ARTIFICIAL INTELLIGENCE IN AGRICULTURE

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1. Introduction

The world of Artificial Intelligence (AI) is quickly on the rise as it makes its way into many different industries. From manufacturing to automotive, you can likely see AI used for many different purposes; and as time goes on, you'll only see it even more. One of the most interesting industries that AI is breaking into is agriculture. Agriculture is a major industry and a huge part of the foundation of our economy. According to the Environmental Protection Agency (EPA), the agricultural industry contributes nearly $330 billion in annual revenue to our economy. As climates are changing and populations are increasing, AI is becoming a technological innovation that is improving and protecting crop yield.

The global population is expected to reach 10 billion people by 2050, which means double agricultural production in order to meet food demands which is about 70% increase in food production. This means that the global agriculture sector is under more strain than ever with 2 billion more mouths to feed within the next 33 years. Farm enterprises require new and innovative technologies to face and overcome these challenges. By using AI we can resolve these challenges.

2. Importance and impact of AI in Agriculture

The technologies which are AI-based help to improve efficiency in all the fields and also manage the challenges faced by various industries including the various fields in the agricultural sector like the crop yield, irrigation, soil content sensing, crop- monitoring, weeding, crop establishment. Agricultural robots are built in order to deliver high valued applications of AI in the mentioned sector. With the global population soaring, the agricultural sector is facing a crisis, but AI has the potential to deliver much-needed solutions. AI-based technological solutions have enabled the farmers to produce more output with less input and even improved the quality of output, also ensuring faster go-to-market for the yielded crops.

Farmers no longer have to apply water, fertilizers, and pesticides uniformly across entire fields. Instead, they can use the minimum quantities required and target very specific areas, or even treat individual plants differently. Benefits include:

- Higher crop productivity
- Decreased use of water, fertilizer, and pesticides, which in turn keeps food prices down
- Reduced impact on natural ecosystems
- Less runoff of chemicals into rivers and groundwater
- Increased worker safety

In addition, robotic technologies enable more reliable monitoring and management of natural resources, such as air and water quality. It also gives producers greater control over plant and animal production, processing, distribution, and storage, which results in:

- Greater efficiencies and lower prices
- Safer growing conditions and safer foods
- Reduced environmental and ecological impact

3. Robots in Agriculture

3.1. Introduction :

Robotics and Autonomous Systems (RAS) are introduced in large sectors of the economy with relatively low productivity such as Agri-Food. Robotics has played a substantial role in agricultural production and management. The main purpose of coming up with this technology is to replace human labor and produce effective benefits on small as well as large scale productions. A basic automated model was introduced to determine the actual position of seeds. For the effective use of water, **automated irrigation systems** were also established.

3.2. Irrigation

Aim:

The agriculture sector consumes 85% of the available freshwater resources across the world. And this percentage is increasing rapidly with the population growth and with the increase in food demand. This leaves us with the need to come up with more efficient technologies in order to ensure the proper use of water resources in irrigation.

Model Used:

The **plant evapotranspiration** which was dependent on various atmospheric parameters such as **humidity, wind speed, solar radiations,** and even the crop factors such as the **stage of growth, plant density, the soil properties, and pest** was taken into consideration while implementing autonomous irrigation machines.

Methodologies and Actions undertaken:

The M2M that is, Machine to Machine technology has been developed to ease the communication and data sharing among each other and to the server or the cloud through the main network between all the nodes of the agricultural field.

I. In (2017) researchers developed an automated robotic model for the detection of the moisture content and temperature of the **Arduino and Raspberry pi3.** The data is sensed at regular intervals and is sent to the microcontroller of Arduino (which has an edge level hardware connected to it), it further converts the input analog to digital. The signal is sent to the Raspberry pi3 (**embedded with KNN algorithm**) and it sends the signal to Arduino to start the water source for irrigation.

II. Savitha and UmaMaheshwari (2018) also developed the idea of an efficient and automated irrigation system by developing remote sensors using the technology of Arduino which can increase production **up to 40%.**

III. Another system for automated irrigation was given by Varatharajalu and Ramprabu (2018). In this approach different sensors were built for different purposes like the soil moisture sensor to detect the moisture content in the soil, the temperature sensor to detect the temperature, the pressure regulator sensor to maintain pressure and the molecular sensor for better crop growth. The installation of digital cameras. The output of all these devices is converted to digital signal and it is sent to the multiplexer through wireless networks such as **Zigbee and hotspot.**

Summary:

Various AI algorithms(**ANN, Fuzzy Logic, ML Algorithms etc**.) along with other technologies(**like sensors(Arduino, Raspberry pi3, Zigbee), hotspot etc.**) are being used nowadays as an automated robotic advancement in agricultural fields especially pertaining to irrigation. The irrigation process can therefore be automated with the help of moisture sensors and microcontrollers.

4. AI in Weed detection

In recent years, weeds have been responsible for most agricultural yield losses. To deal with this threat, farmers resort to spraying the fields uniformly with herbicides. This method not only requires huge quantities of herbicides but impacts the environment and human health. One way to reduce the cost and environmental impact is to allocate the right doses of herbicide to the right place and at the right time (precision agriculture).

Weed detection based on digital imaging processing and computer vision is the most investigated and widely used technique. Spectral features, biological morphology, visual textures, spatial contexts, and patterns present in digital images can be used to discriminate weeds and crops.

Model Used :

This model used an unsupervised collection of a training data set and convolutional neural networks (CNNs). It used a Residual Network with 18 layers (ResNet18) and Transfer learning model pre-trained on ImageNet datasets and fine-tuning to classify images into two categories (crop and weeds).

The proposed method is performed in three steps.

1. We detect crop rows and exploit them to detect inter-row weeds.
2. These inter-row weeds are used to form the training dataset.
3. Finally, the database created in the previous step is used to generate a model from deep learning.

The advantage of this method is that it is adaptive and robust, which means that it is possible not only to use the generated model to detect weeds in a new field with the same crop type but also to generate a new model by applying this method in a new field without any feature selection methods.

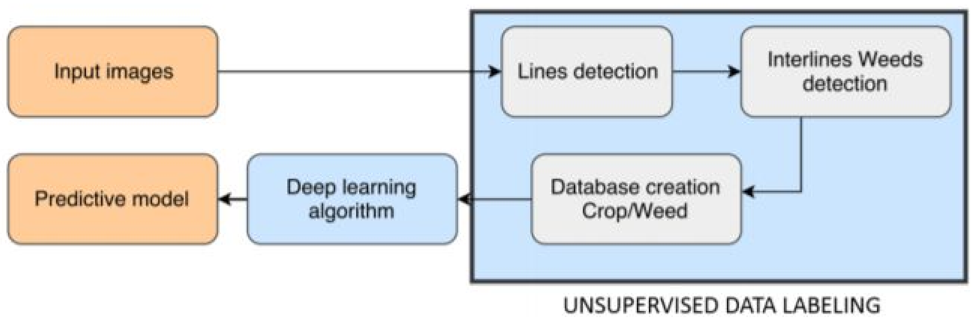

Figure 1. Flowchart of the proposed method.

we first detected the crop rows, then inter-row vegetation was used to constitute our training database, with data categorized into two classes: crop and weed. Thereafter, we performed CNNs on this database to build a model able to detect the crop and weeds in the images. We computed a series of statistical features, shape features, and texture features which have been selected in other works. A procedure for feature selection was then used to analyze the most suitable features.

Summary:

This fully automatic learning method uses convolutional neural networks with unsupervised training dataset collection for weed detection in UAV images acquired from bean and spinach fields. The results obtained show a performance close to that of supervised data labeling. The area under curve (AUC) differences are 1.5% in the spinach field and 6% in the bean field. Supervised labeling is an expensive task for human experts, and given the differences in accuracy between supervised and unsupervised labeling, our method can be a better choice in the detection of weeds, especially when crop rows are spaced well apart. The proposed method is interesting in terms of flexibility and adaptivity since a model can be easily trained on a new dataset.

5. Drones in Agriculture

5.1. Crop Spraying

History:

Drones are extensively being used for crop spraying. The technology was first implemented in Japan in the 1980s when unmanned helicopters equipped with spraying equipment and pesticides tanks were used to spray crop fields.

Manual pesticide spraying causes many harmful side effects to the personnel involved in the spraying process. The WHO estimated around one million cases of ill affected, when spraying the pesticides in the crop field manually. This paved the way to design a drone mounted with a spraying mechanism.

Crop Spraying Drones:

Spray rates for UAV systems are generally 1–2 L/ha, which is 25–50 times lower than conventional spray application systems. However, due to the use of higher concentration sprays, applicators should ensure that there is no excessive overlap or gaps in the spray pattern in order to avoid causing phytotoxicity or deficient prevention.

Typical modern day spraying drones have tank capacity of over ten litres of liquid pesticide with discharge rate of over a litre a minute, allowing them to cover a hectare in ten minutes. However, to leverage drone technology fully as a spraying platform, the spraying needs to be paired and synchronized with imaging, processing and automated analytics capabilities in order to address the affected areas or plants with precision. Such an approach would lead not only to the improvement of dosage in the affected areas, but also leads to a reduction in the overall use of chemicals within the area.

With the small droplets used in low-volume pesticide spraying, UAVs should fly low at a height of 3–5 min order to avoid spray drift. Moreover, UAV spraying should ensure the stability of low-altitude flight and precise control of the spray swath. The accuracy of flight control has been improved through the optimization of automatic guidance systems.

These Drones are divided into 4 categories:

1. **Hydraulic Energy Sprayer :** In Hydraulic Energy Sprayer, the material to be sprayed is pressurized up to 40–1000 psi in any of the two potential ways. Either straightforwardly by utilizing a positive uprooting siphon or by utilizing a vacuum apparatus which will make the gaseous tension over the shower material noticeable all around tight holder. This pressurized material is shot out through the splash spout.

2. **Gaseous Energy Sprayer:** In this Sprayer a blower produces a high speed air stream. This air stream is coordinated through the pipe toward the finish of which spray liquid will be available which will be permitted to be streamed by the activity of gravity through a diffuser plate.

3. **Centrifugal Energy Sprayer:** At the focal point of this sprayer, the shower liquid is nourished under low weight which is additionally atomized by diffusive power as it leaves the outskirts of the atomizer. The droplets are conveyed by the air stream created by the blower of the sprayer

4. **Kinetic Energy Sprayer:** In Kinetic Energy Sprayer the spray liquid streams by gravity to a vibrating or swaying spout which delivers a coarse fan like spray design. This is explicitly utilized for the spraying of herbicides.

Architecture of a Crop Spraying Drone:

A GPS-based automatic spray control system is included in the flight control system, along with the task link, the route planning system and the spray control system.

The flight control system which includes FMU (Flight Management Unit) and data link is semi-integrated with the spray control system. The FMU is a part of the UAV. Based on spraying application, the data link which includes coordinate transformation, waypoint calculation and communication protocol is designed into the chip PC104. The data link sends planned route data to FMU to control the flight, read the position sensor data & to calculate spraying parameters, then send control commands to the spray control system. At the same time, the data link reads the spray control system feedback to communicate to the ground station via the radio.

Summary:

To perform plant-protection operations, an unmanned aerial vehicle (UAV) based automatic control spraying system was designed. The system uses a highly integrated and ultra-low power MSP430 single-chip micro-computer with an independent functional module. This allowed route planning software to direct the UAV to the desired spray area.

The route planning developed for this used the farm field boundary to plan the flight route automatically, then display the UAV position and spray system status in real-time for precision spraying.

5.2. Crop Monitoring

In Section 5.1, we understand the different applications of Drones in Spraying Application, now we will look into the most essential part ie. Crop Monitoring, then we will understand how data collected here can be tested with the Harvest Amount of different patches of land, and future prediction for next year's harvest, seeding pattern, pest control, and compost distribution can be done.

Crop Monitoring Drone:

The advanced sensors and imaging capabilities have provided the farmers with many new ways to increase yields and reduce crop damage. With UAV flights, one does not need to depend on the position of the satellite or having the correct weather conditions and as UAV pictures are taken 400–500 ft. from the ground level, they result in better quality and provide precision.

(a) **Crop Biomass and Nitrogen Status:** A result of contrasts in the introduction settings chosen by the advanced camera. Further, they utilized Normalized Green–Red Difference Index (NGRDI) and directly related it to the standardized contrast of the green and red reflectances.
(b) **Pest Detection:** One camera is sensitive to Infrared radiation while the other is a common RGB camera, they assist farmers in maximizing their harvest by detecting problems early, and managing the crops by using specific cameras to detect pests and water shortages
(c) **Yield Mapping and Monitoring:** Incorporate Grain flow Sensor, Grain moisture content Sensor, GPS antenna (receives satellite sign), Yield screen show with a GPS receiver (geo-reference and records information), header position sensor(distinguishes estimations logged during turns), travel speed sensor (determines the separation the join goes during a specific logging interim)

Programming of the Software:

To conquer these contentions and to mull over every one of the undertakings we utilize four interfere with wellsprings of **P80C592** in the framework, which are the clock and outer intrude on the source, the ADC end- of-transformation intrude on source and the **UART sequential I/O** port intrude on source.

With the utilization of a **Geographic Information System (GIS)** programming, the yield determined at each field area can be shown. The raw log document, contains focuses which are recorded during turns and as the grain move through a consolidate is a deferred process (unless ongoing amendment is connected), the sensor estimations neglect to compare to the careful gather areas

Summary:

In combination with soil examining data, yield maps empowers the arrangement of variable compost maps which considers soil supplement levels just as the supplement which was expelled in the collected harvest. To acquire an exact yield information a legitimate sensor alignment is imperative. Contrasting the scale loads of four with five burdens with the determined yield decides an alignment bend. Yield sensors ought to be recalibrated as factors change, for example, dampness substance or half breed. However, utilizing the Yield Sense screen evacuates the requirement for recalibration after the underlying alignment toward the start of the period (**Precision Planting**).

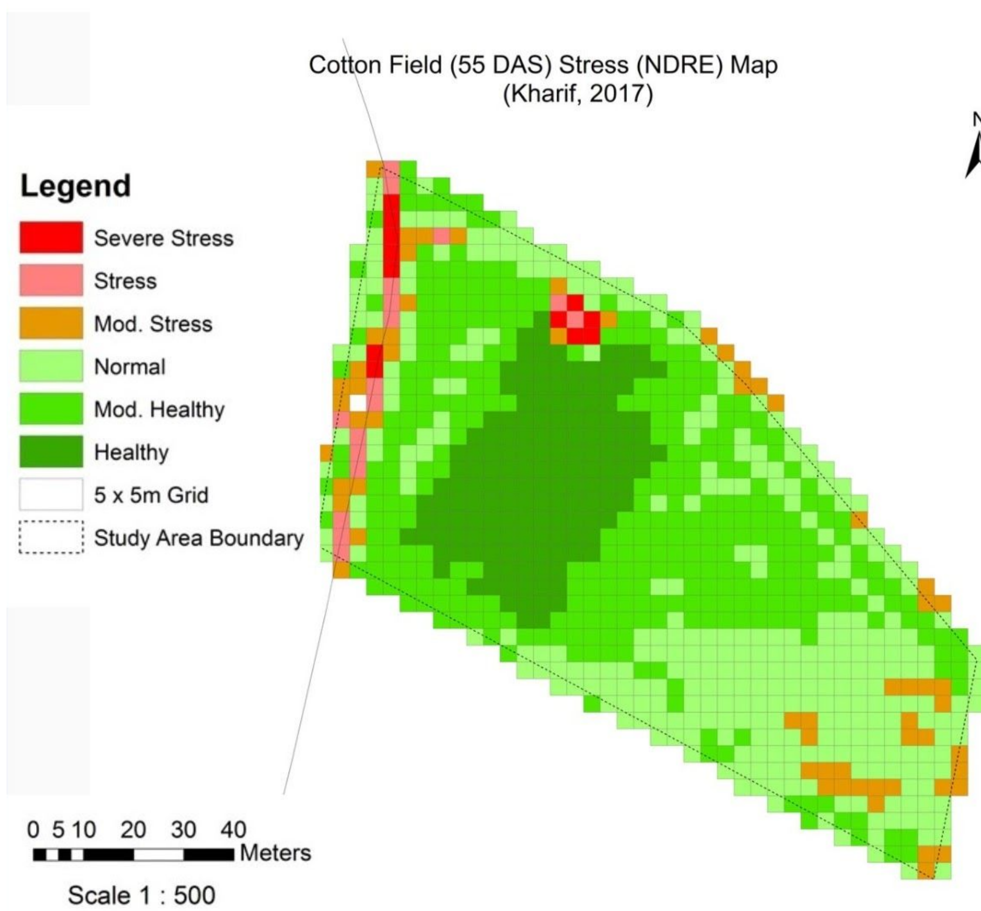

Fig: Interpolated Yield Map using Geographical Information System(GIS)

6. Conclusion

The agricultural industry faces various challenges such as lack of effective irrigation systems, weeds, issues with plant monitoring due to crop height and extreme weather conditions. But the performance can be increased with the aid of technology and thus these problems can be solved. It can be improved with different AI driven techniques like remote sensors for soil moisture content detection and automated irrigation with the help of GPS. The problem faced by farmers was that precision weeding techniques overcome the large amount of crops being lost during the weeding process. Not only do these autonomous robots improve efficiency, they also reduce the need for unnecessary pesticides and herbicides. Besides this, farmers can spray pesticides and herbicides effectively in their farms with the aid of drones, and plant monitoring is also no longer a burden. For starters, shortages of resources and jobs can be understood with the aid of man-made brain power in agribusiness issues. In conventional strategies huge amounts of labor was required for getting crop characteristics like plant height, soil texture and content, in this manner manual testing occurred which was tedious. With the assistance of various systems examined, quick and non-damaging high throughput phenotyping would occur with the upside of adaptable and advantageous activity, on-request access to information and spatial goals.

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