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Research Article

Application of Artificial Intelligence in Agricultural Process

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Abstract

The continuous growth of the global population and rapid scientific advancements have increased the demand for high precision and efficient agricultural practices. Artificial Intelligence (AI) has emerged as a transformative tool to enhance the speed, accuracy, and automation of various agricultural processes. This study reviews the recent applications of AI, particularly image processing and machine vision techniques, in different stages of agricultural production, including planting, plowing, harvesting, and post-harvest operations such as storage, silage preparation, and drying. The findings indicate that AI assisted systems can effectively detect plant diseases, estimate yield, monitor soil and crop conditions, and optimize machinery operations with minimal human interventions. Furthermore, the integration of AI with Internet of Things (IoT) technologies enables real time data collection and intelligent decision making in smart farming systems. Despite the significant process made. Continuous technological development and the emergence of new agricultural challenges highlight the need for further research into advanced image processing algorithms, deep learning models, and data driven optimization approaches. Overall, AI and machine vision technologies have proven to be essential components for achieving sustainable, precise, and intelligent agricultural production.

Keywords

Artificial Intelligence, Machine Vision, Agricultural Processes

1. Introduction

The term Artificial Intelligence in its modern sense was first proposed by John McCarthy, Marvin Minsky, and his colleagues. Artificial intelligence is one of the branches of computer science that emerged in the mid-1950s and was initially focused only on investigating game theory, designing and solving simple problems [1]. At the beginning of the emergence of this branch of computer science, it was difficult to predict that the scope of this branch of science would become so wide and comprehensive [2]. Perhaps artificial intelligence can be described as follows: "Artificial intelligence is the study of how to make computers do things that humans currently do correctly or better." [3] In this issue, there are two general approaches, strong artificial intelligence and weak artificial intelligence. A strong approach to the problem of artificial intelligence seeks to build a machine that will manifest all the capabilities that are associated with intelligence in humans (pre-awareness, will, thinking, understanding of meaning and language, etc.) [4]. Therefore, artificial intelligence refers to systems that can behave by human intelligent behavior, including understanding complex conditions, simulating processes responding correctly to them, and learning and acquiring knowledge [5].

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1.1. Scope of the Study

In this article, we will examine the application of artificial intelligence in the post-harvest processes of agricultural products. As stated earlier, artificial intelligence can replace human work and by benefiting from this branch of science in agriculture, we will be able to increase the production of agricultural products in the same time frame. First, we will start our discussion with the definition of different branches of artificial intelligence and then we will discuss the application of artificial intelligence in agriculture along with its examples.

1.2. Branches of Artificial Intelligence

Various branches of artificial intelligence are used in computer science, some of these branches are:

1) Machine Learning
2) Artificial Neural Networks (ANN)
3) Machine Vision
4) Expert System
5) Fuzzy Logic
6) Natural Language Process (NLP)
7) Genetic Algorithm
8) Robotics [6]

1.2.1. Machine Learning

The study of algorithms and statistical models used by computer systems that use patterns and inferences to perform tasks instead of using clear instructions [7]. Machine learning is a practice that makes computers learn about a specific subject without the need for an explicit program. As a subset of artificial intelligence, machine learning algorithms create a mathematical model based on sample data or training data to make predictions or decisions without overt planning [8]. Machine learning has entered many aspects of daily life. For example, search engines Google or Bing use machine learning because their machine learning software understands how to rank for a web page. Similarly, Facebook and Apple Photo, which identify people's images, is a type of machine learning. [9]

1.2.2. Artificial Neural Networks

Modern computational systems and methods for machine learning are knowledge representation and finally applying the knowledge obtained to predict the output responses of complex systems. The main idea of such networks is partly inspired by the way the biological nervous system works to process data and information to learn and build knowledge. [10] In the communication network of the human brain, the communication signals are electrical impulses, the main component is the neuron, which consists of a cellular structure and a series of grooves and lines, and the grooves are the places where information flows into the neurons and the lines where information flows from neurons. The point of connection between one neuron to another neuron is called a synapse, which acts like a gate. The main goal of the neural network is to design a mechanism that learns and understands what the right and wrong answers are, just like the human brain. [11]

1.2.3. Machine Vision

Of all five senses, touch, smell, taste, hearing, and vision, vision is one of the most important senses for receiving information from the surroundings. [12] Machine vision refers to the use of sensors to receive signals that represent the image of an object that is used by a computer or other signal processing device to interpret and analyze signals received from the device. Machine vision is an engineering tool in digital tools and computer networks, to control other industrial tools such as arm control Robots, or remove defective equipment are used. [13]

1.2.4. Expert System

Expert systems refer to a specific category of computer software that attempts to help experts and human experts or partially replace them in limited areas of expertise. These systems are, in fact, a simpler and more primitive example of the more advanced technology of knowledge-based systems. [14] Expert systems are a widely used field in artificial intelligence and knowledge engineering, which is becoming increasingly important to their role due to the growing need of societies to make quick solutions and decisions in cases where complex and multiple human knowledge is needed. Expert systems solve problems that typically require the expertise of experts and human experts. A single car as an expert system is known to possess certain capabilities, such as knowing its existence, meaning that the machine is aware of its existence. [15]

1.2.5. Fuzzy Logic

Classical logic shows everything based on a binary system, but fuzzy logic shows the correctness of everything with a number whose value varies between zero and one. A human being is capable of understanding millions of colors in sufficient light. But how can a robot recognize that color? To design a robot that can recognize colors, we use fuzzy logic and assign numbers to each color to define it for the robot. Other applications of fuzzy logic include the application of this science in the automotive industry (in the design of Anti-Lock Braking System (ABS) brake systems, and motor control to obtain the highest power efficiency), in the design of some microprocessors and the design of digital cameras, control systems and management in agriculture. [16]

1.2.6. Natural Language Process

One of the most important subfields in computer science and artificial intelligence is the interaction between computers and human languages. The main challenge in this field is understanding natural language and automating the process of understanding and interpreting concepts expressed with a human natural language. To more accurately define natural language processing is the use of subsidies for processing spoken and written language. This means enabling subsidies to analyze, understand, or produce speech or writing in the form and structure of a natural language. [17]

1.2.7. Genetic Algorithm

A genetic algorithm is an algorithm based on repetition and basic principles. This algorithm has been invented by mimicking the science of natural genetics and is used in a variety of problems such as optimization, system identification and control, image processing, and hybrid problems, training artificial neural networks, and determination of topology and decision-based algorithms. [18] Genetic algorithms are often a good option for regression-based prediction techniques. In modeling, a genetic algorithm is a programming technique that uses genetic evolution as a problem-solving model. A problem to be solved has inputs that are transformed from genetic evolution into solutions during a modeled process. The solutions are then transformed as candidates by the function of the genetic algorithm. The fitness function is evaluated and if the condition for the problem is satisfied, the algorithm terminates. [19]

1.2.8. Robotics

The word robot became popular in France after a show was staged in 1920. Robots are currently used in various branches of industry and can be defined as modern, automatic, navigable, and programmable machines. [11] As you know, robotics and artificial intelligence are two separate things, robotics involves making robots while artificial intelligence involves programming. Combining AI with robotics means that robots can be programmed using artificial intelligence that can meet all the needs that a user is looking for. A comprehensive example of this would be search engines and Jogger noted that it responds to users by overturning different sites. [20]

2. Application of Artificial Intelligence in Agriculture

Artificial intelligence can be applied in many different ways in the agricultural industry. One of its subcategories is image processing which is widely used in agriculture. Image processing, in its special sense, is any type of watermark processing whose input, an image, and output is an image or a set of symbols or symbols related to the image. Of all the branches of artificial intelligence, perhaps the most practical is the computerization and mechanization of vision systems. The scope of this growing field of technology is vast, ranging from common applications such as product line quality control and video surveillance to new technologies such as driverless cars. [21]

Control of industrial machinery and tools is one of the most important tasks in manufacturing processes. The use of automatic control and automation is becoming more and more widespread and new approaches using new technologies make it possible to compete in production. Lack of sufficient knowledge of machine vision technology and lack of familiarity with the economic justification of its application has led to doubt in the use of this technology and sometimes there is a negative reaction. Despite this, machine vision has become more and more widely used and its growth has been impressive. [22]

For example, in Figure 1, a sample of fruit sorting based on machine learning is displayed as one of the branches of artificial intelligence. As you can see, the main components of a machine vision system are the image-receiving unit, the image-processing unit, and the control unit. In the unit the image is received by the camera depending on the type of image used. Incoming images are processed and analyzed in the processing system. The output of this part is sent to the control unit, which exerts the final decision on the control line. [23]

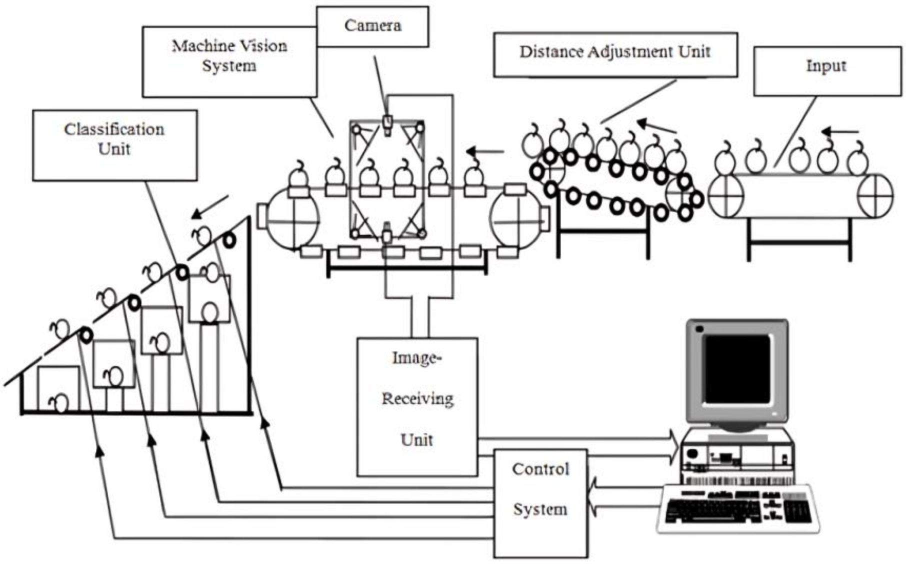

Figure 1. *Schematic apple sorting system [24].*

Many applications of machine vision technology have been developed in agriculture, including land and air surveying for natural resource evaluation, crop monitoring, precision agriculture, automated guidance, nondestructive inspection of agricultural products, postharvest quality control, and classification and separation. [25]

Some different machine vision systems are capable of inspecting objects in invisible areas in addition to imaging in the visible area. Information received from objects in the range of colored light can be useful in determining the maturity of plants before harvest, disease, and stress and determining varieties, maturity, post-harvest quality, functional properties composition, contamination, and disease of plants, seeds, kernels, vegetables, and fruits. [26]

Machine vision can be used to grade different fruits using the color, texture, and shape properties of the image received. Using the Support Vector Machine (SVM) and the Atsu double-class threshold network were used to separate and calibrate apples. This method was evaluated with 300 apples with three trained samples with different color characteristics. [23] It is also possible to identify apple fruit on trees in order to robotically harvest apples in natural light. In this method, we develop and evaluate two algorithms for identifying apple fruit, which are the edge finder algorithm which is used to determine the overall shape of a ripe apple, and the color and shape processing algorithm. The results of this study showed that the edge detection algorithm was not efficient, but the color processing algorithm was able to detect 25 images Identify the fruit, and locate it with 85.17% accuracy. [27]

Another application of artificial intelligence in agriculture is the use of image analysis techniques to diagnose apple tree leaf diseases. In this paper, the disease areas on the leaves were identified and isolated using the classical k-means clustering method and then the color and texture characteristics of the disease regions were extracted. Four models were developed the first model included the properties of the syndicate matrix, the second model included color characteristics, the third model included features extracted from wavelet and Fourier transforms, and the fourth model included all the characteristics and then were classified using artificial neural network of plant diseases. The results showed that the artificial neural network successfully classified disease spots characterized by the classical k-means clustering method with 100% accuracy. [28]

The volume of apples and their indentations were estimated using image processing and neural network in this study. Analysis of the results using T-test and Bland Altman showed that there was no significant difference between the actual volume of apples and the image processing volume at the probability level of 5%, and the mean difference between them was 1.52 cm^3 and had 92% accuracy. Using a neural network with input parameters of apple dimensions and mass increases the accuracy of volume measurement by 97% and reduces the mean difference between two volumes by 0.7. This research showed that image processing and neural network can be used as fast and efficient methods in seeding the volume of agricultural products. [29]

Controlling and identifying pests and identifying contaminated plants and fruits are important issues in this branch. Lots of ways to date have been revealed and tested. In a study, researchers used thermographic technology to classify healthy and infected pistachio kernels with Aspergillus Flavus. The best treatments were 95% emission coefficient, 90℃ hot temperature, heating time of pistachio equal to 90 seconds, and cooling time at room temperature equal to 10 seconds. In this study, a Threshold-Based Classification algorithm (TBC) was developed for thermal image analysis and classification of healthy and infected pistachios in MATLAB software which has the highest classification accuracy compared to other validation methods such as K-fload cross-classification, linear discriminate analysis, qualitative data analysis, SVM and artificial neural network (ANN). [30]

The goal of any farming company is to achieve the highest profit. One of the effective factors in achieving this goal is the management of the replacement of different cars, especially tractors. To this end, it is important to anticipate the possible costs of maintaining and operating tractors. In a study, this important has been studied by comparing the methods of artificial neural network and regression. In this study, the actual data of 60 two-wheel drive tractors were used in the Astan Qods Razavi agro-industry. The performance of these two methods was evaluated by the dataset in the test phase. The optimal model of the neural network was able to predict the value of tractor costs in the test phase with mean absolute error and root mean square error of less than 2.82% and 0.52% respectively and in contrast to 9.5% and 1.39% for the regression model. [31]

They also used artificial intelligence to classify binary images of leaves of different plants. The goal of this is to develop an algorithm that can use a computer to plant type from the leaves of plants. Figure 2 shows an example of this binary image. In this study, the extracted shape characteristics of an artificial network are trained that identify the type of plant. This is of particular importance in botany science. The results of this study showed that the classification rate was 97.14% and the overall sensitivity of the algorithm was 90%. [32]

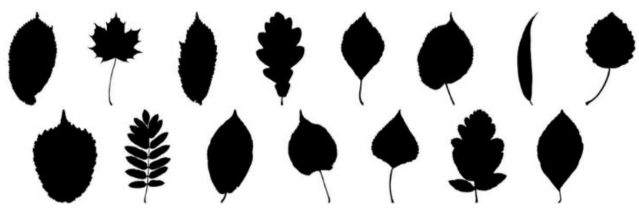

Figure 2. *Example of binary pictures of leaves of different plants [32].*

In this research, we identified the insects feeding the chestnut fruit using near-infrared spectroscopy. Chestnut is one of the seasonal fruits that most of its commercial produce is found in Europe and Asia, most of which reduce the shelf life of this fruit are related to fungal, bacterial, and insect damage. [33] In this study, 60 kg of chestnut fruit was prepared and examined from local orchards in Italy. Fruits were randomly divided into 4 groups that were 15 kg in each group. One of these groups was used for spectroscopic experiments. The other three groups were transferred to a local factory for grading using a floating system. After grading by buoyancy method, the samples were separated in order to determine the accuracy of the grading and the false positive error (the healthy product was sorted instead of the bad product) and the negative false error (consider the bad product instead of the healthy product). The obtained spectra were obtained from 952 chestnuts that were placed at 26 ℃ for 2 hours for temperature balance. In Figure 3 the hyperspectral imaging schematic is displayed. The results of this study showed that this method has higher accuracy and yield than the 55.3% float method. [34]

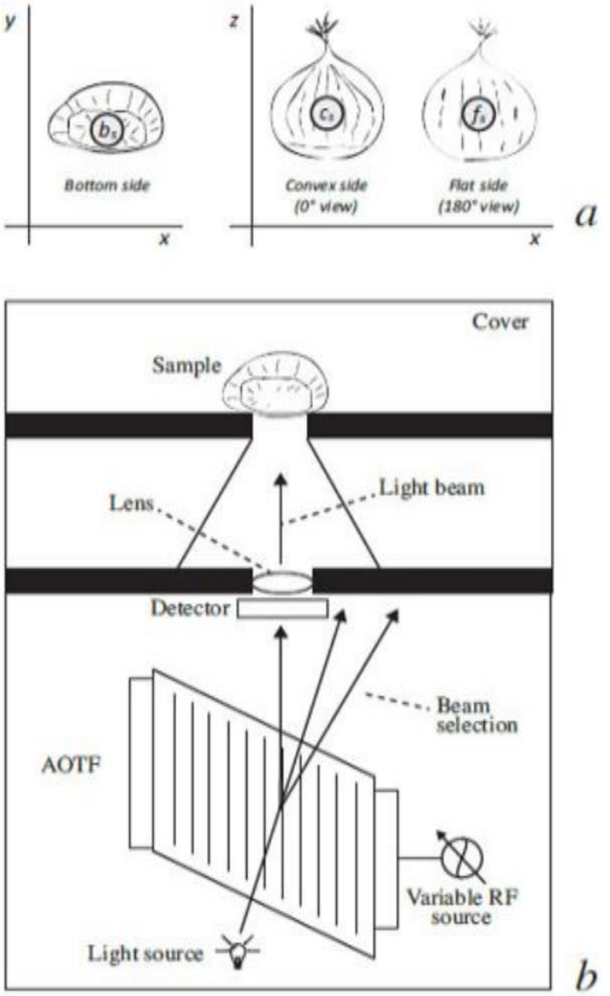

Figure 3. Schematic Hyperspectral Imaging (a) Three Views of Chestnut Fruit (b) Schematic Hyperspectral Imaging of Chestnut Fruit [34].

In another study, using NIR hyperspectral method, they detected olive fruits that were infested by insects. Using a genetic algorithm and combining it with Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), and K-Nearest Neighbors (KNN) methods were used to identify and classify the characteristics of the images. The results of this study showed that a negative false error is equal to zero, a positive false error is equal to 12.5 and total error is 6.25. Optimum wavelengths of 1108, 1232, 1416, 1486 and 2148 nm were obtained. Overall, the results of this study showed that infrared at wavelengths between (1100-2300) can be used as an automatic, non-destructive, and rapid method for detecting larvae in olives. The classification accuracy in this study was 94%. Also, the highest classification accuracy was obtained in QAD method and the lowest in KNN method. [35]

In another study, blue-green fluorescence was used to determine the growth rate of tobacco mosaic virus. The image taken at wavelengths 220 and 800 nm was considered as the reference image. The authors reported that 22 and 20 post-inoculations of the TMV virus increased the fluorescence of blue-green and chlorophyll. Fluorescence imaging showed differences between healthy leaves and patients in a short period of 20 hours compared to reference images. [36]

In another paper, they used color texture characteristics to diagnose grapefruit surface diseases (Shanker, Copperburn, Gracie Spot, Melanous, and Windscar). In this study, 39 tissue characteristics were extracted from each of the components of S, H and I of the disease region using a co-event matrix. In this research, SAS software was used to classify images. [37]

A group of researchers examined the Cytophilus insect (Sitophilus granaries) in a wheat barn using X-rays and image analysis. For this purpose, wheat samples were randomly placed in 12 containers. Then, the samples were stored in an incubator at 28 ℃ and 65% relative humidity for 5, 10, 15, and 20 days. An X-ray machine (Elektronika 25, ARI St. Petersburg, Russia) was used for the imaging of the sample. To analyze the results, the linear regression model was used to predict the relationship between the number of objects in the image and the time of contamination. Independent variables (characteristics extracted from images) include area, radiance coefficient, roundness, and total area. Figure 4 shows a sample of the resulting images in the 5 and 30-day growth stages. In Figure 5, the results of the diagnosis are shown manually using image-processing method. As can be seen, the accuracy of detection is greater in the method of using image processing algorithms. Also, the results of the regression model to predict the growth of this pest show that in all three wheat cultivars, the accuracy is more than 90%. [38]

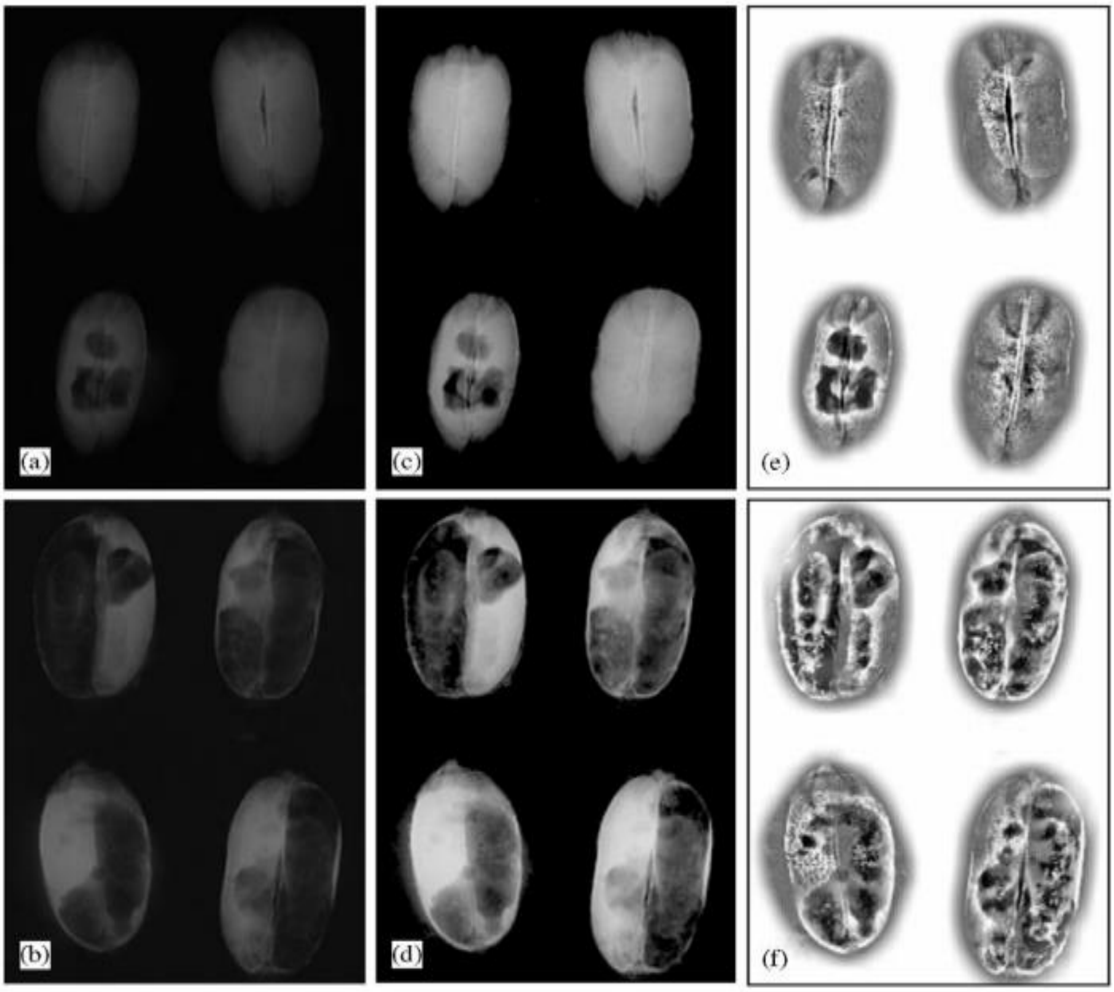

Figure 4. *The stages of image processing in two modes 5 and 30 days after the growth of the pest. The first row is 5 and the second row is 30 days after the growth of pests. From left to right apply improved image filtering [38].*

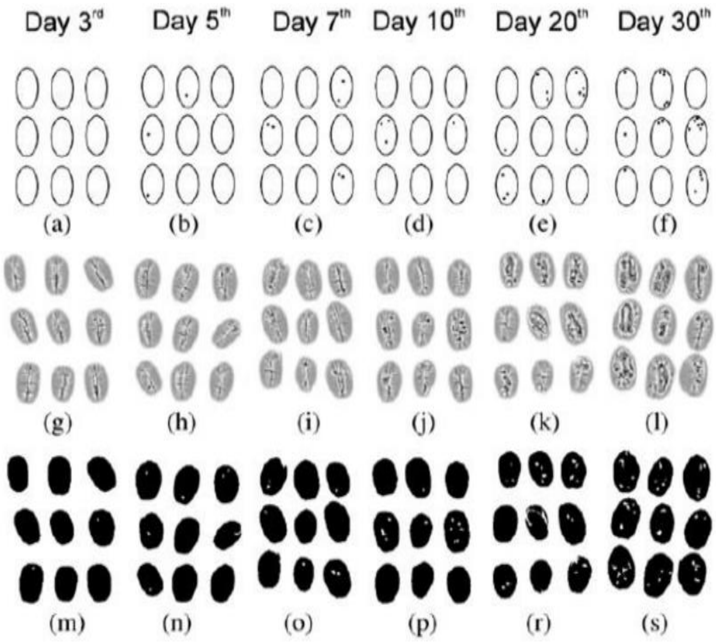

Figure 5. *Images of wheat grains at different stages of growth. Top map detected by experts, middle processed images, and bottom binary images [38].*

Imaging and spectroscopy techniques can be integrated into an automated agricultural vehicle, for early detection of plant diseases. This technology can also be used to determine plant stress and nutrient levels. [39] A multispectral imaging system with a rotating optical filter with six light spectrums can be used to determine whether the leaf texture is healthy or unhealthy and to estimate leaf chlorophyll. [40] This method (image processing and isolation analysis) can identify and classify four diseases related to the grapefruit tree. Image processing can also be done using a color matrix in which the structural properties of citrus leaf color are extracted in the Hue Saturation Lightness (HSL) color channel and then we separate and report diseases using SAS software. the S In it, the highest accuracy is related to the model obtained from all three-color components of the HSL medium with 98.75% accuracy. [41]

3. Conclusion

As you can see in the above research, artificial intelligence today has gained a special place in life, science, and industry. This field of science has made tremendous progress in the past decades. Artificial intelligence researchers are interested in producing a machine that performs the required commands intelligently and with minimal errors. For example, the ability to control, plan, and detect the correct answer to the user's question, linguistics, speech, facial recognition, etc. Image-processing as one of the sub-branches of artificial intelligence has become widely used in the agricultural industry. Among these, in general, are quality assessment of agricultural products and processed food, diagnosis of plant diseases, robotics in agriculture, and precision agriculture. One of the most important advantages of using intelligent systems instead of human resources is the increase in the accuracy of performance and more economical process.

Abbreviations

ABS	Anti-Lock Braking System
AI	Artificial Intelligence
ANN	Artificial Neural Networks
HSL	Hue Saturation Lightness
IoT	Internet of Things
KNN	K-Nearest Neighbors
LDA	Linear Discriminant Analysis
NLP	Natural Language Process
QDA	Quadratic Discriminant Analysis
SVM	Support Vector Machine
TBS	Threshold Based Classification

Conflicts of Interest

The authors declare no conflicts of interest.

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