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APPLICATION OF ARTIFICIAL INTELLIGENCE IN FOOD INDUSTRY— A REVIEW

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Abstract - Artificial intelligence is a promising field for the agriculture as well as food industry. AI can manage the soil nutrients, weather condition, temperature and all these operations are done by crop and soil monitoring, disease diagnosis, intelligent spraying, crop yield prediction. Sorting of food products need many people and time both, machines with artificial intelligence take less time to recognize food items before processing it. In 2050 world's population will reach up to 9.1 billion and only 4% of land will be left by then. During this pandemic situation of covid-19, the thing which needed to maintain our body health is "immunity". To maintain the immunity power of our body, it is necessary to eat healthy foods. This review is a study of – "how artificial intelligence is playing an important role in the production of healthy food products". Food safety is a major concern of today's Era lot of foods are wasted due to contamination, one of the basic sources of contamination of fruits and vegetables is using pest during the crop growth in agriculture which can cause nausea, Diarrhea like problems in human body. It will be a detailed study on how AI can solve the problem of scarcity of food by examine the raw fruits and vegetables before processing it.

Keywords- Artificial Intelligence, Agriculture, Food product, Food Industry, Pesticides, contamination, crop management, irrigation, sorting and grading.

I. INTRODUCTION

Artificial intelligence is a branch of computer science that concerned with building smart machines that can perform tasks that typically requires human intelligence.AI enabled technologies can predict weather conditions, analyze crop sustainability, can identify the pesticides in field, can recognize the defective raw materials during sorting, and can monitor the activities of workers in production area. Utilization of artificial intelligence in agriculture and food industry have a good impact on GDP. Production of high-quality grains need maintenance of soil temperature, humidity, PH, fertility and mineral nutrients present in the soil. Aerial vehicle drone is used for this purpose as this provides 3D maps for early soil analysis. Further these data are helpful in planning seed planting pattern, irrigation and nitrogen level management. Drones can scan the ground and after sensing the requirement of liquid it sprays liquid in the field up to five times faster than traditional machinery. Crop monitoring is a challenging step of food production and it needs more attention than any other step due to unpredictable weather conditions. During crop growth there are many unwanted plants (weed) grow which can interfere during crop growth, drones can differentiate between the useful crops and harmful weeds and accordingly it sprays pesticide only on the weeds. Drones can sense the heat emitted from crops by thermal sensor and obtained data help drones to identify the dry regions where water is needed. Not only weeds but Sometimes Due to imbalance mineral nutrients content and some other factors like bacterial and fungal infection occur in crops can destroy the crops. Some of the bacterial and fungal diseases that has affected the crops are "Black rot" in Brassicas, "bacterial canker" in tomato, capsicum, chili and fungal diseases are Anthracnose, botrytis rots and downy mildews in vegetables.

AI has a huge application in food industry. This technology has helped food industry to deal with the problems of human error. Food processing industry is the fifth largest sector of the country which contributes in GDP [2]. Most of the food products are not consumable in their original stage to make

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it consumable it has to be processed; processing is not an easy task. Before converting the raw materials into final product, it has to undergo many steps like sorting, grading, washing, processing, packaging and marketing. Not only this, cleanliness also has to maintain simultaneously. Utilizing machine learning algorithm, the problems of sorting can be minimized this technique has steps like image acquisition, computer tomography, preprocessing, segmentation, classification and identification. Delivery of the processed food product is a vital process as chances of contamination is very high in this stage, using drones can minimize this risk.

II. APPLICATION OF AI IN SOIL MANAGEMENT

Soil is a prerequisite part of agriculture, habitat of 8 to 15 tons of bacteria, fungus, protozoa, and nematodes due to the presence of some mineral nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, Sulphur, iron, boron, molybdenum, zinc, copper, and cobalt. Microorganisms can convert these mineral nutrients into useful form so that it can be further used by plants for their growth. During erosion these mineral nutrients get eroded hence, Lack of nutrient in soil can inhibit the growth of plants. Larson and colleagues (1893) in 1882 estimated that the value of nitrogen, phosphorus and potassium lost was estimated at $677 million, $17 million, $381 million respectively from US crop land. Organic matters, minerals, air and water is essential for the plant growth generally affected during erosion. Urban soil contains more pollutant than rural soil, pollution can decrease the level of organic matters present in top soil which leads to the reduction of crop yield and quality as well. Nitrogen is a main component of soil frequently increases the root growth and foraging capacity for phosphorus, without nitrogen plant growth will be stunted. When the clay portion of soil exceeds to one third, nature of the soil would be sticky when wet and brick like when dry. Due to lack of oxygen, it may be difficult to prepare land before planting the seed. AI Techniques which work best for management of soil is summarized in the table 1. utilizing AI for examining soil gives a predictable analysis of data which help farmers to monitor the crop and soil so that yield can be maximize. Soil problems like nitrate leaching, erosion, soil temperature, soil texture can be solved by applying artificial intelligence. Management oriented modeling (MOM) is a local search domain makes decision of real world, it first identifies the initial condition of the soil before application of the fertilizer and irrigation after that it selects the required management action for improving the soil quality. it can reduce the problem of nitrogen leaching, without nitrogen plant cannot make their own cells and due to lack of protein cells plant growth will stop. MOM system consists of generator, simulator and evaluator. This whole system of management-oriented modeling works on "HILL CLIMBING" method [3]. This method is same like a "blind folded man climbing the hill". Fuzzy logic is a general form of logic that handles the concept of partial truth, in this technique truth value will lies in between completely truth and completely false. It is generally used to determine the silt content; clay content; and infiltration rate of the soil and the output will be transferred into fuzzy variables. For good crop production clay content, silt content and PH of the soil should be checked before plantation to take appropriate action for plantation [4] Decision support system (DSS) is consisting of details of climate, season, variety, cultivation practices, nutrient management etc. it increases the supply of individual soil function like primary productivity or nutrient cycling while neglect other important soil function such as water purification and regulation, climate regulation. DSS are the application-based software system used for making right decision about the soil management (Dicks et al. 2014). Artificial Neural Network (ANN) can predict the moisture content, monitor enzyme activities, temperature, texture of soil and nutrient left after erosion. ANN works on the principle of machine learning algorithm. It classifies the soil on the basis of layer, it can examine how, how much and when to irrigate the field. It is generally used to produce high resolution soil properties before preparing an ANN for soil, input data and target data should be made. Depending on the number of input parameters number of nodes combine to form layers and these layers are called as neural networks. Information's are collected by input layer, processed by hidden layer and result will be transferred to the output layer which give result to the external world. Generally, 3 kind of data set is required 1. crop dataset to determine the name of the crop 2. fertilizer data set which determines how much fertilizer is required and 3. PH data set.

TABLE -1 SUMMARY OF TECHNIQUES

Technique	Method	Merit	Demerit
Management Oriented Modeling (MOM)	Hill Climbing	Nitrogen leaching	Backtracking cannot be done by this method
Fuzzy Logic	It works in between the truth and false value	It determines the exact value of silt content (%), clay content (%), and filteration rate (mm/h) of the soil	Huge amount of data is required
Artificial neural	Information are collected	It determines the	Unexplained functioning of network.

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network(ANN)	by input layer, processed by hidden layers and results are transferred to output layer.	requirement of nutrients in the soil,crop name and PH level of the soil.	Duration of network is unknown.
Decision Support system	It supplies individual soil function like primary productivity or nutrient cycling.	It helps to increase the supply of nutrients in the soil, to prevent the soil erosion.	It neglect other important soil function such as water purification and regulation,and climate regulation.

III. AI IN CROP MANAGEMENT

Larger field with poor crop management can create problem during crop management. Ensuring the use of natural resources, reducing soil erosion; a variety of crop and soil maintenance as well as weed removal practices may be under taken during crop growth. After sowing there is a high risk of attacking insects, weeds, fungi and several other pests on crops. However, Plants have their own defense against these kinds of pest, but sometimes these may be overwhelmed especially in stressed habitat plants. To overcome the problem of food shortage certain countries, grow number of crops on the same land per year. Pesticide life ranges from few hours to 4-5 years hence, Extensive use of pesticide can destroy microorganisms present in the soil and due to that plant will not get sufficient amount of nutrients for their growth. Weed is a major problem occur during crop management this may interferes in the growth of normal crops by releasing toxic material. Using herbicide increases the quantity of food products however, it has some harmful effect on the non-targeted crops and on the human health as well.

During the production of food products in the food industry the possibility of hazard in the raw materials may be higher because the process is not risk free. Lettuce crop shown positive results with residue level exceedingly frequent than any other crop investigated. More than 90% of corn, soybean and cotton in US are genetically modified to be resistant to herbicides. Frederick Bawden in 1933 has used aerial imaging to detect disease in potato crops. Some of the techniques of artificial intelligence used for monitoring crops is summarized in table 2. Artificial Neural Network (ANN) can predict crop yield, production of crops depends on the various factors such as temperature, photoperiod, and water stress. Kaul et al stated that ANN produces better result than traditional statical methods when predicting soybean yield. (Uno et al) have developed a model which used to predict corn yield from compact airborne spectrographic image data. Robotic Demeter is an automatic harvester, can differentiate between the crop that has to be cut and the crop which should not be cut. It is a computer-controlled speed rowing machine, equipment with a pair of video cameras and global positioning sensor for navigation. Robots are used for the management of weeds; it can sense the need of crops and applies fertilizers when needed. Calex system is generally used to provide a complete schedule of irrigation system and estimated date of irrigation. Fuzzy Cognitive Map (FCM) is a soft computing technique used to illustrate how FCM can leverage expert knowledge to identify effective farming management strategies that are likely to optimize crop in sustainable agriculture. Fuzzy cognitive map is introduced by Kosko in 1986.

Prolog is a logic in programming language used in agriculture to detect weather condition, crop estimation, machinery capacities. it can interact with the real world, having the capacity of understanding human language, its location is specific.

TABLE -2 SUMMARY OF TECHNIQUES

Techniques	Application
Artificial neural network(ANN)	Predict crop yield
Robotic Demeter	Two Navigation system one is position based and second is camera based used to accomplish the task of harvesting.
ROBOT	It is used to sense the need of fertilizer to get rid from weed.
Fuzzy Cognitive Map (FCM)	It identifies effective farming management strategies.
Fuzzy Logic	Classifies images of the crop.
Prolog	Due to its declarative language,it has the capacity to interact with real world and it is applied to detect plant disease.
Calex	It is responsible for estimating the irrigation schedule.

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IV. APPLICATION OF ARTIFICIAL INTELLIGENCE IN FOOD INDUSTRY

It was estimated that the market size of the food and beverages industry across the nation will be around 46 billion US dollars in 2020. India stood at second position in food production, food processing sector is one of the largest sectors in the world and its output is expected to reach $535 billion by 2025-2026. India's total horticulture production stood at 313.85 million tons in 2018-2019. Food processing waste is A major concern of today's era as it contains many useful vitamins, minerals and many other nutrients, food waste occur throughout the food system, food processing, distribution, retail and consumption. Food waste mainly occurs due to chemical contamination from environment, contaminants may be present in the food in their raw stage and sources of this contamination is vehicle, exhaust of diesel and petrol, long distance transport. According to Nageli and Kupper, 2006; Villanueva et al., 2017 contaminants can invade the food materials in the cleaning phase of food production due to residue left on the surface of food handling equipment. Heavy metals such as mercury, lead, cadmium, zinc, and copper can float into the soil and enter into the food chain to infect the raw food materials in field (Krishna and Govil, 2006). Majority of food contamination occur by toxins and naturally occurring pollutants or during processing, packaging, preparing, storage and transportation of food. Some of the contaminants occurs during processing of food is nitrosamines (in cured meat, cheese, nonfat dry milk and some types of fish), polycyclic aromatic hydrocarbons (PAH) it can enter in food chain either directly from environment or during processing(in dried fruits, smoked food, grape seed oil, cocoa butter, smoked meat products), heterocyclic amines have carcinogenic and mutagenic property formed during cooking of muscles(beef, pork and fish), histamine(Fermented foods, milk, spinach, dried fruits and many more) , acrylamide ((French fries, potato chips, bread, biscuit, and coffee), furan(soup, sauces, beans baby foods), benzene, semi carbazide mainly present in glass jars food products like baby food, Ethyl carbamate(fermented food) . .AI help food industry in number of ways to reduce the risk of contamination and maintain the food safety. 1. Sorting and grading 2. maintaining cleanliness 3. developing new products. 4. food transportation. 5. decision making of customers.

IV.1 SORTING AND GRADING

Sorting is a separation unit operation that is based on one single measurable property, on the other hand grading is overall assessment of quality based on multiple properties or multiple attributes. One of the important steps of food processing is sorting, a process of separation of food or raw materials on the basis of size, shape, weight, image and color. Grading is a process of separation of food stuff based on quality such as size, weight, quality (Afrianto et al, 2008). It is done by hand to remove fruits and vegetables which are not suitable for storage or market due to damage by mechanical injuries, insect, diseases, immature, over mature and misshapen etc. By utilizing machine learning algorithm, artificial intelligence can minimize human error during sorting process. Machine learning uses programmed algorithm that receive and process input data to output data. Algorithm helps to turn a set of data into model to identify whether this algorithm is supervised, unsupervised, classification or it is regression etc. It is utilized by food industries to identify which items are fruits and vegetables while also detecting impurities and anomalies. Weight sorting, size sorting, shape sorting, and color sorting being done on the basis of image recognition. Many food items are seasonal they are only available in their season of growing, in order to eat those food products whole year, Processing industry process them so that customer can get those food products throughout the year. But for preservation of these food items, it needs sorting and grading because raw material comes from the field may contain pesticide, herbicide and some disease also so these fruits and vegetables should be checked before processing otherwise shelf life of the food products will decrease. Sorting is a labor-intensive process and there is a high chance of human error, to reduce those errors automatic sorters are used by food industries. Whole process of automatic sorting and grading are discussed below.

IV.1.1. IMAGE CAPTURING METHOD

Image capturing method is an electronic technology, in this method object is focused by a light source. Absorption of that light by the object is sensed by a light measuring device, and light absorbing characteristics of the object is converted to an electronic record on pixel basis. Some of the sensors like CCD (charged coupled device), CMOS (complementary metal oxide semiconductor) are used in digital camera for this purpose. pixels are the smaller unit of an image; an image is composed of a thousand or millions of pixels arranged in two-dimensional form in square shape. Initially the images are in discrete form and it is tough to read the images, after arranging the pixels in an orderly manner images can be read by human eyes

IV.1.2. IMAGE ACQUISITION

Image acquisition is retrieving an image from hardware-based source for processing. Image acquisition system composed of a mini camera mounted perpendicularly to the imaging stage on which fruits and vegetables are placed. Two light sources are connected in two side of the imaging stage at a distance of 30cm and cameras is connected to the computer, where images of raw materials are casted. Digital image processing is used for evaluating external features of the food products such as size, shape and color. Identifying the size and shape of food products, for image recognition name of the tools which are used for this purpose are camera, magnetic resonance imaging (MRI), computed tomography (CT), ultrasound and electrical tomography. Some of the image sensors are there which can sense the raw materials on the basis of size and shape

are used in camera is charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS).

IV.1.3. COMPUTER VISSION SYSTEM

Computer vision system technology helps in automatic inspection of the food products. It is a technique to identify the size, shape and color of the food products. It is usually done by capturing, processing and analyzing images. Images are taken from physical sensors and software is used to analyze the image. Sorting on the basis of shape is easy for human beings but quality sorting is tough and it is labor intensive as well. Sometimes it is difficult to identify the quality of the fruits and vegetables because of the homogeneity in color of the fruits and vegetables. Light is consisting of different ranges of wavelengths of light, each wavelength shows color, in computer vision system color of the raw materials are determined by the wavelength emitting from the surface of fruits and vegetables. Sometimes defects occur due to texture and color is identical to skin which is a challenging task to detect. Hyperspectral images produced by computer vision system (Lorente et al. 2012) having both spectroscopic and imaging techniques, can detect this problem. Images are named as hyper cube; hyperspectral image cubes are obtained by 3 scanning method point scanning [49]. For quality checking purpose nowadays, this concept is widely used in food industries. Whole setup of computer vision system is composed of lighting system, digital camera/image acquisition and image processing.

IV.1.4. IMAGE PROCESSING

Image processing is usually done through number of stages like image preprocessing, segmentation, feature extraction and selection. K Tarale et al proposed method for fruit recognition system. Image enhancement and sharpening are usually done to improve the blurred and noisy images by sharpening them [50].

Image preprocessing is a method refers to the conversion of real images into grey scale image it helps in texture feature extraction using MATLAB, images captured by camera are further converted into a digital image which is read by the computer in the form of tiny dots(pixel). Preprocessing section have median filter which performs the following function like reduction of noise, geometrical correlation, grey level correction and improving image quality, so that images of fruits and vegetables can be recognized easily and machine can identify the defects present in the fruits and vegetable. Background can act as a resistance during the examination of a particular image, denoising remove the noise and increase the focus on object.

IV.1.5. SEGMENTATION

segmentation is a process of partitioning images into a set of pixels so that it can be simplified or change into the meaningful images. It is generally used to recognize fruits and vegetable diseases and to note the issue and challenges. It is an important step of image analysis, analysis of image means dividing the images into regions that have a strong connection with the object. input images might be different in arbitrary position. Subtracting the background may be necessary for reducing image complexities, like variation in illumination. Fruit disease recognition system depend upon the defects segmentation. Segmentation can be done by three different techniques 1. Thresholding 2. Edge segmentation and 3. Region segmentation. Thresholding is an effective tool for separating the image from background, various factors like motion, noise, ambient illumination, gray level within the object act as a resistance in thresholding. Segmentation of common regions are done by this method; in this method a threshold is selected and an image are splits into pixels, have values less than the threshold. Region segmentation method includes region growing, split and merge, histogram thresholding region growing is a procedure that groups pixels or sub region into larger region. This method is less sensitive to noise and it is found to be an effective technique for Noisy images. Region splitting, region merging. As the name indicates edge means boundaries, edge-based segmentation algorithm identifies the edge of the object(pixel).

IV.1.6. FEATURE EXTRACTION

After segmentation, feature extraction is done to recognize certain features of the image that can be detected and represented for further processing, it is used to identify whether the fruit and vegetable is defective or non-defective, color feature is the most widely used visual feature in image retrieval and indexing to do this R Venkata Raman et al in 2012, images in RED, GREEN, BLUE(RGB) color projection values of the pixels are extracted using MATLAB programming [6]. Ripeness and unripens will also be calculated by this technique. To determine the defects and maturity of the food products some properties like color feature, morphological feature and textural features are used.

IV.1.6.1. COLOR FEATURE

The property which attracts the customers attention to buy fruits and vegetable is color. RGB color space and HSI space is commonly used in color inspection of the fruits and vegetable. Generally, images are acquired by using primary colors like Red, Green, Blue which is nonlinear with the visual inspection of human eye, and due to this problem human being cannot recognize the sensory property of the food items therefore, Hue, Saturation, Intensity (HSI) which is a leading tool for improving the image processing algorithm stablished on color which is commonly received by human were introduced. Kondo et al in 2005, had taken digital image of eggplant by using 4 monochrome CCD camera and 6 color CCD camera but due to low color contrast of the camera, defect detection and extraction were not possible therefore a new NIR based color CCD camera were used to detect the feature of the digital image. Color features are computed from peel of the papaya fruit using digital

imaging to detect the ripening and this approach was proposed by Pereira et al. In 2018.

IV.1.6.2. MORPHOLOGICAL FEATURE

Morphological features like size and shape are important for grading of fruits and vegetables on the basis of price in food industries. Shape features like Roundness, aspect ratio, compactness is combined to sort apples (Blasco et al.2003), papaya (Riyadi et al 2007) and eggplant (Kondo et al.2007). This shape feature combination is more sophisticated and reliable (Costa et al 2009). (Dimatira et al 2016) uses a technique Fuzzy Logic to determine the maturity of tomato as this technique gives the exact value of ripeness.

IV.1.6.3. TEXTURE FEATURE

Texture feature can be determined by the group of pixels, according to (Bagri and Johari 20015) there is six types of quantitative (contrast, coarseness, line likeness, directionality, roughness and regularity) and four types of qualitative (contrast, correlation, entropy and energy) analysis are used to classify the images. Color texture feature can be utilized to detect diseases in fruits and vegetables as well, citrus peel disease is major problem in citrus industry to detect the disease at the early-stage Zhao et al.2009 proposed a method which uses texture feature method to prevent the disease. It is also used to detect the maturity level and defects in fruit, Sahu and Potdar in 2017 proposed an algorithm to determine the maturity level of mango on the basis of quality ratio. Algorithm states that if the value of quality ratio is greater than threshold value then the mango is mango is rotten and if the quality ratio is value is less then threshold value than the mango is good.

V. CONCLUSION

This Review is all about the application of "ARTIFICIAL INTELLIGENCE" in food industry, according to food and agriculture organization more than 40% of the food produced is wasted due to human error. Automating the food processing can reduce the human error. From agriculture to industry there are many stages where contamination can be occurred leading to the destruction of raw materials. In this review article, various methods and techniques are described which is used by machines for inspecting the food materials at every stage. In field soil condition are determined by using various techniques listed in the above table. Checking the crops In field can prevent the contamination by pest. In sorting and grading techniques food materials are checked by using various sensors, which can detect the food items and classify them accordingly.

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