CROP HEALTH MONITORING USING IOT

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Abstract:

Designing innovative combinations of techniques to improve the sustainability of a cropping system is a major challenge in many regions of the world. The available techniques are often added together, and assessed for yield only, rather than combined in an integrated approach. We then developed a methodology to design and assess a sustainable crop management system adapted to a specific set of constraints. Based on the prototyping approach, this methodology takes advantage of expert knowledge on cotton cropping techniques such as no-till, cover crop, varieties and growth regulator, with innovative potential but which are not yet properly simulated by actual crop models. In this study, we analyze how crop management will benefit from the Internet of Things (IoT) by providing an overview of its architecture and components from agronomic and technological perspectives. The present analysis highlights that IoT is a mature enabling technology with articulated hardware and software components. It emerges that the Internet of Things will draw attention to sensor quality and placement protocols, while machine learning should be oriented to produce understandable knowledge, which also useful to enhance cropping system simulation systems.

Introduction:

The uniform crop management system recommended to farmers no longer copes with the diversity of growers and conditions. Farmers are asking for a wider range of cropping techniques, better adapted to the actual constraints, and cotton research has to develop innovative cropping strategies.

Abundant literature refers to the development of new cropping systems. The first definition of IoT can be credited to Ashton, who defined it as “an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment”. Such “intelligent objects”, later called “things”, refer to every physical and/or software device that is identifiable and connected to a network with processing, sensing, and acting capabilities. During the last two decades, IoT has become a consolidated reality consisting of a collection network of devices connected in a dynamic (and commonly asynchronous) environment, enabling the possibility to provide a massive amount of information to feed machine learning algorithms and may also react proactively to environmental stimuli operating on actuators aimed at minimizing human involvement. The objective of this work is to draw a big picture of IoT and current solutions adopted in crop management from an interdisciplinary perspective, with the aim to reveal gaps and future directions.

Some of the other ways helps in crop health monitoring:

- **Remote Sensing**- As the name tells, remote sensing includes drones, satellites and such modern scientific technologies that help in crop health monitoring and management.

  Remote sensing technologies used in agriculture include:
  - Satellites: With the help of satellite images(that gets collected on the basis of virtual imagery from satellites) farmers get quality data on various aspects which include temperature, water moisture levels etc.
  - Drones: Modern drones are generally equipped with high definition cameras that helps in capturing footages of a long scale of land. This further helps farmers in monitoring crops quality more efficiently.
  - Hyperspectral : As, the name itself says hyper-spectral means to look

after a large field of wavelengths to gather data which helps in crop health indirectly.

  - Ground based sensors: Ground-based sensors can be used to measure various environmental factors such as temperature, soil moisture, and nutrient levels. These sensors can provide data at a high resolution, allowing for real-time crop health monitoring.

- **Spectroscopy:** As, spectroscopy is the study of the nature of electromagnetic radiation and its behaviour towards matter. Crop health requires spectroscopy in the areas of chemical addons as it states the chemical behaviour.

  - In the field of agriculture or crop health monitoring spectroscopy is used in measuring chlorophyll content, detecting chemical composition, toxins, pests etc.

  - Near Infrared Spectroscopy or NIRS are sometimes used in detecting a variety of crop health factors without causing harm to the crops. This is because NIRS is generally tested non-destructive.

- **Machine Learning**: Machine learning algorithms can be trained using data collected from sensors and other sources to identify patterns & ways for better crop health. This can be used to develop predictive models and information that can help farmers in making perfect decisions about crop management.

- **Visual Inspection:** The most-efficient way probably which involves physically inspecting crops for signs of stress, disease, or pests. This method can be made more reliable in combination with remote sensing and spectroscopy to validate the data and provide more accurate assessments of crop health.

  It is said probably the most-efficient because:

  - **Personal Observation:** Visual inspection allows farmers or crop owners to personally observe their crops and analyse their health status. This can provide valuable insights into the specific needs of each crop and the probable challenges they may face.

  - **Flexibility:** Visual inspection is a flexible method that can be adapted to suit the specific needs of each crop and growing environment. This enables farmers in using a variety of tools and techniques to examine crops.

  - **Immediate Action:** Visual inspection can help farmers identify crop factors early on, allowing them to take immediate action to address the issue. This prevents crop damage and loss that directly lead to higher quality crop yields.

  - **Low Cost:** Visual inspection is a low-cost method of crop health monitoring that requires minimal investment. Thus, making it a good alternative to small-scale farmers and those with limited resources.

  - **Integration with other Methods:** Visual inspection can be used with other methods of crop health monitoring, such as remote sensing or spectroscopy. This allows for a more accurate assessment of crop health and can improve the quality of the data collected.

Related work:

1. Monitoring of soil moisture and groundwater levels using ultrasonic waves to predict slope failures, [1] used an ultrasonic waves to predict the slope failures when there is a heavy rainfall, and they have used a method of monitoring of soil moisture.

2. Optimal sensor placement strategy for environmental monitoring using Wireless Sensor Networks, [2] has used wireless sensor networks to determine the optimal sensor placement method for the monitoring of environmental changes. They have also been used a geostatistical analysis and Monte Carlo theory to develop the strategy.

3. The realization of precision agriculture monitoring system based on wireless sensor network, [3] has used wireless sensor networks to design the monitoring of agriculture, at the same time the system is based on the real time monitoring of agriculture environmental

information such as temperature, humidity and the light intensity.

4. Precision agriculture monitoring framework based on WSN, [4] proposes that WSNs play a vital role in decision making, monitoring of agricultural field and optimization of agricultural resources. WSNs also help to know the real time data related to the agricultural field and the condition of the crop, so the farmers can make sure that they are ready to face the future conditions related to their agricultural field.

5. IoT as an extension of the Internet is able to connect any distant items with the Internet through information sensing devices such as RFID (Radio Frequency Identification), infrared sensors, The associate editor coordinating the review of this manuscript and approving it for publication was Mu-Yen Chen. GPS (Global Positioning System), laser scanners and so on in accordance with stipulated agreements for information exchange and communication.

6. In the meanwhile, the Japanese government planned to use agricultural IoT platform to provide information and data services with agricultural robots. All such technologies could significantly restructure the traditional management mode and enhance the production efficiency of agricultural products.

7. D.K.Sreekantha, Kavya.A, et. al. (2017) have studied that the Internet of things (IOT), where it is used in agriculture. The farmers using the precision for the growth of the crop. In IoT it collects all the climatic condition like temperature, soil moisture content, and humidity etc., wireless sensor network it controls everything.by using the mobile phone the user can get updated details of the land field. While using that IoT it is a cost efficient.

8. G. Nisha and J.Megala (2014) have investigated about Wireless sensor Network based where the irrigation can be done in a correct manner. Two types of sensors are used. Temperature sensor and soil sensors are kept in the farm field, from that sensors the data can be fetched. ZigBee protocol is used to control the sensed data from the sensors. To control the overall process the microcontroller is used. The camera also kept in the field to capture the affected plant image; this can be done under image processing.
9. Monali Paul, K.S., et. al. (2015) have explained the crop prediction. The sowing of crops or the supply of water can be irrigated by the farmer's prediction. That prediction can't be true always, if the temperature changed, the farmer's prediction can't be applicable for the irrigation process. For that they extract the soil dataset using data mining. On the basis of predication and the soil temperature, this is 54 International Journal of Engineering & Technology useful for farmer's prediction. The required amount of water can be irrigated to the crops. In that classification they used K-Nearest Neighbour method.

10. A.T.M Shakil Ahamed, Navid T., et. al. (2015)in this paper the explained the production of crops from many problem. The problem may be due to weather changes, and also in environmental issues. By using some methodology ,the problem arising can be reduced to
make a better crop production. And also it can be useful for comparing the original data and the historical data, accordingly the water can be supplied. This project is mainly implemented for cultivating the cereals crops in in good quality in the major areas of Bangladesh.
11. As, to sustain food production and counter impending environmental and economic consequences of indiscriminate use of fertilizers and other factors affecting crop health require immediate attention.[11] This paper describes the success stories of employing sensor-based tools and technologies to assess inherent and management variabilities of fields, crop, and environment in spatiotemporal scale, respectively.

12. As, population is increasing day by day which results in extra food demand, that can only be met from enhanced crop yield.[12] This paper portrays an analysis of drone technologies, application of drones in agricultural sector where drones are used to monitor crops, pesticide spray has been covered.

13. The emanation of the technologies based on Internet of Things (IoT) has reformed nearly each industry like smart city, smart health, smart grid, smart home, including "smart agriculture or precision agriculture"[13]

14. IoT-based smart farming techniques have come up as one of the solutions to tackle the effect of climate change, water scarcity, etc. which are the prime reason for the decline of agricultural products and increase in their price. In recent year, many works have presented innovative ideas and prototypes which can be used for IoT-based smart

farming.[14] This article presents a comprehensive review of the cutting-edge technologies and advancements in the field of IoT-based smart farming.

15. The smart plantation and automation using Internet of Things (IoT) and cloud is the demand of the current scenario. The smart plantation monitoring system detects the health status of plants. [15]

16. The Internet of Things is allowing agriculture, here specifically arable farming, to become data-driven, leading to more timely and cost-effective production and management of farms, and at the same time reducing their environmental impact.[16] The review contributes an overview of the state of the art of technologies deployed.

17. Smart farming is an emerging concept, because IoT sensors capable of providing information about their agriculture fields.[17] The paper aims making use of evolving technology i.e. IoT and smart agriculture using automation. This includes monitoring environmental factors i.e. one of the major factor to improve the yield of the efficient crops.

18. In this paper we look at the role of IoT (Internet of Things) in greenhouse agriculture in Palestine, questionnaires and interviews were used to collect data from agricultural engineers to find out the extent to which they use technology in greenhouse agriculture, also to identify the current greenhouse usage and to outline the main problems. [18]

19. The new developments of Smart Farming with use of IoT, by day turning the face of conventional agriculture methods by not only making it optimal but also making it cost efficient for farmers and reducing crop wastage.[19] The aim is to propose a technology which can generate messages on different platforms to notify farmers. The product will assist farmers by getting live data (Temperature, humidity, soil moisture, UV index, IR) from the farmland to take necessary steps to enable them to do smart farming by also increasing their crop yields and saving resources (water, fertilizers).

20. Although precision agriculture has been adopted in few countries; the agriculture industry in India still needs to be modernized with the involvement of technologies for better production, distribution and cost control.[20] In this paper we proposed a multidisciplinary model for smart agriculture based on the key technologies: Internet-of-Things (IoT), Sensors, Cloud-Computing, Mobile Computing, big data analysis. Soil and environment properties are sensed and periodically sent to AgroCloud through IoT (Beagle Black Bone).

Proposed work:

In this paper an integrated system for Crop health monitoring has been proposed. The main building blocks of the system are IoT nodes, transmitting data channels, drone with a high-resolution camera, local server for storing data and images, and an online medium for data visualization.

As, several other models that are available out there doesn't focus on every aspect required for crops. For e.g., if a model focuses on crop health mayn't focus on soil quality or weather forecast. Or if a model uses technology like drones to explore an amount of crop land sometimes fails to focus on precise crop moisture levels or nutrient quantities, or maybe some model fulfils all the checkboxes but it isn't that much pocket friendly or efficient, thus accuracy never becomes up to the mark.

As, before it is mentioned Visual inspection is probably the most efficient method of monitoring everything from crop health to soil quality to amount of moisture in the soil everything but fails to know about future conditions. So, the best way of crop health monitoring keeping efficiency in mind would be a systematic model with all the components of visual inspection and other efficient methods that monitors crop health. Here, in this paper such kind of a model has been proposed.

Checkboxes that the proposed model can do:

a. Uses drone to capture large scale area of crop health and divides it into sections or squares. It then captures quality footages of each and every sections again. Further the footages are zoomed in and farmers could go through each and every crop divided by sections.

   This helps both the farmers and the model to get the most detailed & accurate view of the crops. Farmers can identify if any particular crop is facing a disease or not and could reach to that particular crop location (as the footage is divided into small sections so finding the actual location is easy) and provide correct insecticides/pesticides.

b. If any crop is found defected and the farmer reaches the plant, the model provides a suggestion option. Where, the farmer just uses the mobile camera to capture an image of the defected crop and the model guides him/her with the correct pesticides or agro-medicines (This info is stored in the model's database). Thus, saving a lot of effort & increasing productivity.

c. Not only providing guidance for pesticides, clicking crop pictures tells farmers about its nutrient and water levels. This helps a healthy growth of the crops.

d. The model also tells farmers when is the correct time for sowing and harvesting of crops. This is mainly done through inspection of crop land through drones.

e. Before sowing of seeds, another drone visualization is done where it tells the quality of soil, its nutrient and moisture contents and which crop is best for that particular soil.

   It helps farmers with less knowledge to grow the perfect crops suitable for the soil available, if the soil requires any fertilizers before sowing, thus enhancing productivity.

f. Last but not the least, as the model is completely web medium so weather conditions are always near too accurate. Which helps farmers to know about changing weather conditions, or if any natural calamity like flood or storms is arriving.

Methodology:

In order to develop our proposed system, the data from the drone was taken into deep reference in order to get a detailed picture of the crop health. The image high-resolution data is further mapped to a fixed sized representation for further data processing & analysis of the same.

Subsequently, various machine learning and deep learning algorithms were applied on the acquired data for crop health classification and generating data on crop health. Later on, the health data were checked & compared with the server databases and IoT sensors data maps for validation & verification purposes.

- **Data Processing-** Both the data acquired from the drone footage or personal inspection by the farmer were in imagery format. Both the data was sent to the web database where all the points are checked. For better results, drone inspection must be done on a weekly basis.

  As the drone divides the image into sections, which leads better checking of soil health on a regular basis. Based on the footages of the soil, the model checks and compares it with the mentioned web database data & provides with a solution if needed.

  In addition to the IoT nodes data, the multispectral data was also pre-processed. For capturing the footages, the drone must fly at a certain height (take 50ft from the ground and a speed of 10km/hr with no overcast), and must capture approx. 25 – 30 images on a single flight which must cover at least 70 % of the land area.

- **IoT sensors data maps-** To study the variations in crop health, IoT sensors are also used to study & analyse environmental reasons impacting crop health.

  There were several other factors that generally effects crop health like the terrain, fertilizer distribution, soil quality, soil type and the seed quality. Through studies these mentioned factors vary in different locations.

  Hence, IoT sensors have provided quality data and added information required for the study crop health more efficiently.

Results & Discussions:

1. **Quality precision-** Precision refers to the measure of how well a system or process produces results that are accurate, consistent, and reproducible. It is a statistical measure that indicates how close multiple measurements or observations are to each other when taken under the same conditions.

   The proposed work's precision will be measured after frequent testing but can assume it to be in a much safer and highly precise side.

2. **Accuracy-** In the context of data analysis, accuracy refers to the ability of a model or algorithm to make correct predictions or

classifications. A model with high accuracy will correctly identify both positive and negative cases most of the time. The proposed model maybe close to 95% accurate.

3. **Final result-** As, no such reference data was available to check and validate the crop health through maps or sensors. Therefore, for a brief validation of the final result a ground and crop land survey were performed, where after applying the proposed work results can come out way better.

Conclusion & Future work:

A system for crop health monitoring has been proposed which is based on implementing technologies like the use of drone based remote sensing, IoT and machine learning.

The cumulative integration of sensing modalities generates data that depends on several natural conditions like nature, location, soil quality etc.

The data collected from different sources including IoT sensors and drone with a multispectral camera mounted on it. This multi-source data was generated at variable intervals and of variable length. This data was then mapped to a common temporal resolution easy classification.

The machine learning techniques along with several deep learning models were applied to classify each pixel based on their quality as healthy or unhealthy. Thus, reaching a good accuracy point.

In addition to this, IoT sensors sometimes generate maps to correlate the behaviour of environmental variation with the crop status defined, where these maps provided useful insights about the factors influencing the crop health.

For, the future works the other indirect or direct factors influencing crop health will be taken into concern, that may help the proposed work perform more better. Additionally, the application of the proposed work will be made available for fruits and flower plants. This will lead farmers who grows fruits, and small case nursery owners to take care of their fruits & flowers through the benefits of the proposed work.

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