Image Processing: Review on the uses of this technology in the field of agriculture

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***Abstract*—Agriculture could be completely changed by image processing, a rapidly evolving technology. An overview of the many image processing uses in agriculture is provided in this study. The study emphasizes the use of image processing in agriculture and offers a summary of the several image processing methods applied there. The benefits and drawbacks of these strategies, as well as the difficulties in applying them, are covered in the study. The research highlights the significance of applying image processing methods for yield estimation, quality evaluation, and plant disease identification. It also emphasizes the possibilities of image processing for agriculture using remote sensing technologies. The paper ends with suggestions for more studies aimed at enhancing the precision and efficiency of image processing methods in agriculture. Overall, this analysis offers insightful information about the level of image processing in agriculture today and its potential to raise the sector's productivity and sustainability.**

***Index Terms*—Image processing, development, agriculture, technology**

I. Introduction

A sub-field of mathematics known as "image processing" deals with the manipulation of digital images using various mathematical methods and algorithms. It involves doing numerous operations to an image, such as filtering, enhancing, compressing, and restoring it, using computer algorithms. Among other applications, image processing is essential to robotics, remote sensing, robotic imaging, and video surveillance. In this paper, we'll discuss the principles of image processing, a variety of image processing techniques, and how image processing is applied in agricultural research. A digital image is a depiction of an item or scene that is kept on a computer in the form of a binary file. Each pixel in an image, often known as a dot, has a unique value that represents its color or intensity. To create the image, these pixels are organized in a grid-like pattern. Image processing's main objective is to change these pixel values in order to improve or change the image. Four basic operations are involved in image processing: acquisition, prepossessing, analysis and post-processing. Around the world, image processing is becoming more and more common in a variety of industries, including agriculture. Farmers and academics may learn a lot about crops, soil, and weather patterns by employing computer algorithms to evaluate photos. Crop growth and health can be monitored via image processing. Farmers can monitor crop health and spot early indications of stress, such as nutrient deficits, pests, or illnesses, by analyzing photos taken by drones or satellites. Farmers are then able to take corrective action before the issue gets worse, increasing crop yields and lowering waste. Image processing can also aid farmers in more effective crop management. Farmers can locate regions that need extra irrigation, fertilizer, or other inputs by examining photographs of crop fields. By doing this, waste is decreased and resources are utilized where they are most required. The analysis of soil qualities can also be done via image processing. Researchers can learn about soil texture, structure, and moisture content by studying pictures of soil samples. In order to increase crop yields, farmers can use this to optimize their soil management techniques, such as irrigation and fertilization. The study of weather patterns can also benefit from image processing. Farmers can forecast weather conditions and modify their farming techniques by examining cloud photos and weather patterns. This can lower the risk of crop losses and assist farmers in preparing for adverse weather conditions like droughts or floods.

II. Applications of image processing technology in agriculture

The paper [1] discusses Image processing technology has the ability to completely transform the agricultural industry by giving farmers access to insightful information and data that will allow them to optimize their methods and increase yields. The following agricultural applications can make use of image processing:

To identify fruit, stem and leaf disease: Plant diseases of the fruit, stem, and leaf can be recognized using image processing technology by examining photographs of the plants that were taken using different imaging techniques. Advanced algorithms are used to analyze the photos in order to find patterns and anomalies in the plant images that can point to the presence of a disease. Image processing methods can be used to recognize and analyze abnormalities in the leaves or fruit, such as colour changes, lesions, and other abnormalities. Based on distinctive patterns in the photos, image processing algorithms can also be trained to recognize particular diseases. Overall, image processing offers a non-intrusive and effective way to detect and track plant illnesses, which can eventually result in more efficient disease management and higher agricultural yields.

The article [2] discusses To calculate the disease-affected area: By examining photographs of the crops taken with drones or other imaging equipment, image processing can be utilized to determine the disease-affected area in agricultural fields. To reduce any noise and accentuate the important details, such as the sick areas, the photos are first pre-processed. Then, using methods like threshold, clustering, or machine learning algorithms, the diseased areas are recognized and separated from the healthy areas. By examining photographs of the crops taken with drones or other imaging equipment, image processing can be utilized to determine the disease-affected area in agricultural fields. To reduce any noise and accentuate the important details, such as the sick areas, the photos are first pre-processed. Then, using methods like thresholding, clustering, or machine learning algorithms, the diseased areas are recognized and separated from the healthy areas.

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The study [3] discusses identifying the afflicted area's shape: Techniques for image processing can also be used to determine the form of the damaged region in agricultural fields. This is accomplished by examining and figuring out the shape of the infected region's boundary, which can assist in comprehending the disease's spread. Several algorithms, including edge detection and segmentation, can be used to precisely pinpoint the affected area's boundary. While segmentation techniques divide the image into different regions based on the pixel intensity values, edge detection methods use sudden changes in pixel intensity to identify the edges of the diseased area. These algorithms can be used to analyze the boundaries of the affected area and identify the form and size of the affected area, allowing for improved disease management and control (Qiu et al., 2006).

The article [4] discusses identifying the hue of the impacted area: Using image processing methods, it is also possible to detect the hue or color of the damaged area. To do this, look at the image's color distribution and look for any areas with odd color patterns. For instance, when a plant is sick, the affected area's hue may be different from that of the plant's healthy areas. By analyzing the color distribution in the image, image processing algorithms can identify these areas, and they can then create a color map that illustrates where the damage has occurred. The disease's severity and the progression of the condition over time can be determined using this data. Making a more accurate diagnosis can be accomplished by identifying different diseases based on the colour of the affected area.

The study [5] determines the fruits' size and shape: In agriculture, image processing is used to assess the size and shape of fruits. Knowing the fruit's size and shape is crucial when harvesting fruit automatically so that the robot can recognize and select the fruit precisely. Camera-captured photos of fruits can be analyzed by image processing algorithms to assess their size and form. The procedure entails separating the fruit from the surrounding area, spotting its borders and features, and figuring out how big it is. The algorithms created using this information can then precisely detect and choose the fruit based on its size and shape. Fruit harvesting can be made more effective and precise by analyzing fruit size and form using image processing (Iqbal et al., 2015).

III. Case studies on the use of image processing technology in agriculture

The application of image processing technology in agriculture has attracted attention on a global scale lately. This technology has the potential to enhance resource management, soil analysis, and crop monitoring. For instance, using smartphone photos, a study team has created a machine learning-based application to identify and categorize plant illnesses. The program, "Plant Disease Diagnosis from Images Using Deep Learning," employs a machine learning algorithm to examine pictures of plants that were taken with smartphones (Sanga et al., 2020). Based on visual signs including spots, deformations, and discolouration, the algorithm can recognize a number of different plant illnesses. The tool provides a number of benefits, including portability, affordability, and simplicity of use. Farmers can immediately diagnose a problem with their plants using their smartphones, which allows them to take action to stop additional harm. Convolutional Neural Networks are a deep learning technique that researchers utilize to train their machine learning model. To train the algorithm to correctly recognize and classify diverse plant diseases, they gathered a sizable collection of plant photos displaying various sorts of diseases. The instrument has demonstrated high levels of accuracy in identifying plant diseases when tested on a number of crops, including tomato, wheat, and rice. Farmers can use the team's user-friendly mobile application to upload photographs of their plants and get a diagnosis by uploading them. The creation of this instrument could have a big impact on Bangladesh's agriculture, where plant diseases pose a serious danger to agricultural productivity and food security. The instrument can assist to lower crop losses and increase output by helping farmers to swiftly identify and cure plant illnesses. The technology has wider implications for machine learning applications in agriculture in addition to its potential advantages for farmers. It shows how machine

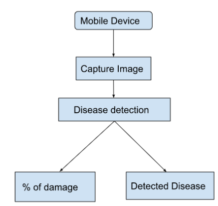

Fig. 1. working procedure

learning algorithms have the capacity to evaluate massive volumes of data and generate precise forecasts, empowering farmers to make more informed decisions regarding crop management and resource allocation (Sanga et al., 2020). To improve agricultural practices in Bangladesh, machine learning-based systems for identifying and categorizing plant diseases are being developed. However, the availability and calibre of the data used to train these tools play a significant role in their efficacy. The restricted availability of a comprehensive dataset of annotated photos of plant diseases affecting crops in Bangladesh is one of the major obstacles that such technologies encounter in this environment. A lack of data can result in poorly trained models, which can produce predictions with low accuracy. To improve agricultural practices in Bangladesh, machine learning-based systems for identifying and categorizing plant diseases are being developed.

Another study [6] monitors rice fields and gives farmers up-to-the-minute information using remote sensing and image processing methods. The project seeks to monitor rice fields and give farmers up-to-the-minute information using remote sensing and image processing methods. The initiative is centred on using satellite data to track Bangladeshi rice farms. To determine rice crop acreage, growth stage, and production potential using satellite data, image analysis techniques are used (Kalpoma et al., 2020). In order to give real-time information on weather conditions that may have an impact on rice production, the initiative also uses weather data. A smartphone application is used to make the project's information accessible to farmers. Another project monitors rice fields and gives farmers up-to-the-minute information using remote sensing and image processing methods. The project seeks to monitor rice fields and give farmers up-to-the-minute information using remote sensing and image processing methods. The initiative is centred on using satellite data to track Bangladeshi rice farms. To determine rice crop acreage, growth stage, and production potential using satellite data, image analysis techniques are used. In order to give real-time information on weather conditions that may have an impact on rice production, the initiative also uses weather data. A smartphone application is used to make the project's information accessible to farmers. It illustrates the potential for these technologies to offer in-the-moment data on crop development and yield potential, empowering farmers to choose more wisely how to manage their crops and allocate resources. This kind of endeavour might increase rice yields and lower production costs, which would help Bangladesh's agriculture sector grow as a whole

The paper [7] discusses the integration of nascent technologies within the agricultural sector has the potential to facilitate the adoption of sustainable farming practices. The implementation of advanced techniques in precision agriculture can lead to improved farm output and enriched farm inputs, resulting in a reduction of errors and costs. This approach can ultimately contribute to the achievement of ecologically and economically sustainable agriculture. The utilization of image processing is a viable approach for precise and cost-effective measurement of agronomic parameters. The present case study centres on the utilization of image processing techniques in the agricultural sector, with a specific emphasis on weed identification and fruit/food classification. The technique of remote sensing is extensively employed within the agricultural sector, with the capacity to furnish pertinent information pertaining to groundwater, environmental evaluation, disaster surveillance, weather patterns, climate conditions, and village resource centres. Various techniques for weed detection have been developed using image processing, such as edge detection, colour detection, and classification based on wavelets and fuzzy logic algorithms. The precise grading and sorting of fruits and foods are of utmost importance in the field of agriculture. To achieve this, image processing techniques have been employed, which rely on factors such as size, colour, and shape. In general, the implementation of image processing technology has brought about a significant transformation in the agricultural industry by providing farmers with solutions that are both precise and cost-effective in addressing various challenges. This technology holds great potential in facilitating the enhancement of crop yields and quality, while simultaneously promoting resource efficiency and environmental sustainability.

Image processing technology has been used in agriculture to locate and measure damaged leaves, stems, and fruits as well as to evaluate the size, shape, and colour of afflicted areas. Gathering photos, converting them into numbers, segmenting, representing, and summarizing the resulting numerical data are all steps in the process. Different methods of classifying images have been used, including supervised and unsupervised classification, parametric and non-parametric classifiers, and per-pixel and sub-pixel classifiers, depending on the characteristics of the image. This technology has the potential to improve disease management and increase yields by providing quick and accurate information for agricultural decision-making. Image processing technology has been used in agriculture to locate and measure damaged leaves, stems, and fruits as well as to evaluate the size, shape, and colour of afflicted areas. This paper [8] Gathering photos, converting them into numbers, segmenting, representing, and summarizing the resulting numerical data are all steps in the process. Different methods of classifying images have been used, including supervised and unsupervised classification, parametric and non-parametric classifiers, and per-pixel and sub-pixel classifiers, depending on the characteristics of the image. This technology has the potential to improve disease management and increase yields by providing quick and accurate information for agricultural decision-making.

The paper [9] explores the application of image processing technology in the field of agriculture. The text explains that image processing has gained significant importance in the agricultural sector. It serves as an expert system that provides decision support. The paper provides an overview of the key components involved in image processing, which comprise image acquisition, image enhancement, image segmentation,

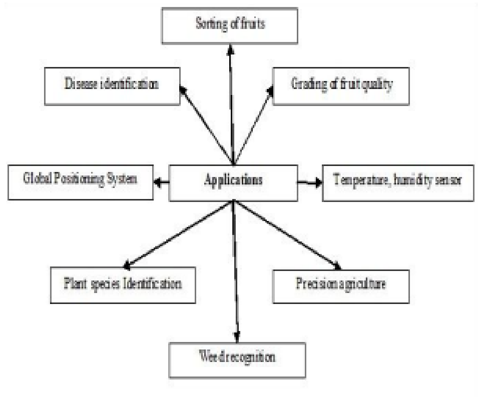

Fig. 2. Satellite Imaging using USGS Earth Explorer

object recognition, and image representation and description. The text explores different methods employed in image processing, including computer vision, machine vision, and image analysis. The paper highlights the significance of identifying plant diseases and emphasizes the use of image processing to identify different diseases in agricultural crops caused by pests, bacteria, viruses, and nematodes. The conclusion of the paper is that implementing image processing technology in the agriculture sector can assist farmers in maximizing their profits while minimizing costs. The article ”Image Processing Technology in Agriculture” explores the use of image processing technology in modern agriculture. The writers begin by highlighting the necessity for agriculture to adopt new technologies in order to boost efficiency and productivity. They go on to discuss how image processing technology may help with this effort by offering accurate, non-destructive, and real-time analysis of crops, soil, and other agricultural elements. The study [10] presents an overview of several image processing techniques, such as picture enhancement, segmentation, classification, and feature extraction, that may be used in agricultural photographs to extract meaningful information. The writers also examine the usage of unmanned aerial vehicles (UAVs) or drones to capture photos of crops from various angles and heights. The authors then show how image processing technology has been used in agriculture, such as crop categorization, yield prediction, and plant disease detection. They describe how machine learning algorithms and deep learning approaches were utilized to increase the accuracy of these applications. The report finishes by emphasizing the advantages of image processing technology in agriculture, such as better crop yields, lower costs, and enhanced sustainability. The authors also underline the necessity for more study in this subject to further expand and perfect these strategies for general usage in agriculture.Overall, the article presents a detailed review of the usage of image processing technology in agriculture, as well as its potential to transform the way we generate food. It is an excellent resource for scholars, practitioners, and policymakers interested in the convergence of technology and agriculture.

The article [11] presents an overview of the many uses of computer vision and image processing in precision agriculture. The authors begin by highlighting the relevance of precision agriculture in increasing agricultural output, decreasing environmental impact, and optimizing resource utilization. They then explain how computer vision and image processing may be utilized to automate agricultural operations such as plant counting, weed identification, disease diagnosis, and yield calculation. The study also addresses the various image acquisition techniques, such as RGB imaging, hyperspectral imaging, thermal imaging, and LiDAR, and how each of these approaches may be employed for different agricultural purposes. The authors then go into the different image processing techniques, such as segmentation, feature extraction, and classification, and how these might be used to evaluate agricultural photos. The study also examines the constraints and limits of employing computer vision and image processing in precision agriculture, such as the requirement for high-quality pictures, image processing time, and correct calibration. The authors also explore potential future advances in the field, such as the use of drones and robotics for picture acquisition and the application of machine learning techniques for image analysis. Overall, the article presents a detailed review of the many uses of computer vision and image processing in precision agriculture, highlighting the potential benefits and limitations connected with this technology.

The paper [12] presents a detailed overview of several advanced control tactics utilized in precision agriculture. The report emphasizes the importance of precision agriculture in increasing agricultural output and quality, decreasing environmental impact, and lowering production costs. The study primarily focuses on three important technologies: image processing, unmanned aerial vehicles (UAVs), and artificial intelligence (AI), and explores their integration in the agriculture industry. It also covers current breakthroughs and trends in these technologies, as well as their prospective uses in agriculture. The review paper goes through the many image-processing applications in agriculture, such as plant counting, growth monitoring, disease detection, and yield prediction. It also describes how unmanned aerial vehicles (UAVs) may be utilized for crop mapping, monitoring, and spraying. The report also emphasizes AI’s substantial contribution to agriculture, such as the creation of predictive models, decision-making systems, and automation of numerous agricultural operations. Furthermore, the study delves into the problems and limits of these technologies, such as the expense of equipment and infrastructure, concerns about data privacy and security, and the need for specific skills and expertise. The authors also propose potential solutions to these constraints, making precision agriculture more accessible and successful.Overall, this study gives a complete evaluation of improvements in precision agricultural control systems utilizing image processing, UAVs, and AI. The article believes that integrating these technologies has the potential to change agriculture and enable sustainable food production.

Fig. 3. Satellite Imaging using USGS Earth Explorer

IV. Advantages and limitations of image processing technology in agriculture for Bangladesh

The utilization of image processing technology in agriculture presents a significant benefit as it enables farmers in Bangladesh to enhance their crop management practices with greater efficiency. Through the utilization of this technology, agricultural practitioners are able to expeditiously identify crop-related issues such as inadequate nutrient levels, water deprivation, or the emergence of diseases. This enables the implementation of timely corrective actions and enhances crop productivity. The utilization of image processing technology in agriculture can aid in the efficient management of resources, including water and fertilizers, thereby leading to cost reduction and a more sustainable farming approach.

The study "Image Processing Technology in Agriculture" examines several agricultural uses of image processing technology. Bangladesh, being an agricultural country, may benefit from many of the ideas discussed in this study. Image processing technology may be utilized to boost crop productivity and quality in Bangladesh. Remote sensing and aerial imagery can assist in mapping crop health and identifying locations where fertilizer and pesticides are required. This can assist farmers in optimizing inputs and increasing yields. Image processing technology may be utilized to detect plant diseases and pests at an early stage. This can assist farmers in taking prompt interventions to reduce disease and insect spread and crop losses.Image processing technology can aid with precision agriculture, which entails using sensors and imaging systems to accurately target resources such as water and fertilizer to crops. This can assist to reduce waste and improve efficiency. Using drones for image processing in agriculture can aid in the monitoring of big fields and inaccessible locations. This can assist to reduce labor expenses while also enhancing efficiency.

Image processing technology has the potential to offer farmers a plethora of information pertaining to crop health and growth, thereby constituting an additional benefit in the field of agriculture. The aforementioned data can aid farmers in making well-informed decisions regarding crop management, which can lead to improved yields and heightened profitability. The utilization of image processing technology has the potential to assist farmers in Bangladesh in determining optimal planting periods, resulting in increased crop yields and improved market values.

Whilst image processing technology offers numerous benefits, its application in agriculture within Bangladesh is not without limitations. The cost of implementing this technology poses a formidable challenge, particularly for small-scale farmers, and may serve as a deterrent. Apart from the expenses incurred in procuring equipment and software, supplementary expenditures related to training and upkeep may also arise.

An additional constraint of image processing technology pertains to the necessity of possessing specialized knowledge and skills in order to employ it proficiently. The lack of technical proficiency among farmers in Bangladesh may impede the extensive implementation and utilization of this technology. In addition, potential constraints related to infrastructure, such as inadequate access to dependable internet connectivity or electricity provision in certain rural regions, may present a hurdle to the optimal utilization of this technology.

V. Future directions of image processing technology in Bangladesh agriculture

However, the availability and caliber of the data used to train these tools play a significant role in their efficacy. The restricted availability of a comprehensive dataset of annotated photos of plant diseases affecting crops in Bangladesh is one of the major obstacles that such technologies encounter in this environment. Lack of data can result in poorly trained models, which can produce predictions with low accuracy. Given the variety of crops and diseases that can affect them, obtaining an extensive dataset can be time-consuming and difficult. It takes a lot of labelled data encompassing different crops and diseases to build a machine-learning model that can properly identify plant diseases. Without these data, the model might not have access to sufficient knowledge to learn and create precise algorithms. The bias that can appear in the dataset used to construct machine learning-based solutions is another key shortcoming of these tools. Machine learning models can be skewed and more effective at diagnosing some diseases than others if they are trained on datasets that are not representative of the actual population. The tool may be more effective at identifying a certain disease than others if the dataset used to generate it contains more photos of that disease than others. As a result, the tool may be much less accurate and useful as it may miss or misidentify some diseases, which could result in improper treatment and crop loss.

In many agricultural initiatives involving remote sensing and machine learning methods, data limits are a typical problem. Particularly in the detection and categorization of plant diseases, these constraints might have a major negative impact on the precision and efficacy of these instruments. To get over these restrictions and increase the dependability and accuracy of these instruments, a number of techniques can be used.

Combining remote sensing data with ground truth data is one potential approach to overcoming data constraints in remote sensing projects. Field surveys or sensors placed in the fields can be used to gather ground truth data. The remote sensing data can be calibrated and validated using this data, resulting in outputs that are more accurate and dependable. Farmers can get real-time information about their crops by merging these two forms of data. This information can then be used to inform decisions regarding irrigation, fertilizer use, and insect control.

Working with other institutions or organizations to compile a comprehensive dataset of plant diseases that damage crops is another option for dealing with the data issues in machine learning-based technologies. The machine learning model can be trained using this dataset, producing outputs that are more accurate and dependable. Assuring that the dataset used to construct the tool is representative of the actual population can also be accomplished through cooperation with other institutions or organizations. This can aid in lowering bias and enhancing the tool's accuracy.

It is crucial to employ a stratified sampling strategy to address bias in the dataset. In order to do this, the population must be divided into subgroups, and a proportional representation of each subgroup must be included in the dataset. For instance, the tool may be more effective at recognizing one form of disease than others if the dataset has more photographs of that condition than others, which may restrict its accuracy. By using stratified sampling, it is possible to make sure that the dataset is accurate and that the machine learning model is not biased against any particular disease. Additionally, it is crucial to guarantee that the data used for these projects is accurate and of high quality. Standardized data gathering techniques, data consistency, and data validation procedures can all help with this. The precision and efficiency of these technologies can be increased with the use of high-quality data, which could ultimately result in increased crop yields and a better standard of living for farmers. The usefulness of remote sensing and machine learning-based applications in agriculture can be severely impacted by data restrictions. To overcome these drawbacks and raise the precision and dependability of these technologies, a number of strategies can be used. Farmers can obtain real-time information about their crops, which can help them make more informed decisions about their farming practices, by combining remote sensing data with ground truth data, working with other institutions or organizations, using stratified sampling, and ensuring data quality and reliability.

VI. Conclusion

To conclude, the utilization of image processing technology bears the substantial potential to revolutionize the agricultural sector in Bangladesh through the enhancement of crop management practices, amplification of yields, and the promotion of sustainability. It is imperative to acknowledge and tackle the constraints of expense, specialized knowledge, and infrastructure in order to ensure the accessibility and efficacy of this technology for all agricultural practitioners throughout the nation. Through the implementation of this approach, Bangladesh has the potential to fully leverage this technology and attain elevated levels of agricultural productivity, profitability, and sustainability.

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