IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Ingénierie des Systèmes d'Information
Vol. 28, No. 2, April, 2023, pp. 401-407
Journal homepage: http://iieta.org/journals/isi

Smart Farm: Agriculture System for Farmers Using IoT

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https://doi.org/10.18280/isi.280215

Received: 3 July 2022
Accepted: 12 March 2023

Keywords:
CNN algorithm, IoT in agriculture, Smart Farm, THR (Temperature, Humidity, Rainfall)

ABSTRACT

In 2050, the worldwide populace is assessed to be about 9.7 billion, because of which there will be incredible food inevitability. So as to address this issue, it is important to build the current arrangement of agriculture system. The conventional method of agribusiness is fine, yet at the same time it won't meet the world's whole food necessities. Here utilization of past information mining methods in assessment of yields and environmental change is used to take better decision of crop for farmer, choices made for cultivating and increase the necessary financial return. A huge issue that can be beaten reliant on past experience is the issue of yield assessment. Thus, from crop cultivation to crop market systematic approach is proposed using CNN framework with Smart Farm IoT. Utilizing Temperature, Humidity, Rainfall (THR) concept to get to trim creation design in light of climatic conditions, for example, precipitation, temperature, humidity and so on. Harvest expectation is a pre-condition, and forecast of illness is a post- condition for the assortment of information from a field or zone from a climate boundary test. Furthermore, utilizing this proposed framework farmer gets correct fertilizer prediction for diseases as well as the nearest fertilizer shops are recommended.

1. INTRODUCTION

The smart agriculture is the main application utilized in IoT [1]. IoT comprise no. of utilizations which control quality of-usage (QoS) [2]. India is a rural nation and 70% of the populace relies upon agribusiness. So, there will be extraordinary food interest. So as to address these issues, it is important to expand the current arrangement of agribusiness. It's fine, as indicated by the conventional method of horticulture, yet it won't meet the whole necessity about food. Using data innovation, it is anything but difficult to take choice in agribusiness area. it is helpful for agriculturalist to utilize IoT idea and improve development in agriculture. To defeat existing issue in agribusiness framework, the proposed designed framework is intended to create and oversee various sorts of yields with correct usage of fertilizer with respect to climate. Agribusiness depends on different spaces (crop, climate, soil, bug, manure or fertilizer, profitability, water system) [3]. Here data mining assumes the cardinal function for choice on a few issues identified with horticulture field. Various components have impacted the sufficiency of cultivating in India. Yield depends on climate condition like temperature, precipitation, mugginess (humidity), soil type regarding cultivating land [4]. It is viewed as development of plants their required composts, gathering etc. The development of a plant relies upon the atmosphere. Proposed framework planned two modules for crop forecast and likely infectious prevention in light of access climate. The plant leaf is considered for the identification of sickness which shows the illness side effects. To take care of this issue CNN calculation is planned. In this proposed framework CNN calculation to be utilized for infectious prevention, which is regularly utilized while applying profound to figure out how to process picture. Detecting and dealing with the spread illnesses is one of the main parts of cultivating, so it should be control. Various harvests comprise of verity of fertilizers. To increase food creation its need to forestall crop diseases with good management. The proposed framework having diverse crop data set with particular diseases. Detection of plant infection utilizing CNN will be assess just as it prescribes to farmers for high accuracy with the help of IoT is to be used. Here Kaggle data set is used for to access all types of crops with their diseases and suitable recommendation of fertilizers like a prescription. It is open access for all. In this proposed designed system such a big data set used to store crop details data. Most important thing is that, it gives information to farmer about nearest fertilizer shops to get an idea about diseases with solutions. Proposed system which will work on local host as well as on android mobile also so every farmer can use this application as easiest way. In this paper a framework is planned which will propose rancher reasonable yield as indicated by climate and suggest manures for likely disease prevention.

2. LITERATURE SURVEY

Standard or typical gather yield want approaches subject to

far off distinctive contributing grouped old style AI systems, for example, Backing Vector Machines and Choice Trees. Convolutional Neural Organization (CNN] and Long-Momentary Memory Organization (LSTM] are huge neural affiliation models that are proposed for crop yield want beginning late. This examination focused in on soybean yield gauge of Lauderdale County, Alabama, USA using 3D CNN model that utilization the spatiotemporal features [5].

IoT PC is an implicit organization with sensors which needs remote availability. The inserted framework comprises of field programmable door clusters or microchip, interfaces for network, memory and info/yield. The drawback is that Standard remote correspondence definition is utilized. Inside 100 m, the short reach principles will traverse separations. The long-range levels of contact will arrive at separations of up to 10 s/km. So, its limited over area [6]. To satisfy the need of food, issues, for example, extraordinary climate conditions consistently and expanding environmental change will be settled. Savvy IoT-based cultivating would permit ranchers to diminish waste and increment efficiency from the measure of manure utilized. In this way, keen cultivating is a capital-concentrated, innovative framework for masses to develop food neatly and reasonably. It presents an idea of current ICT (Information and Communication Technologies) in cultivating. Here the IoT equipment and programming for shrewd cultivating is presented, notwithstanding sharing the victories [7].

In this framework Internet of Things and Data Analytics is utilized as a shrewd horticulture to improve working effectiveness and efficiency in the rural area. The IoT joins many existing advancements, as applications for WSN, radio recurrence acknowledgment, distributed computing, and end clients. Utilization of remote sensor organization (WSN) to utilize IoT and DA as a significant perspective on keen horticulture. IoT has recognized numerous chances and dangers. Utilizing the IoT idea with environment and consolidating IoT and DA makes shrewd cultivating conceivable. It gives future business patterns and openings, and attractiveness of items [8].

The main factor for plant improvement is soil dampness is explained in this manner using farming IoT systems. Soil mugginess sensor is intended for this framework. Since the sensor comprises of copper, wet underground soil dampness sensors are mounted, and rust destroys the sensor copper covering. In view of rural IoT Environments, soil dampness subtleties can be acquired from rusting of sensors on a shrewd homestead framework makes for an effective savvy crop. Here another sort of soil dampness sensor to expand the lifetime [9].

To request to improve farming item, quality, amount its requirements to oversee great administration in present day horticulture area. In this paper utilization of huge information is inferred to observing framework. New utilization of horticulture is planned that is distributed computing just as Internet of Things. In this proposed framework various sorts of information base is planned. Development in Modern horticulture depends on IoT is actualized [10].

The plant sickness and safeguard component against the illness is utilized in this framework. Here utilizing the assistance of web information base was kept up. In this proposed information base different plant illnesses information was put away which comprises of the exactness and level of the venture. The new idea Convolution Neural Network (CNN) was utilized of plant illness forecast. As well as robot model was planned. Robot is utilized to get the pictures of plants. Utilizing CNN calculation exactness level was accomplished of 78%. This framework is utilized python to plan this system [11]. In this paper MATLAB is used for picture preparing, utilizing to come at weed zones in a picture. To over please the issue as expanding populace and their food prerequisites. Its need to execute great item as for their food quality idea is actualized. The green insurgency idea is utilized to actualize normal techniques. In this paper numbers of references are utilized to plan the proposed framework [12]. The use of advance development, for instance, Mobile Computing, Sensors, Internet of Things, Cloud Computing, Big limit Analysis in Agriculture. The properties of soil and climate are watched and constantly sent through IoT to Agro Cloud. Huge information preparing on Agro Cloud innovation is performed for the necessities of manures, best yield arrangement handling, by and large development, and existing prerequisites for stock and request. Expanded rural creation and cost the executives of agro-items are helpful for this. The machine doesn't have explicit sensors of soil supplements and neglects to create right outcomes [13].

It proposes a home robotization network engineering using prepared to utilize, savvy and energy effective equipment like raspberry pi, microcontrollers, XBee modules and hand-off sheets. Utilization of these components brings about complete program arrangement being savvy, adaptable and dependable. Utilization of these components brings about complete program organization being cost-, adaptable and solid. The framework dribble water system makes water and manure for simple to utilize. An email is shipped off an offered address to begin the dribble water system framework. The issue is that the breakdown of some particular segment or unit isn't alarmed and should be physically checked. Not appropriate for enormous agribusiness areas [1].

To defeat for the food prerequisite, its need to tackle issues, for example, change in climate and diverse environmental change is to be settled in this framework. Keen IoT-based cultivating would permit ranchers to diminish waste and increment profitability from the measure of manure used to the quantity of excursions that ranch vehicles have made [9, 14].

The utilization of Internet of Things and Data Analytics (DA) is used as a sharp cultivating to improve working capacity and usage of land in the farming [5]. The IoT framework have numbers of employments, for example, applications for WSN, radio recurrence acknowledgment, distributed computing, and end clients. In the vast majority of case remote organization is executed using IoT and DA in savvy horticulture. In this framework it utilized sensors to ascertain highlights of agriculture. IoT has recognized numerous chances and dangers. Utilizing the IoT environment and joining IoT and DA makes keen cultivating conceivable. It gives future business patterns and openings, and attractiveness of items [9].

In the plant development soil dampness is one of the main factors to be thought of. Utilizing IoT frameworks in horticulture soil dampness sensor is clarified. Since wet underground soil dampness sensors are mounted, rust destroys the sensor copper covering and the sensor comprises of copper. In view of horticultural IoT Environments, soil stickiness subtleties can lead to rusting of sensors on a brilliant ranch framework. It makes for a fruitful keen harvest. In this paper proposed sensor utilized for extensive stretch of time with their climatic condition [15].

Wolfert et al. [16] focused on improvement of the utilization of water to upgrades crops. Framework planned as a

calculation which constructed to measure soil dampness and temperature edge esteems. Microcontroller is customized to compute water amount. Utilized gadget was worked by photovoltaic boards. Just as idea of duplex correspondence association is to be utilized. Which permitted a page to program information review and water system booking. The issue is that it will be hard to put resources into electric force flexibly [14]. To build smart campus at Udayana university usage of ESP8266, a highly Wi-Fi dependent module controlling sensors, and web server to port sensor collected information to internet is explained. Also, Wi-Fi non-availability situation was handled using XBee 802.15.4 radio and Arduino [17]. IERC initiated IoT standardization to identify gaps between present and future IoT standardization requirements and explore areas to apply it like cloud computing, networking [18]. Brewster et al. [19] suggested technologies and design solutions for the agrifood industry and underlined the need of cultural change with the help of IoT in agriculture. Comparison of IoT and Wireless Sensor Network [WSN] shows that WSN is now part of IoT ecosystem. Requirements of IoT based system in terms of hardware, software and communication and risks associated with them is analyzed [20]. IoT based Modern Agriculture system is proposed using Cloud Computing, Big data and Machine Learning. It greatly simplifies the work of agri monitoring with the help of latest technologies available [21]. WSN based crop monitoring system suggested to realize precision agriculture. It exploits capabilities of WSN to investigate environmental conditions to help agro-ecological resource management of rice crop [22]. To estimate fruit maturation and size distribution of mango a RGB-D (depth) camera method is used for precision fruiticulture claiming cost effective solution. This implementation of machine vision fruit sizing in field is using night imaging [23]. An automated grading system for tomato maturity classification in terms of colors (Red, Green, Yellow) using 'AlexNet,' the pretrained network based on Transfer Learning is developed and Accuracy, Loss curves, and confusion matrix are considered for result comparison. The model proposed works slowly as a result of intensive data calculations involved in deep learning [24]. The key pillars of IoT RFID, WSNs, NFC, BLE, LoRa, and Sigfox are analyzed and the obstacles which may hamper the growth of each and the challenges posed are reviewed [25]. Temperature and humidity monitoring system [THMS] implemented based on low-power and wide-area network (LPWAN). The tedious job of Manual registration of end devices on the application server was eliminated as well [26].

3. PROPOSED METHODOLOGY

The proposed system designed for identification of plant disease and provides remedies that can be used as a defense mechanism against the disease. The plant disease detection can be done by observing the spot on the leaves of the affected plant. The method adopted in the proposed system is to detect plant diseases image processing using convolution neural network (CNN). Proposed system is designed to reduce the attack of diseases by using proper fertilizer and remedies. Here the main objective is to recognize the plant diseases using 1. Image processing, 2. Image segmentation, 3. Feature extraction, 4. Image enhancement, 5. Classification of the disease by using deep learning. The proposed system classifies the disease with optimum accuracy and predicts suitable fertilizer to be used. Convolution Neural Network which comprises of different layers used for prediction. After the suitable prediction it will recommend precision/fertilizers.

The proposed system developed as per the recommendation of crop as per area. Different area having differ in weather condition. As well as according to distinct seasons (winter, spring, summer) in India it differs in environment. To obtain good quality of crop system predict THR (Temperature, Humidity, Rainfall). It suggests crop with cultivation process, prediction of crop disease and its process as well as fertilizers and prediction and this system also recommends the nearby fertilizer shop. The proposed technique involves the following steps:

CASE 1: Pre-condition

Stage 1: Registration/login of agriculturalist.

Stage 2: Crop yield and disease expectation according to farm and harvest.

Stage 3: Predict THR.

Stage 4: Recommend accuracy/fertilizer.

Stage 5: Shop suggestion according to area.

Stage 6: Notification given by agriculturalist.

In this planned framework first, it catches the leaf pictures utilizing picture handling and distinguishes the disease. Rely upon illness framework will suggest fertilizer. Rely upon soil type framework will likewise give fitting yield development. Following advances are utilized to distinguish the infection of plant in which division include extraction classifiers assumes an exciting job.

CASE 2: Post-condition

Step 1: Input the leaf affected by disease image.

Step 2: Preprocessing of the image which diminishes the noise information from it.

Step 3: Image division is performed which partitions the picture into the little fragments.

Step 4: Extract the highlights from the portions of the picture.

Step 5: Selects the upgraded highlights by enhancement measure utilizing Deep learning strategy.

Step 6: Features learned by the classifier.

Step 7: Detect the influenced leaf.

Step 8: Analysis of Accuracy, Precision, and review.

Stage 9: Recommend to agriculturalist about suitable fertilizer with their nearest shop.

3.1 Enhancement in existing system

The proposed framework (Figure 1) just distinguishes the influenced leaf to upgrade the current framework. the proposed framework plan CNN calculation for expectation of infections and prescribe the fertilizers for that disease to stay away from the diseases.

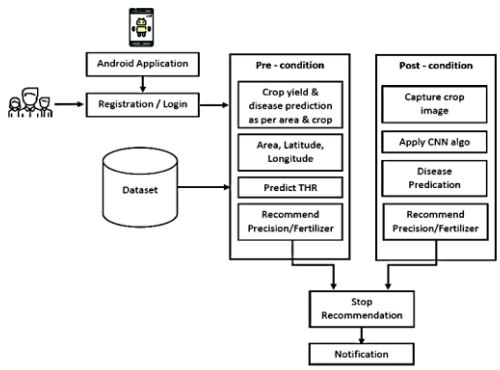


Figure 1. System architecture

The proposed system designed Convolution Neural Network (CNN) which comprises of different layers (Convolution Layer, Stride, Padding, Pooling) which are used for prediction for various plant disease detection. At that point utilizing preparing information it will prepare classifier and afterward yield will be anticipated with ideal precision. Precise conjectures of these climatic boundaries would bring about exact creation figures later on. Henceforth this model will be solid steady apparatus for the ranchers in settling on best choices for development well ahead of time to accomplish greatest harvest.

Following are the used algorithm in the proposed work. The Gray wolf enhancements are utilized to enhance the highlights which are given by CNN.

CNN Algorithm

The convolutional neural networks (CNNs) have achieved a forceful outcome in the locale of picture conveyance. CNN calculation utilized in the advancement of plant defect (disease) ID model. It comprises distinctive plant leaves from their environmental factors. For CNN, different structures are incorporated as follows:

1. Convolution Layer: Convolution is the principal layer where highlights get from an info picture of plant leave. Convolution keeps up the connection between pixels by utilizing little squares of information to learn picture highlights from the plant leaves.
2. Strides: Stride is the quantity of pixels moved over the vector of the information. At the point when the stage is 1, we moved the channels all at once to 1 pixel. In the event that the progression is 2 we moved the channels simultaneously to 2 pixels, etc.
3. Padding: Sometimes channel doesn't fit the information picture consummately. It has two alternatives: Patch the image of the plant leaves with zeros (zero-cushioning) to mix in and fall the picture area of the plant leaves where the channel neglected to coordinate.
4. Pooling: Layer Part of pooling layers will bring down the quantity of boundaries when the pictures of leaves are excessively huge.

Following are the steps involves in image processing:

1. Image Acquisition*:* It shows actual view or the inside structure of an item. In this picture obtaining measure it stores picture from picture. In proposed framework it catches picture by equipment device. It is a first stage to take input picture, without a picture, no preparing is conceivable. Utilizing picture procurement measure it produce normal picture and is the result of any equipment which was taken care of to deliver it.
2. Image Segmentation: After picture procurement, picture division assumes significant job, where it centers on most required piece of picture. The objective of division is to change the portrayal of leaf picture into something that is easier to investigate and important. Leaf picture division having foundation contains leaves, plants and some different components of yield. It finds items and limits (lines, bends and so on) in leaf pictures. The consequence of division shows the real deformities. It shows influenced parts into no. of portions which are removed from the picture.
3. Feature Extraction: In this component extraction it gets feature values from a picture. It takes a shot at an alternate section, for example, shading, surface, morphological and shading intelligibility vector. Highlight extraction dismisses unaffected parts or fragments and concentrate highlights of just influenced section parts. So, it diminishes time need for extraction of picture.
    a. Color features: The adjustment in shade of plants is seen as shading highlight. Picture have diverse tone and items. Utilizing this shading highlight human can perceive most pictures and items in rearranged structure. Shading highlight is utilized for grouping of plant illnesses. There are numerous strategies for shading highlight extraction, for example, shading histogram, histogram crossing point, shading co- event grid, shading rationality vector and so on.
    b. Texture features: Surface is assortment of spatial neighbor components. It orders diverse part picture district and again group those locales to get to surface component. Since each plant infection have one-of-a-kind structures, so those illnesses are ordered by surface component.
    c. Morphological features: The interesting structure followed by the surface component is sent to morphological element. It utilizes shape or a specific type of an article. Morphological component is utilized for plant illness location. As plants and plant infections accompany different shapes. It is anything but difficult to separate between them. It is utilized for removing the limit which isolates various locales in a picture. Henceforth plant infection easily identified.

The objectives of framework are:

- Simplified and diminished the manual work.
- Big volumes of information can be put away.
- It gives smooth work process.

Advantages:

- It will catch the picture and distinguish the illness.
- Recommend the pesticide for the illness.
- Real time working model.

4. RESULTS AND DISCUSSION

Exact estimates of these climatic boundaries would bring precise creation conjectures later. Consequently, this model will be strong instrument for the farmers to select best crop for development ahead of time, so as to accomplish greatest harvest. Crop details database is followed as per given Table 1.

Database Information is stored in cloud. In proposed framework a few types of harvest incorporated and related sickness with their exact manure is recommended. So, it is useful for rancher to take crop regarding atmosphere just as there is appropriate arrangement of manure proposed. Dataset

shows three yield set (wheat, potato, tomato) with their illness and arrangement of manure. Like this way other harvest dataset (corn, potato, tomato, wheat, grapes) is additionally put away on cloud. This dataset is utilized at the hour of preparation. It shows suitable disease control with fertilizer as an outcome.

The model is prepared using CNN, KNN, and SVM. From calculated yield it is noticed that the preparation time required for SVM and KNN is less compared to CNN (Table 2). Exactness and accuracy of CNN calculation is high contrast as compared to SVM and KNN as shown in Figure 2.

Table 1. Some selected crops and their possible fertilizer with disease based Smart Farm agriculture

S. No.	Crop	Disease	Fertilizer
1	Corn	Cercospora_leaf_spot Gray_leaf_spot rust	Cercospora Zeina
2	Corn	Common_rust	Proclaim Insecticide Syngenta
3	Potato	Late_blight	Chlorpropham
4	Potato	Healthy	Flutolanil
5	Tomato	Bacterial_spot	Fluazinam
6	Tomato	Early_blight	Bonide Liquid Copper Fungicide
7	Wheat	Leaf rust	Strobilurin
8	Wheat	Soilborne mosaic	Convax, Promactin
9	Grapes	Healthy	Fenpropathrin
10	Grapes	Leaf_blight	Aliette

Table 2. Comparison of algorithms

S. No.	Algorithm	Accuracy (%)	Time (sec)	Precision (%)
1	**CNN**	**92**	**60**	**90**
2	KNN	89	15	87
3	SVM	90	30	88

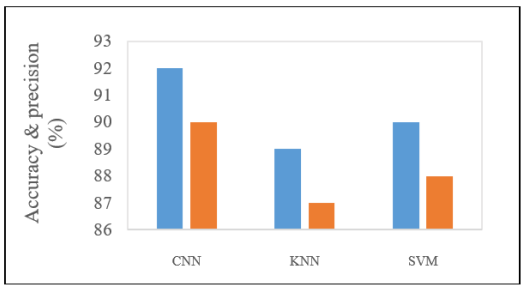
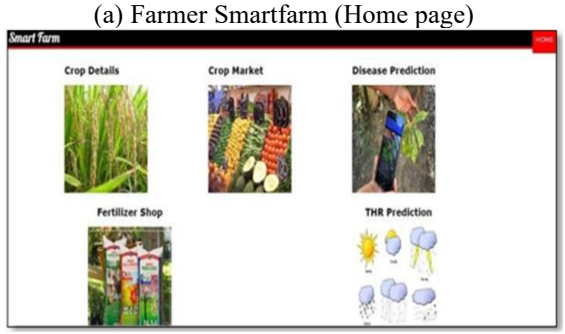


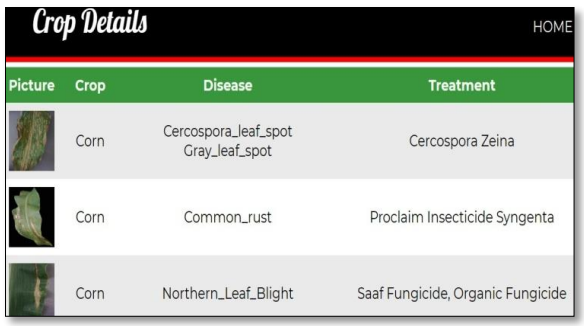
Figure 2. Variation of accuracy and precision for datasets

The screenshots of the proposed Smart Farm agriculture system at farmer side are shown in Figure 3 respectively. The description of farmer side view where all related information is in Figure 3(a). All tabs related to crop details, crop market, disease prediction, fertilizer shop, THR prediction are displayed in Figure 3(b) for farmer to access it easily. Selected crop details dataset is used to store all crop related data using cloud represented in Figure 3(c). A crop market tab linked to government agriculture website is given in Figure 3(d). It is for farmers to search data related all crops, market, fertilizer etc. easily In Figure 3(e) disease prediction is done. Farmer captures image of leaf affected using mobile application and is uploaded at server side. Then the proposed system recommends precise/fertilizer with respect to the disease. As per the recommendation of the disease nearby fertilizer shops suggested which is shown in Figure 3(f). Farmer searches nearby fertilizer shops according to area or location. THR prediction is displayed in Figure 3(g) which is done with the help of location or area of farmer. Farmer gets more precise information about current temperature, humidity, rain fall value. Thus, it is very useful for crop to get information about climate in advance. As per the proposed system it is easy to predict which crop cultivation will be done in the future.

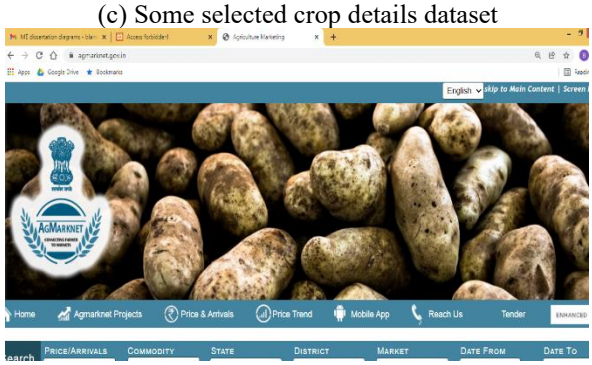
(a) Farmer Smartfarm (Home page)



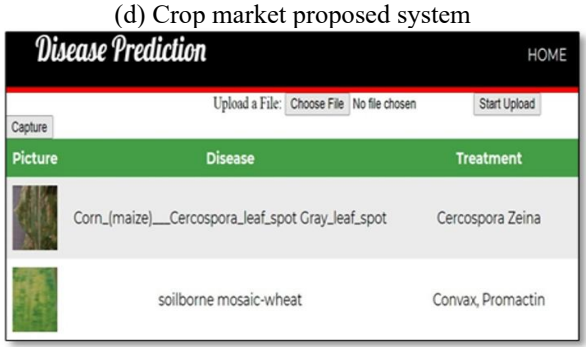
(b) i) Crop Details; ii) Crop Market; iii) Disease Predication; iv) Fertilizer Shop; v) THR Prediction



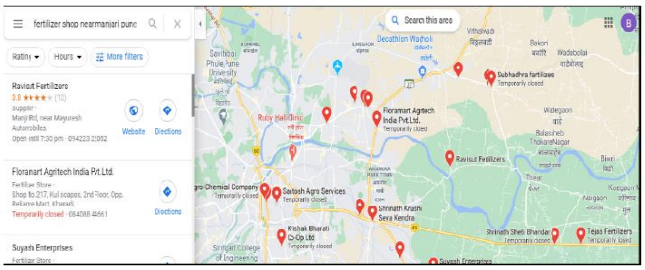
(c) Some selected crop details dataset



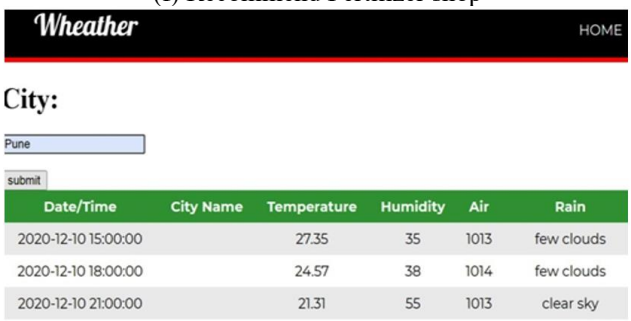
(d) Crop market proposed system



(e) Recommend precision/fertilizer (Disease prediction)



(f) Recommend Fertilizer shop



(g) Weather (THR Prediction)

Figure 3. Screenshots of proposed system at farmer side

5. CONCLUSION

In IoT based smart farming, the proposed system is built to monitor the crop yield with the help of climatic conditions. The proposed system is designed taking into consideration the benefits of the farmers and agricultural sectors. The proposed system helps farmers from beginning to end i.e., from sowing up to harvesting. It recommends a crop from the past data, detect disease in plant using CNN algorithm and also suggests the suitable fertilizers that can be used against the diseases. The system provides accuracy of 92% while predicting the plant disease and also provides the details of nearby fertilizer shops availability.

REFERENCES

[1] Agrawal, N., Singhal, S. (2015). Smart drip irrigation system using raspberry pi and Arduino. In International Conference on Computing, Communication & Automation, Greater Noida, India, pp. 928-932. https://doi.org/10.1109/CCAA.2015.7148526

[2] Colezea, M., Musat, G., Pop, F., Negru, C., Dumitrascu, A., Mocanu, M. (2018). CLUeFARM: Integrated web-service platform for smart farms. Computers and Electronics in Agriculture, 154: 134-154. https://doi.org/10.1016/j.compag.2018.08.015

[3] Belanche A., Martín-García A. Ignacio, Fernández-Álvarez J., Pleguezuelos J., Mantecón, Á.R., Yáñez-Ruiz D.R. (2019). Optimizing management of dairy goat farms through individual animal data interpretation: A case study of smart farming in Spain. Agricultural Systems, Elsevier, 173(C): 27-38. https://doi.org/10.1016/j.agsy.2019.02.002

[4] Kaushal, G., Bala, R. (2017). GLCM and KNN based algorithm for plant disease detection. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 6(7): 5845-5852. https://doi.org/10.15662/IJAREEIE.2017.0607003

[5] Terliksiz, A.S., Altýlar, D.T. (2019). Use of deep neural networks for crop yield prediction: A case study of soybean yield in Lauderdale County, Alabama, USA. In 2019 8th International Conference on Agro-Geoinformatics (Agro-Geoinformatics) Istanbul, Turkey, pp. 1-4. https//https://doi.org/10.1109/Agro-geoinformatics.2019.8820257

[6] Raza U., Kulkarni P., Sooriyabandara M. (2017). Low power wide area networks: An overview. IEEE Communications Surveys & Tutorials, 19(2): 855-873. https://doi.org/10.1109/COMST.2017.2652320

[7] Mat I., Mohd Kassim M.R., Harun A.N., Yusoff I.M. (2018). Smart agriculture using internet of things. IEEE Conference on Open Systems (ICOS), Langkawi, Malaysia, pp. 54-59. https://doi.org/10.1109/ICOS.2018.8632817

[8] Elijah O., Rahman T.A., Orikumhi, I., Leow C.Y., Hindia, M.N. (2018). An overview of Internet of Things (IoT) and data analytics in agriculture: Benefits. IEEE Internet of Things Journal. 5(5): 3758-3773. https://doi.org/ 10.1109/JIOT.2018.2844296

[9] Jeong, Y.J., An, K E., Lee, S.W., Seo, D. (2018). Improved durability of soil humidity sensor for agricultural IoT environments. In 2018 IEEE International Conference on Consumer Electronics (ICCE) Las Vegas, NV, USA, pp. 1-2. https://doi.org/10.1109/ICCE.2018.8326223

[10] Liu S., Guo L., Webb H., Ya X., Chang X. (2019). Internet of Things monitoring system of modern eco-agriculture based on cloud computing. IEEE Access, 7: 37050-37058. https://doi.org/10.1109/ACCESS.2019.2903720

[11] Karol A.M., Gulhae D., Chadiwade T., (2019). Plant disease detectio usig CNN and remedy. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 8(3): 622-626. https://doi.org/10.15662/IJAREEIE.2019.0803014

[12] Prakash K., Saravanamoorth P., Sathishkumar R., Parimala M. (2017). A study of image processing in agriculture. International Journal Advanced Networking and Applications. 9(1): 3311-3315.

[13] Channe, H., Kothari, S., Kadam, D. (2015). Multidisciplinary model for smart agriculture using Internet-of-Things (IoT), sensors, cloud-computing, mobile-computing & big-data analysis. International Journal Computer Technology & Applications, 6(3): 374-382.

[14] Gill, S.S., Tuli, S., Xu, M., et al. (2019). Transformative effects of IoT, blockchain and artificial intelligence on cloud computing: Evolution, vision, trends and open challenges. Internet of Things, 8: 100118. https://doi.org/https://doi.org/10.1016/j.iot.2019.100118

[15] Gutiérrez, J., Villa-Medina, J.F., Nieto-Garibay, A., Porta-Gándara, M.Á. (2014). Automated irrigation system using a wireless sensor network and GPRS module. IEEE Transactiotablens on Instrumentation and Measurement. 63(1): 166-176. https://doi.org/10.1109/TIM.2013.2276487

[16] Wolfert, S., Ge, L., Verdouw, C., Bogaardt, M.J. (2017). Big data in smart farming-a review. Agricultural Systems, 153: 69-80. https://doi.org/10.1016/j.agsy.2017.01.023

[17] Sastra N.P., Wiharta D.M. (2016). Environmental monitoring as an IoT application in building smart campus of Universities Udayana. International

Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS), Denpasar, Indonesia, 85-88. https://doi.org/10.1109/ICSGTEIS.2016.7885771

[18] IERC, I. (2015). European Research Cluster on the Internet of Things. Internet of Things. Position Paper on Standardization for IoT Technologies, 1645-1660.

[19] Brewster, C., Roussaki, I., Kalatzis, N., Doolin, K., Ellis, K. (2017). IoT in agriculture: Designing a Europe-wide large-scale pilot. IEEE Communications Magazine. 55(9): 26-33. https://doi.org/10.1109/MCOM.2017.1600528

[20] Manrique, J.A., Rueda-Rueda, J.S., Portocarrero, J.M.T. (2016). Contrasting internet of things and wireless sensor network from a conceptual overview. In IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Chengdu, China, pp. 252-257. https://doi.org/10.1109/iThings-GreenCom-CPSCom-SmartData.2016.66

[21] Liu, S., Guo, L., Webb, H., Ya, X., Chang, X. (2019). Internet of things monitoring system of modern eco-agriculture based on cloud computing. IEEE Access, 7: 37050-37058. https://doi.org/10.1109/ACCESS.2019.2903720.

[22] Sakthipriya, N. (2018). An Effective method for crop monitoring using wireless sensor network. Middle East Journal of Scientific Research, 20(9): 1127-1132. https://doi.org/10.5829/idosi.mejsr.2014.20.09.114152

[23] Wang, Z., Walsh, K.B., Verma, B. (2017). On-tree mango fruit size estimation using RGB-D images. Sensors, 17(12): 2738. https://doi.org/10.3390/s17122738

[24] Das, P., Yadav, J.K.P.S., Yadav, A.K. (2021). An automated tomato maturity grading system using transfer learning based AlexNet. Ingénierie des Systèmes d'Information, 26(2): 191-200. https://doi.org/10.18280/isi.260206

[25] Gherbi, C. (2021). Internet of things and heterogeneous networks technologies: Concepts, challenges and perspectives. Ingénierie des Systèmes d'Information, 26(4): 403-408. https://doi.org/10.18280/isi.260408

[26] Danladi, M.S., Baykara, M. (2022). Design and implementation of temperature and humidity monitoring system using LPWAN technology. Ingénierie des Systèmes d'Information, 27(4): 521-529. https://doi.org/10.18280/isi.270401