both preventive and curative methods. The disease can be prevented and treated by removing affected leaves, enhancing air circulation, avoiding overhead watering, applying fungicides, rotating crops, and keeping healthy plants. Drone based image acquisition techniques are effective and FIS algorithm helped to categorize the healthy and unhealthy leaves. Fig. 3 represents the main GUI panel for disease classification. Fig. 4, 5 represents the bacterial infection on paddy leaves and cercospora infection respectively.

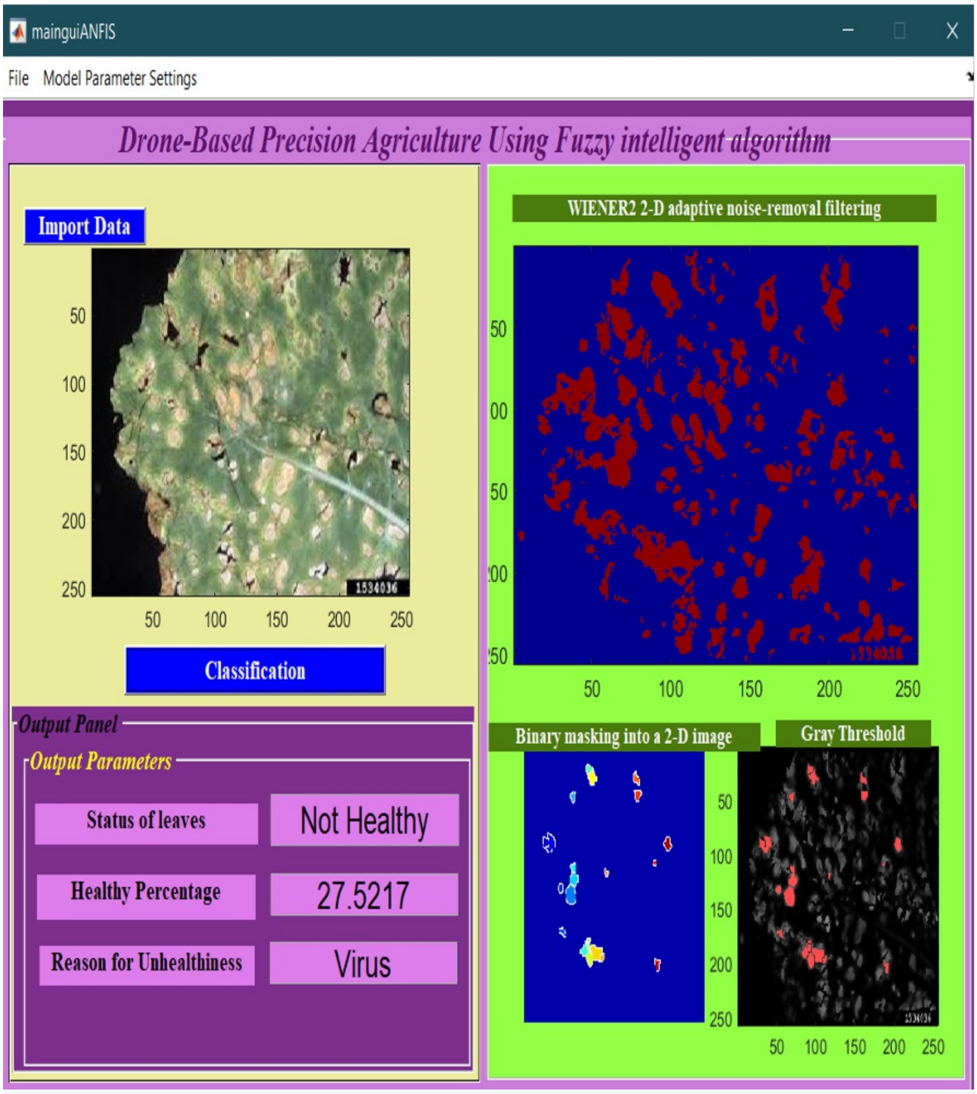

Figure 6. Represents the bacterial blight

Using a combination of preventive and therapeutic actions, bacterial blight can be resolved. Infected plant material should be removed, overhead watering should be avoided, copper-based fungicides should be used, antibiotics should be applied, crops should be rotated, and excellent hygiene should be followed. Fig. 6 and 7 represents the bacterial blight and alternata disease infection.

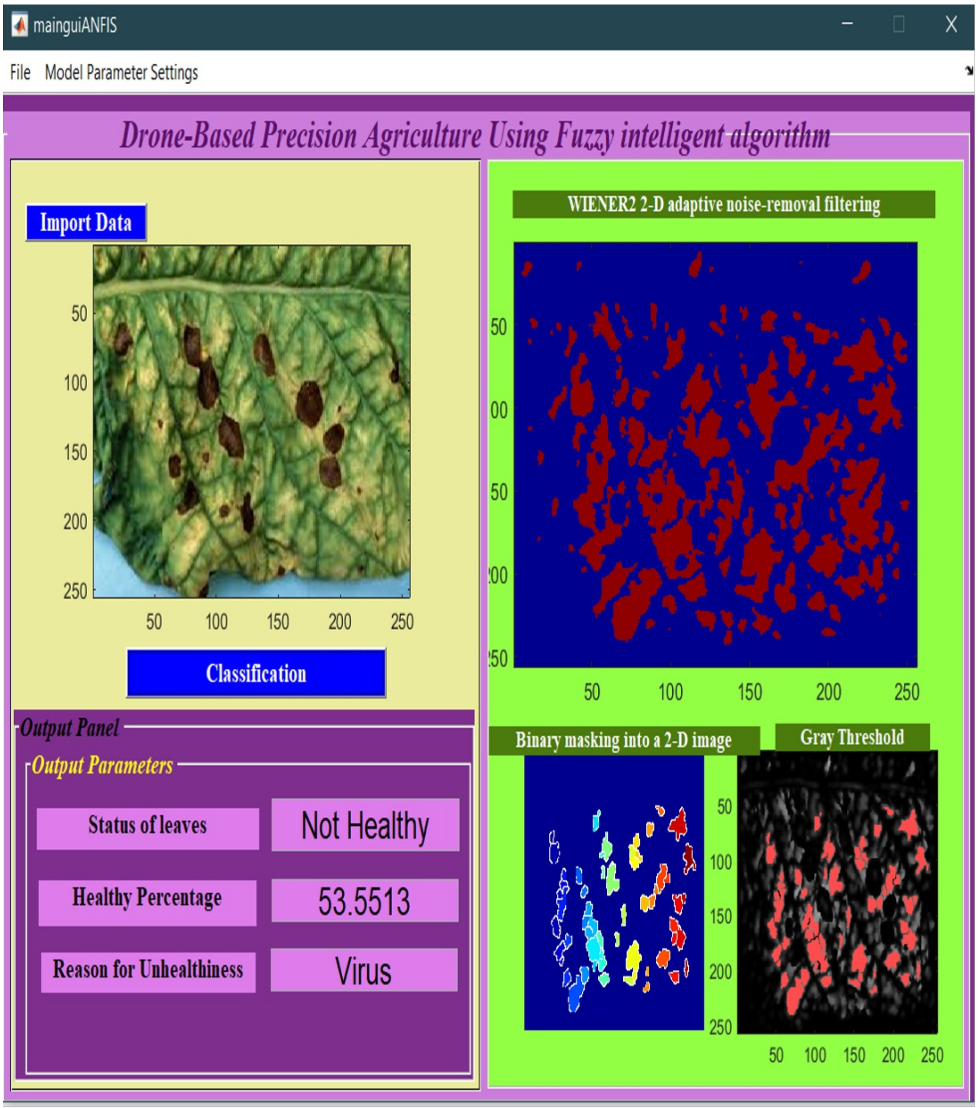

Figure 7. Shows the Alternaria Alternata disease infection

Alternaria alternata is a parasitic sickness that influences various plants, including tomatoes, potatoes, and cucumbers. It is described by the presence of dim injuries on the leaves, stems, and products of the plant. Here are far to redress Alternaria alternata sickness contamination:

Eliminate Tainted Plant Material: The initial step to correct Alternaria alternata illness contamination is to eliminate any tainted plant material, including leaves, stems, and natural products. This will assist with forestalling the spread of the infection to different pieces of the plant.

Further develop Air Flow: Alternaria alternata flourishes in sticky conditions, so further developing air course around the plant can assist with keeping the sickness from spreading. This can be accomplished by pruning close by trees and bushes or expanding the space between plants.

Abstain from Above Watering: Above watering can increment dampness levels and advance the development of Alternaria alternata. Consequently, it is prescribed to water the plant at the base rather than from a higher place.

Use Fungicides: Fungicides can be utilized to treat Alternaria alternata, however it is essential to choose the right item for the plant and adhere to the guidelines cautiously. Copper-based fungicides are successful against Alternaria alternata and can be applied protectively or as a treatment. To forestall Alternaria alternata from repeating, it is fundamental to routinely pivot crops. Fig. 4, 5 represents the bacterial infection on paddy leaves and cercospora infection respectively.

This assists with forestalling the development of contagious spores in the dirt. Keeping up with sound plants is basic in forestalling Alternaria alternata. Solid plants are less powerless to parasitic illnesses, so it is essential to give the plant satisfactory supplements and water and to routinely prune. Alternaria alternata illness contamination can be corrected through a blend of preventive and medicinal measures. Eliminating contaminated plant material, further developing air course, abstaining from above watering, utilizing fungicides, pivoting crops, and keeping up with sound plants can assist with forestalling and treat the sickness.

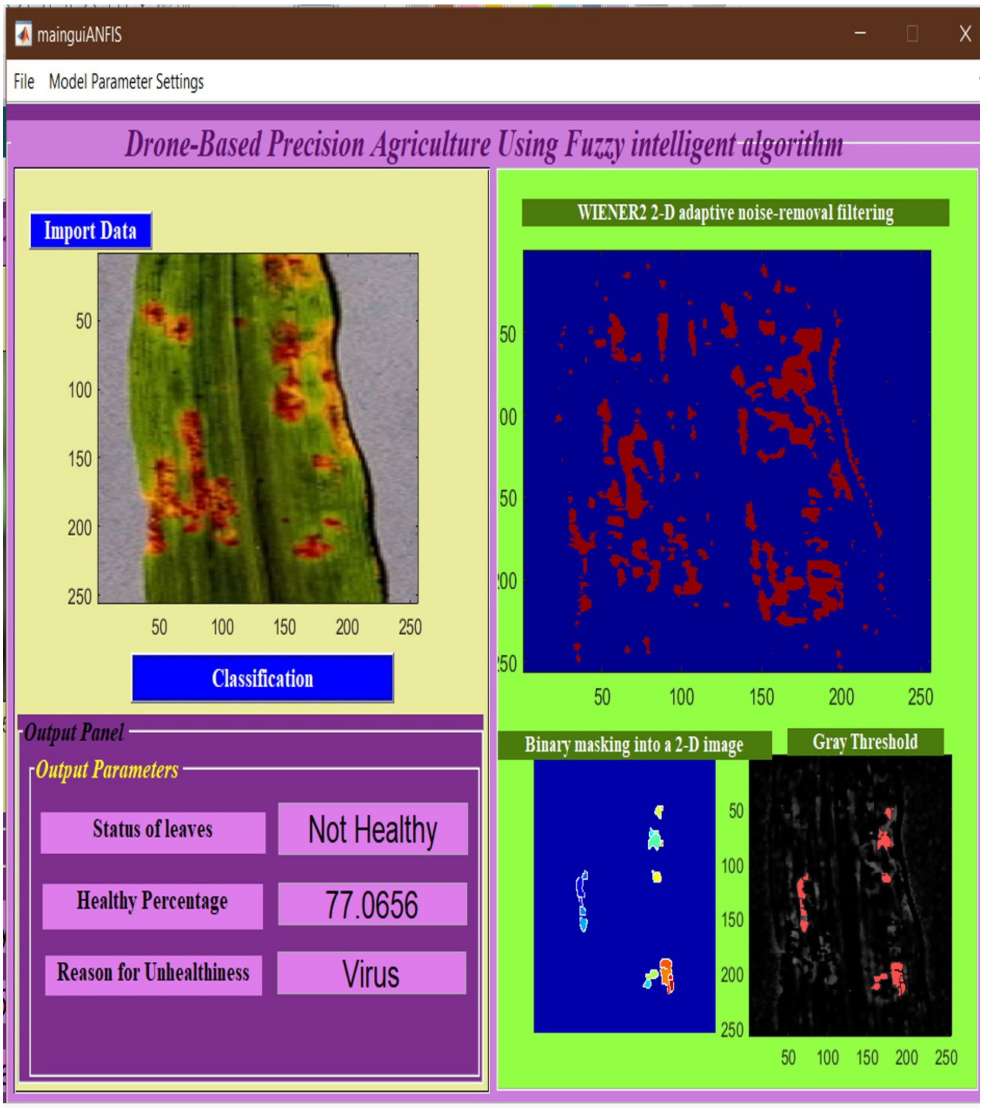

Figure 8. Shows the unhealthy paddy leaves after investigation with fuzzy algorithm

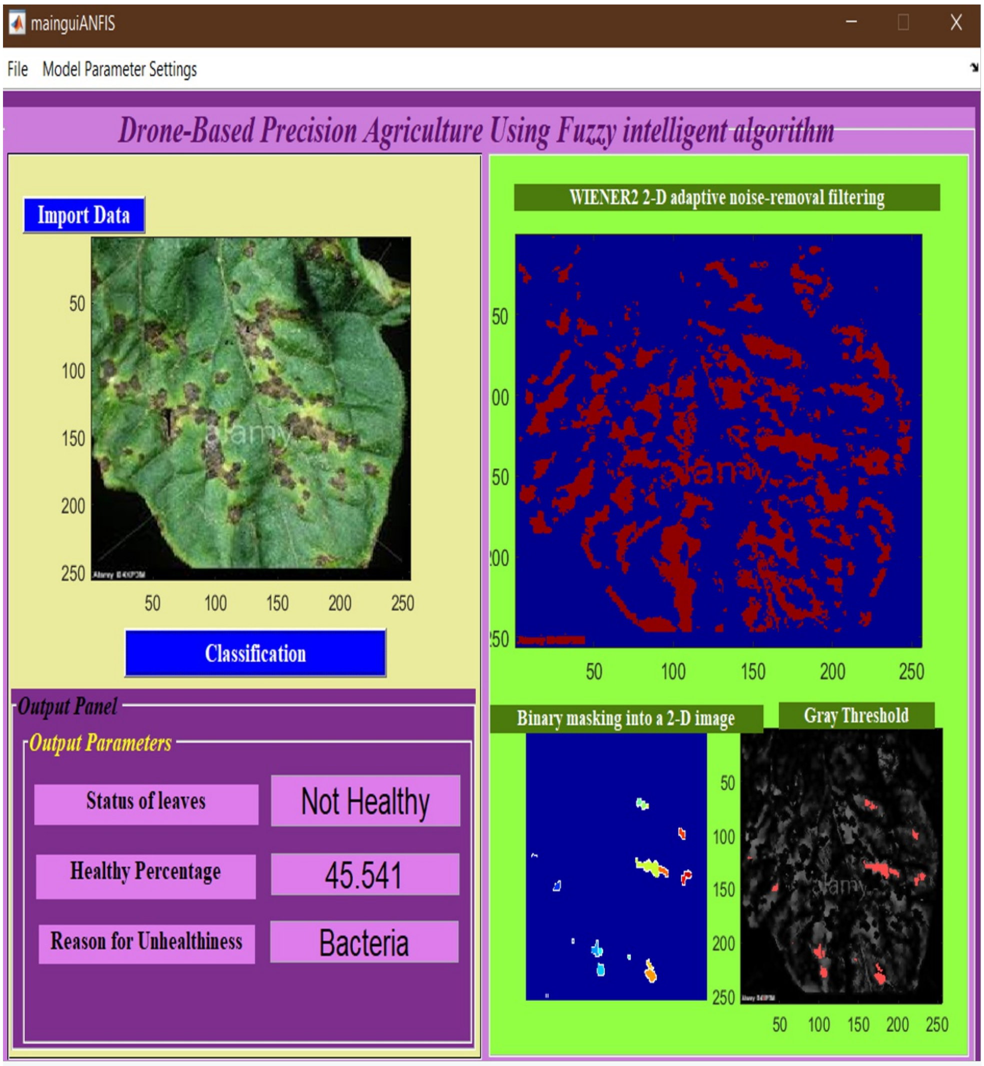

Figure 9. Shows the Anthracnose infection in leaves

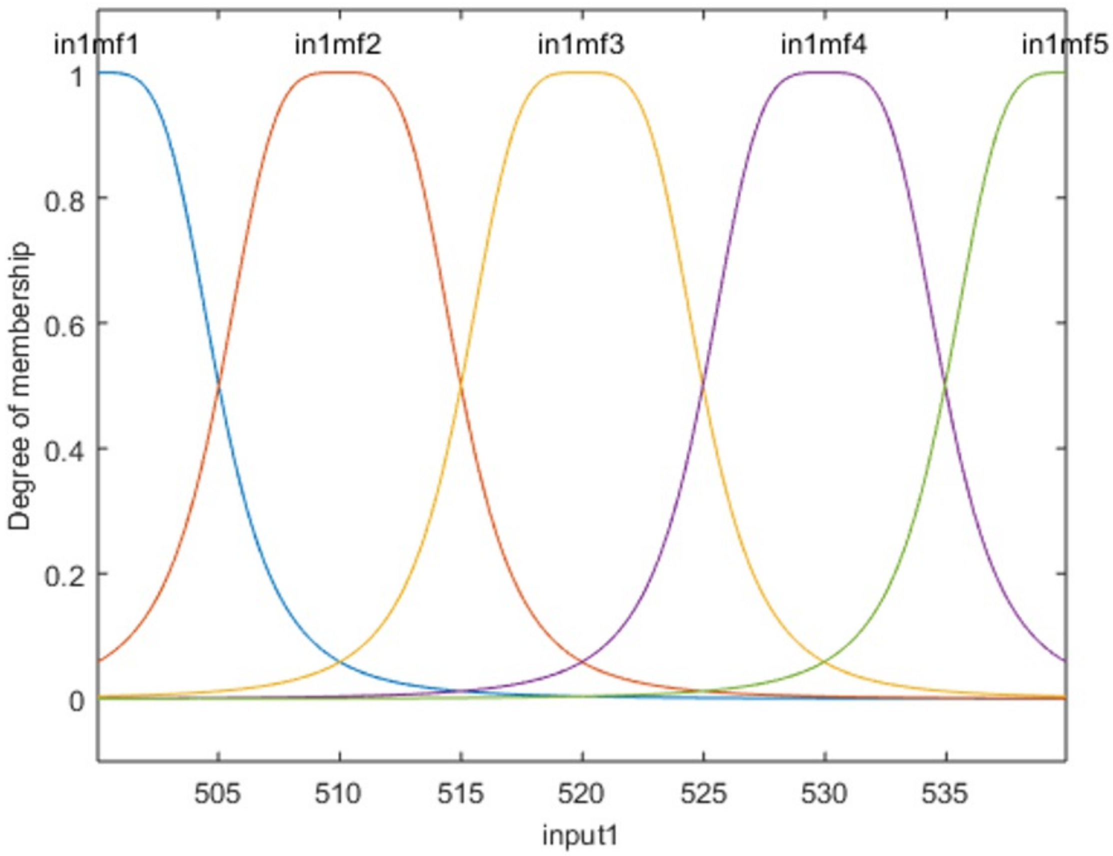

Figure 10. Shows the membership functions used in this algorithm

Fig. 8 and 9 represents the virus and bacterial infection and fig. 10 represents the membership functions used in this algorithm. Anthracnose disease in leaves can be corrected through a mix of preventive and medicinal measures. Eliminating contaminated plant material, further developing air course, abstaining from above watering, utilizing fungicides, applying natural medicines, and keeping up with solid plants can assist with forestalling and treat the sickness.

7. Results and Discussion

Unhealthy paddy leaves can be brought about by different elements, including supplement inadequacies, illnesses, bothers, and ecological pressure. Here are far to amend undesirable paddy leaves The most important phase in correcting unhealthy paddy leaves is to recognize the reason. Supplement lacks can be tended to by treating the dirt with the proper supplements, while sicknesses and irritations might require the utilization of fungicides or insect sprays. Paddy plants require a great deal of water, and insufficient watering can prompt undesirable leaves. Thusly, it is critical to give the plant sufficient water to keep the leaves from becoming dry and weak. Weeds can rival paddy plants for supplements and water, which can prompt undesirable leaves. Accordingly, it is essential to control weeds in and around the paddy field. Paddy plants require a great deal of supplements to develop solid leaves, and compost can assist with giving the important supplements. In any case, it is essential to apply the perfect sum and kind of compost to stay away from overpreparation, which can prompt consuming of the leaves.

8. Conclusion

In conclusion, the combination of cutting-edge technology along with intelligent computing strategies will help the drone-based accuracy farming. It has shown extraordinary potential in further developments in harvest yield and quality. The utilization of fuzzy based algorithm has furthermore improved the exactness and proficiency of these methods by giving shrewd dynamic abilities to the farmers to adapt themselves to updated technology.

Using drone-based agriculture farming practises has a number of benefits, such as:

- Drones with cameras and sensors may give farmers high-resolution aerial imagery of their fields, enabling them to spot problem areas like pest infestations, disease outbreaks, or nutrient deficits. This is known as precision farming. This enables farmers to treat these problems in a targeted and precise manner, which may ultimately result in increased agricultural yields and improved crop quality.
- Drones can be used to monitor climatic variables like soil moisture, humidity, and temperature that have an impact on agricultural growth. Farmers can use this information to determine when to sow and harvest their crops, as well as how best to use irrigation and other resource management techniques.
- Crop management: Farmers may assess crop health and growth patterns over time by using drones that are fitted with cutting-edge sensors and software. This can aid farmers in making better decisions regarding insect control, irrigation, and fertilization, ultimately resulting in healthier crops and greater yields.

References

1. ^*Federal Highway Administration, How do weather events impact roads?. https://ops.fhwa.dot.gov/weather/q1_roadimpact.htm last accessed: 26.01.2022.*
2. ^*https://morth.nic.in/sites/default/files/RA_2021_Compressed.pdf*
3. ^*J. Wu, S. Yang, F. Yang, X. Yin, Road weather monitoring system shows high cost effectiveness in mitigating malfunction losses, Sustainability 13 (22) (Jan. 2021), https://doi.org/10.3390/su132212437. Art. no. 22.*
4. ^*Nurmi, P., Perrels, A., Nurmi, V., Expected impacts and value of improvements in weather forecasting on the road transport sector, Meteorol. Appl., Volume 20, Issue 2 p. 217-223, https://doi.org/10.1002/met.1399.*
5. ^*Economic value of weather forecasts on transportation–Impacts of weather forecast quality developments to the economic effects of severe weather.*
6. ^*The quiet revolution of numerical weather prediction*
7. ^*Monitoring the observation impact on the short-range forecast*
8. ^*Lagkas, T., Argyriou, V., Bibi, S. and Sarigiannidis, P., 2018. UAV IoT framework views and challenges: Towards protecting drones as “Things”. Sensors, 18(11), p.4015.*
9. ^*Review UAV IoT Framework Views and Challenges: Towards Protecting Drones as “Things”.*

10. ^Potter, B., Valentino, G., Yates, L., Benzing, T. and Salman, A., 2019, April. Environmental Monitoring Using a Drone-Enabled Wireless Sensor Network. In 2019 Systems and Information Engineering Design Symposium (SIEDS) (pp. 1-6). IEEE.
11. ^Review of using small UAV based meteorological measurements for road weather management.
12. ^Drone-based meteorological observations up to the tropopause
13. ^Achtelik, Michael C., Stumpf, Jan, Gurdan, Daniel, and Doth, Klaus M. "Design of a Flexible High Performance Quadcopter Platform Breaking the MAV Endurance Record with Laser Power Beaming." IEEE International Conference on Intelligent Robots and Systems. pp. 5166– 5172. San Francisco, CA, September 25–30, 2011. DOI: 10.1109/IROS.2011.6048336
14. ^Cruz, Patricio J. and Fierro, Rafael. "Cable-Suspended Load Lifting by a Quadrotor UAV: Hybrid Model, Trajectory Generation, and Control." Autonomous Robots Vol. 41 No. 8 (2017): pp. 1629–1643. DOI: 10.1007/s10514-017- 9632-2
15. ^Mueller, Mark W. and D'Andrea, Raffaello. "Relaxed Hover Solutions for Multicopters: Application to Algorithmic Redundancy and Novel Vehicles." International Journal of Robotics Research Vol. 35 No. 8 (2016): pp. 873– 889. DOI: 10.1177/0278364915596233.
16. ^Guerrero, M. E., Mercado, D. A., Lozano, R., and Garcia, C. D. "IDA-PBC methodology for a quadrotor UAV transporting a cable-suspended payload." International Conference on Unmanned Aircraft Systems. pp. 470–476. Denver, CO, June 9-12, 2015. DOI: 10.1109/ICUAS.2015.7152325
17. ^Klausen, Kristian, Fossen, Thor I., and Johansen, Tor Arne. "Nonlinear control of a multirotor UAV with suspended load." International Conference on Unmanned Aircraft Systems. pp. 176–184. Denver, CO, June 9-12, 2015. DOI: 10.1109/ICUAS.2015.7152289
18. ^Dai, Shicong, Lee, Taeyoung, and Bernstein, Dennis S. "Adaptive Control of a Quadrotor UAV Transporting a Cable-Suspended Load with Unknown Mass." IEEE Conference on Decision and Control. pp. 6149– 6154. Los Angeles, CA, December 15–17, 2014. DOI: 10.1109/CDC.2014.7040352
19. ^Goodarzi, Farhad A., Lee, Daewon, and Lee, Taeyoung. "Geometric Stabilization of a Quadrotor UAV with a Payload Connected by Flexible Cable." American Control Conference. pp. 4925-4930. Portland, OR, June 4–6, 2014. DOI: 10.1109/ACC.2014.6859419
20. ^Guerrero, M. E. and Mercado, D. A. and Lozano, R. and Garc´ıa, C. D. "Passivity Based control for a quadrotor UAV transporting a cable-suspended payload with minimum swing." IEEE Conference on Decision and Control. pp. 6718–6723. Osaka, Japan, December 15–18, 2015. DOI 10.1109/CDC.2015.7403277
21. ^Faust, Aleksandra, Palunko, Ivana, Cruz, Patricio, Fierro, Rafael, and Tapia, Lydia. "Learning Swing-free Trajectories for UAVs with a Suspended Load." IEEE International Conference on Robotics and Automation. pp. 4902–4909. Karlsruhe, Germany, May 6-10, 2013. DOI: 10.1109/ICRA.2013.6631277
22. ^San Juan, V´ıctor, Santos, Matilde, and Andujar, Jos ´ e´ Manuel. "Intelligent UAV Map Generation and Discrete Path Planning for Search and Rescue Operations." Complexity Vol. 2018 (2018). DOI: 10.1155/2018/6879419
23. ^Trachte, Jan Erik, Toro, Luis Felipe Gonzalez, and McFadyen, Aaron. "Multi-Rotor with Suspended Load: System Dynamics and Control Toolbox." IEEE Aerospace Conference. Big Sky, MT, March 7–14, 2015. DOI:

10.1109/AERO.2015.7119210

24. ^*Application of Drones in Indian Agriculture (Abhishek Beriya).*
25. ^*A Comparative Study on Application of Unmanned Aerial Vehicle Systems in Agriculture.*
26. ^*Motlagh, N.H.; Bagaa, M.; Taleb, T. UAV-based IoT platform: A crowd surveillance use case. IEEE Commun. Mag. 2017.*
27. ^*Kersnovski, T.; Gonzalez, F.; Morton, K. A UAV system for autonomous target detection and gas sensing. In Proceedings of the Aerospace Conference, Big Sky, MT, USA, 4–11 March 2017.*
28. ^*Kumbhar, A.; Guvenc, I.; Singh, S.; Tuncer, A. Exploiting LTE-Advanced HetNets and FeICIC for UAV-assisted public safety communications. IEEE Access 2018, 6.*
29. ^*Bupe, P.; Haddad, R.; Rios-Gutierrez, F. Relief and emergency communication network based on an autonomous decentralized UAV clustering network. In Proceedings of the SoutheastCon, Fort Lauderdale, FL, USA, 9–12 April 2015.*
30. ^*Merwaday, A.; Guvenc, I. UAV assisted heterogeneous networks for public safety communications. In Proceedings of the Wireless Communications and Networking Conference Workshops (WCNCW), New Orleans, LA, USA, 9–12 March 2015.*
31. ^*Luo, C.; Nightingale, J.; Asemota, E.; Grecos, C. A UAV-cloud system for disaster sensing applications. In Proceedings of the 2015 IEEE 81st Vehicular Technology Conference (VTC Spring), Glasgow, 2015.*
32. ^*Zanella, A.; Bui, N.; Castellani, A.; Vangelista, L.; Zorzi, M. Internet of Things for Smart Cities. IEEE Internet Things J. 2014, 1, 22–32. DOI: 10.1109/JIOT.2014.2306328*
33. ^*Al-Hourani, A.; Kandeepan, S.; Jamalipour, A. Modeling air-to-ground path loss for low altitude platforms in urban environments. In Proceedings of the 2014 IEEE Global Communications Conference, Austin, TX, USA, 8–12 December 2014; pp. 2898–2904. DOI: 10.1109/GLOCOM.2014.7037248*