AGRIBOT: Energetic Agricultural Field Monitoring Robot Based on IoT Enabled Artificial Intelligence Logic

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Abstract. In these modern days agriculture is one of the major concern to take out from the loss and need to be improvised in next level of production ratio. The latest technologies such as Internet of Things and Artificial Intelligence are associated with many applications to improve the standards as well as provide a drastic support to customers to achieve their communication needs. In this paper, a new agricultural robot is designed called as agriBOT, in which it is used to monitor the entire agricultural field and the associated crops in an intelligent manner by using Artificial Intelligence logic. The agriBOT has a provision to act like a drone to survey all fields in an intelligent manner. This provision allows the robot to move in all fields even the crops are in so dense, in which the agriBOT is integrated with many smart sensors to monitor the crop details well such as Soil Moisture Level Identifier, Crop Leaf Image Accumulator, Rain Identification Sensor and Surrounding Temperature level Identification Sensor. These sensors are associated with the proposed agriBOT to make the robot as powerful and robust in association with Artificial Intelligence and Internet of Things (IoT) strategies. The Internet of Things is used to carry the local sensor data from the agriBOT to the remote server for processing as well as the data available into the remote server can easily be monitored by the respective farmer from anywhere in the world at any time. The alert is utilized over the proposed agriBOT to pass the emergency condition alerts to the respective farmers instantly as well as the Global Positioning System (GPS) is utilized to retrieve the location details of the crop and report that to the server immediately by using IoT. This paper introduced a new machine learning strategy to analyze the server data, in which it is called as Modified Convolutional Neural Scheme (MCNS). This approach of MCNS provides the facility to predict the climate conditions and the associated crop details instantly based on the data which is collected already and stored into the server. With the association of these two strategies made the proposed approach of agricultural field monitoring system too robust and efficient to analyze the crop related details as well as the plant lea disease is also identified by using this approach based on the images captured by

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the agriBOT in an intellectual manner. All these details are experimentally tested and the resulting section provides the proper proof for the mentioned things.

Keywords: Smart sensors · agriBOT · Modified convolutional neural scheme · MCNS · IoT

1 Introduction

In this modern era, each and every individual has an attention to do agriculture oriented business, but the major complexity is the locality of the people. Because the person need to do agriculture needs to stay near to the Agri-Land and monitor the field every day. This creates a complexity to every individual because of the civilization problems as well as the other major complexity is the crop diseases affect the agricultural business in drastic manner, so that it needs to be identified and resolve it in a proper way [3, 4]. These constraints are the major case of the agricultural field down and reduce the interest level of the person to do such business and many youngsters are not yet interested to do this agriculture. This paper is intended to develop a new agricultural architecture to support farmers and improve their life and lifestyle in next level as well as through this many youngsters gets attracted in this field and do the agricultural job as their profession. In many countries agriculture is the major financial source to improve the nation's economy level. In India 80% of the economy growth fully belongs to the agricultural fields as well as the associated things. Now-a-days, agricultural field is also gets lots of change with the adaption of new technologies such as Internet of Things and Artificial Intelligence. This tends to move the field of agriculture from loss to attain some profitability [1, 2].

Agriculture Field Monitoring is the most important and complex task to deal with some intelligent techniques, in which the ideologies such as AI, IoT and the machine learning features helps the farmers to improve their position in society as well as attaining the production ratio much better. The technologies such as Solar PV based power associations and the smart motor pump handling logics reduces the electricity consumption charges well with less power usages [5, 6]. These kinds of innovative solar technologies eliminate the struggle of the farmers by reducing the electricity charges in great manner. With the help of such smart devices and the associated things the manpower is highly reduced to do such agri based business as well as this logic provides a high level yield in outcome [7]. This paper is intended to design a new agricultural field monitoring system with powerful AI logics as well as the association of Internet of Things with proposed robotic design helps to monitor the crops and the field in clear manner. In this paper a novel machine learning strategy called Modified Convolutional Neural Scheme (MCNS) is implemented to provide clear classification logics of two strategic things such as plant leaf disease predictions as well as the environmental details prediction. These all are possible only with the help of integrating new robust machinery called agriBOT, in which it associates several sensor units and the digital camera to monitor the crop details and forward that to the remote server by using Internet of Things web services.

1.1 agriBOT: A Summary

This paper utilizes several latest technologies to propose a new algorithm to monitor the agricultural field in several constraints. A new robust machinery tool called agriBOT is designed with different sensors to acquire the details from the agricultural field and provide that details to the server with the help of Internet of Things associations. The smart sensors connected with the agriBOT are as follows: Soil.

Moisture Level Identifier, Crop Leaf Image Accumulator, Rain Identification Sensor and Surrounding Temperature level Identification Sensor. Along with this the agriBOT contains the Global System for Mobile Communications (GSM) and Global Positioning System (GPS) unit to identify the location details of the respective crop with exact latitude and longitude as well as the alert mechanisms are handled with the help of GSM. A small digital camera with high intensity coverage is placed into the agriBOT for capturing the crop images and pass it to the server unit for identifying the plant leaf diseases in an intelligent manner by using the proposed machine learning based classification logic called MCNS. The agriBOT design is fixed as like the flying drone, in which it can fly around the agricultural field for 30 to 45 min continuously with the power ratios handled by means of solar assisted battery units. The 12v DC power enabled Nano Solar PV Panels are placed into the agriBOT to capture the power source from the sunlight and stores that energy to the battery to provide the continuous flying ability to the agriBOT. The estimated flying distance of the proposed robot called agriBOT is around 2 to 5 feets above from the crop level, in which the level of flying is automatically controlled by the controller as well as the captured image analysis is also handled in a proper way [8]. The working of all sensors are illustrated one by one as follows.

Soil Moisture Level Identifier: The soil moisture sensor associated with the agriBOT is used to monitor the soil wet level and the crop growth belongs to that. The soil wet level is low means the water pump handling system immediately switch-on the pump and provides the sufficient level of water to the crops and switch it off when the soil wet level reaches the threshold ratio. This sensor is placed into the agri-land and the associated transmission unit passes the soil moisture level values to the agriBOT once it is nearer to the sensor, so that the agriBOT collects those values and pass it to the server for processing. The following figure, Fig. 1 shows the soil moisture sensor with the connectivity unit associated to the sensor for converting the digital values to analog.

Fig. 1. Soil moisture sensor

Crop Leaf Image Accumulator: The digital camera associated with the agriBOT is helpful to capture the plant leaf images from the agricultural land and pass that to the remote server unit for further processing. In which the crop leaf image accumulator acquires the plant leaf image from the agricultural field and identify the leaf diseases to prevent to surf further for other crops into the field. The classification process associated with the plant leaf disease model is used to identify the diseases affected in the respective plant as well as the alert will be passed to the farmers with respect to the location and the disease name as well. The following figure, Fig. 2 illustrates the perception of digital camera associated with the agriBOT.

Fig. 2. Digital agriBOT camera

Rain Identification Sensor: The rain detection sensor is used to identify the status of rainfall, in which the sensor produces the digital values such as either true or false. This sensor is associated with the agriBOT to detect the rainfall condition and provide the respective triggers to the controller to manage the status into the server unit for further training as well as the level indicates the rainfall means, the motor pump need to be cross-checked for off state. The soil moisture level indicates the level is low means the water pump position will be turned ON by the controller automatically. At the same time the rainfall is coming the pump will immediately be switched OFF by the trigger generated by using this rain identification sensor. The following figure, Fig. 3, illustrates the perception of rainfall identification sensor associated with the agriBOT.

Fig. 3. Rain identification sensor

Surrounding Temperature Level Identification Sensor: The climate conditions are the major concern of the agriculture field, in which the climate condition monitoring is the most essential task in such field. So, that a temperature identification sensor is associated with the agriBOT to identify the temperature level of the circumstance and report that properly to the server unit by means of Internet of Things enabling. These sensor readings are analog, in which these values are stored into the server for dual purpose such as training the data for future climate predictions as well as monitoring the details from the remote end. The following figure, Fig. 4, illustrates the perception of temperature level identification sensor associated with the agriBOT.

Fig. 4. Temperature sensor

1.2 Internet of Things with Machine Learning Process

The purpose of enabling the internet services to smart devices are to transfer the local device data to the remote server as well as the acquisition of triggers from the remote server end to the local devices. The recent technology called Internet of Things (IoT) provides such ability to the agriBOT to carry the sensor data from the agricultural field and pass that vales to the server end without any delay. Once the agricultural data reached into the server end the machine learning process begins and analyze the incoming data with proper thershold levels and produce the alert oriented tasks accordingly as well as the periodical data will be uploaded into the server without any interference. The machine learning process associated with the proposed approach called Modified Convolutional Neural Scheme provides a clear predictive analysis of the agricultural data and report it to the respective farmers accordingly. So, that the farmers can take an appropriate precautions to handle the affections in good way. The general process of training the agriBOT values and created the model based on that as well as the testing live input with that trained model will provide high end efficiency in outcome as well as the processing time complexity is highly redced with the help of this proposed metrics. The following figure, Fig. 5 illustrates the data with respect to the modern as well as latest technology assisted agricultral field management and monitoring lifecycle.

The rest of this paper describe regarding Related Study over Sect. 2, further section of Sect. 3 illustrates the proposed system methodologies in detail with proper algorithm flow and the Sect. 4 illustrates the Result and Discussion portion of the paper and the final section, Sect. 5 illustrates the concept of Conclusion and Future Scope of the proposed paper. These all will be explained in detail over the further section summaries.

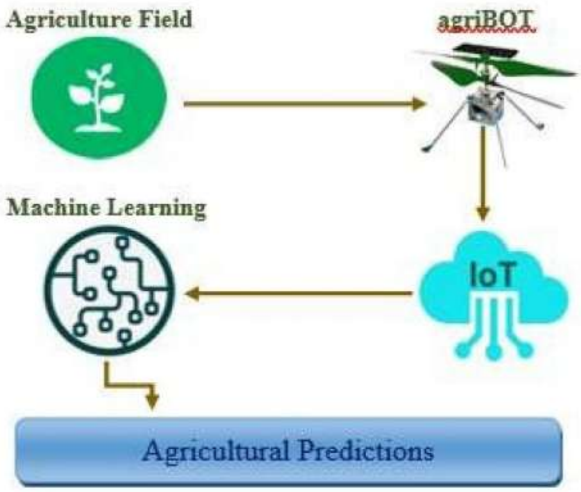


Fig. 5. Agri-field management and monitoring lifecycle

2 Related Study

In the year of 2020, the authors "Wei Zhao' et al. [10]" proposed a paper related to agricultural field development and the adaption of latest technologies such as Internet of Things with agricultural field. In this paper [10], the authors described such as: independent agriculture schemes are a potential option for bridging the gap between the labor shortage of agricultural tasks and the ongoing need to increase agricultural productivity. Automated mapping and navigation will be a cornerstone of the most independent farming system. Therefore, in this paper [10] authors introduce a ground-level mapping and navigation system based on machine viewing technology to produce a 3D farm map at the border as well as the cloud (Mesh SLAM) or Internet of Things. The technology in this framework includes three layers as sub-systems, i.e. (a) the ground level robot vehicle layer for frame selection with a single camera only, (b) the edge node layer for the data and communication edge image and (c) the general management and deep computation cloud layer. By enabling the robot vehicles to directly stream continuous frames into their respective edge node, they allow high efficiency and speed mapping level. Each edge node, which organizes a certain range of robots, introduces a new frame-by-frame Mesh-SLAM whose core constructs the map with a mesh based system with scalable units in order to reduce the data size of the function through a filtering algorithm. In addition, cloud computing enables vast arrangement and extremely deep computing. The system can be scaled to larger fields and complex environments by distributing the calculation power dynamically to the borders. The evaluation shows that: (a) the Mesh-SLAM algorithm exceeds the mapping and localization accuracy and yield prediction error (in cm resolution) and (b) the IoT architecture's scalability and versatility allow new consists of several modules or IoT sensors to be modularized and easily removed. We conclude that the tradeoff among price and efficiency greatly increases the feasibility and practicability of this system in real farms.

In the year of 2020, the authors "Qiang Dai' et al. [11]" proposed a paper related to plant leaf disease estimations with respect to dual attention laws based on fusion logics.

In this paper [11] the authors described such as plant disease classification of images obtained are usually vague, leading to bad clearly demonstrates in real critical applications. The image quality has an important effect on the accuracy of the recognition of pre-trained feature classification models. To tackle this issue, we are proposing a generational confrontational service called DATFGAN, which has dual attention and computational complexity fusion mechanisms. This network will turn ambiguous objects into elevated objects. In addition, our cross-layer weights suggested technique will substantially lower the quantity of variables. Respectively, it is observed that the results of DATFGAN are visually more appealing than province approaches. In addition, processed images are analyzed on the basis of action recognition. The results reveal that the improved method succeeds other methods dramatically and is stable enough realistic usage [11].

In the year of 2020, the authors "Ferhat Gölbol et al. [12]" proposed a paper related to systematic motion-controlled robot design for agriculture management system. In this paper [12] the authors described such as both domestic and international research, the benefits of autonomous farming over conventional agriculture have been stated. Motioning and trajectory preparation are one of the main problems to be overcome by an agricultural robot. In the literature, numerous configuration warning trends were created. A graphical motion planning framework available on Google maps is built in this work and A+ model is introduced. The vehicle location obtained via GPS is displayed in real time on the interface.

In the year of 2020, the authors "Omer Gulec' et al. [13]" proposed a paper related to design a new smart agricultural framework with Solar PV panel implementations for energy efficiency improvements with respect to wireless sensor network associations. In this paper [13] the authors described such as Current computer software technical advances impact various areas of production processes. One of the many areas influenced by these changes is the efficiency of an agricultural operation. The amount of production is increased with not only new models of farm production, but also with the use of technological developments in the manufacturing process. Also wireless sensor innovations are often used to capture distinctive effects to optimize output parameters and maintain the product at certain levels of quality. However, nodes that play an important role in such systems are susceptible to battery failure. Recently, the integration of foundry modules into the process is considered to ease this power issue. However, it is not enough to have certain nodes to boost the existence of the system. The paper proposes a new distributed linked dominant set method on wireless sensor network applications for precision farming with solar tracking nodes. In smart agricultural applications, the latest distributed dominant solar energy construction application, called CDSSEHA, is contrasted with the conventional flood methods and an efficient energy CDS method. According to the findings, in comparison with conventional flood approaches and the CDS based approach; the suggested methodology improved the resilience of the WSNs up to about six times and 1.4 times. In addition, the CDS building process represents just roughly 15% of the lifespan.

In the year of 2020, the authors "Lukáš Vacho et al. [14]" proposed a paper related to agricultural plant monitoring robot design with proper navigation features. In this paper [14] the authors described such as the method of navigation for mobile robot is applicable in the agriculture plant lines. The proposed clustering algorithm method uses data from the laser sensor Hokuyo. The created solution helps the plant to be identified in a row if the local navigation concept is used by a mobile robot. Crops in a row are common ways to build the polygon vertices. The moment of inertia is determined from this polygon, which defines the starting lineup including its plant lines. The moment of inertia is determined from this polygon, which defines the center line of the plant lines. This location is used for the algorithm of mobile robot control. The processed data by sensors do provide details on paths but also on barriers in the crop lines.

3 Proposed System Methodologies

This paper introduced a new novel methodology called Modified Convolutional Neural Scheme (MCNS), in which it provides a proper machine learning abilities to the agricultural field maintenance scheme as well as the agriBOT is initiated over this system

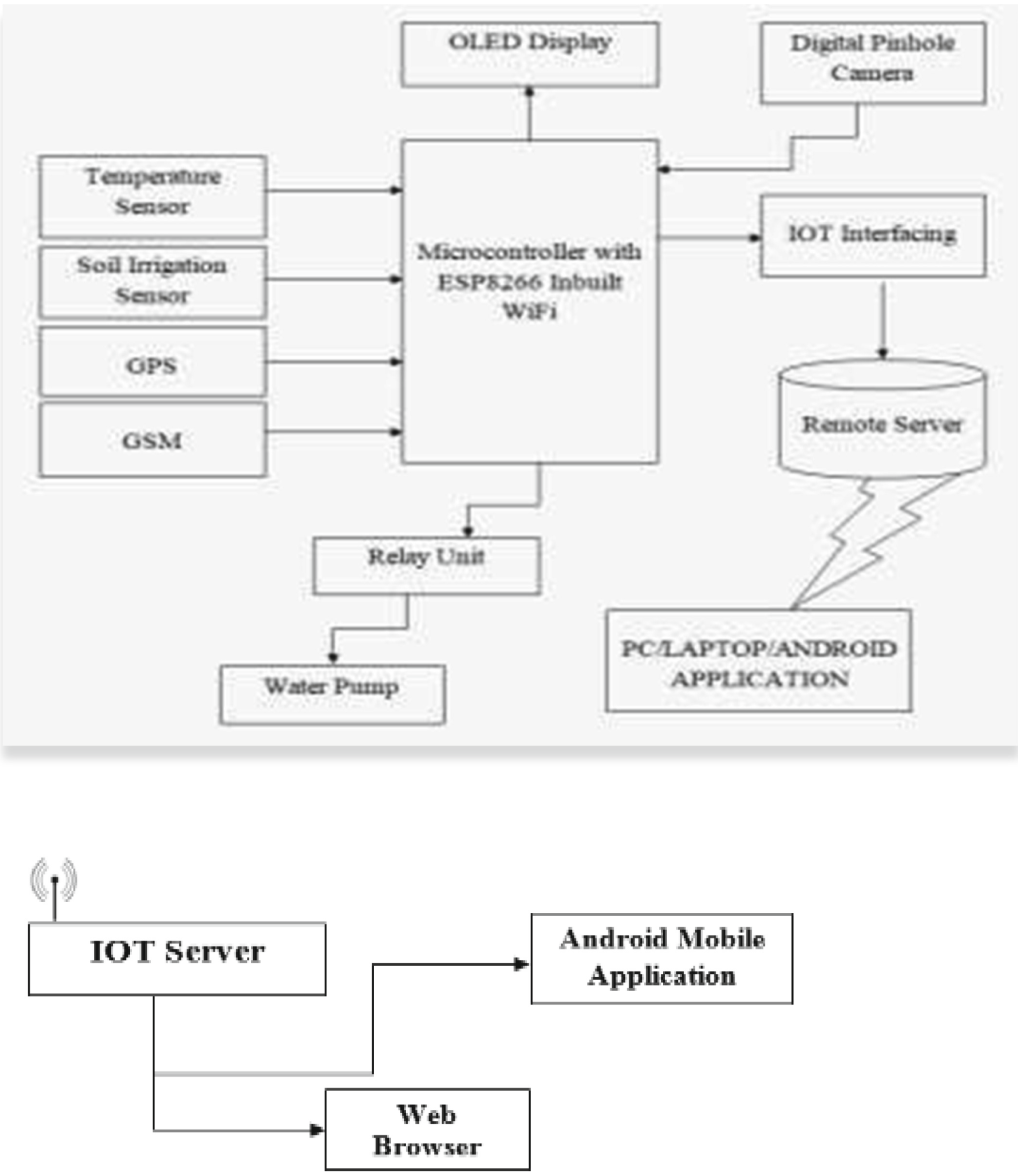


Fig. 6. Transmitter block of agriBOT and receiver block of agriBOT

to acquire the agri field data and pass it to the remote server with the help of Internet of Things (IoT) features. The proposed approach highly belongs to two things such as agriBOT and the Artificial Intelligence logic. The agriBOT is a robot, in which it has an ability to fly around the agricultural field and capture the data from the fields and pass it to the remote server entity to maintenance as well as manipulations. The manipulated results will be in a boolean format such as either true or false, in which the returned value from the prediction is true, the data is considered to be the most significant data as well as the alert mechanism is triggered to raise an alert to the respective farmer. And the prediction result is returned as false, the data is considered to be the regular periodical data and it is going to be stored into the remote server for monitoring purposes. The Artificial Intelligence logic is applied to the proposed approach to identify the incoming data is normal or abnormal, such kind of classifications are done in the server end for manipulating the incoming data from the agricultural field as well as the leaf images are cross-validated with respect to the disease detection principles.

The leaf disease detection principles are handled with the help of digital image processing assisted machine learning strategy and the associated classification logic identifies the disease of the given leaf and report that to the farmers instantly without any delay. So, that the appliance of proposed logic with the agricultural field improves the production as well as increase the profit ratio to the farmers in good manner. The following figure, Fig. 6 illustrates the proposed agriBOT block diagram with transmitter and receiver entities in clear manner.

The internal process of machine learning and the leaf disease identification principles are taken care by the server end and the following equation provides the process for estimating the classification principles with respect to segmented image features as well as the following algorithm provides the clear view of digital image classification principles with proper Pseudocode definitions.

$$R_{ACC} \leftarrow C_O S\{I^m(c^{vt}\{L_G, U_G, L_B, U_B\} \cdot [RGB, BGR])\} \quad (1)$$

Where the RAcc indicates the final accuracy estimation, COS indicates the classification outcome with respect to segmentation principle of S, I^m indicates the image masking of c^{vt} with RGB and BGR color deviations in association with Lower and Upper green color variants (LG and UG), Lower and Upper brown color variants (LB and UB).

Algorithm: Plant Leaf Image Classification

Input: *Extract the image features from the agriBOT memory unit/server storage.*

Output: *Disease Classification Result with Prediction Accuracy ratio.*

Step-1: *Initialize the function for image segmentation called "img_segment" with the input parameters of RGB and Hue-Saturation Value color variants.*

Step-2: *Define the lower and upper green value combinations for the plant leaf image gathered from agriBOT, in which it is acquired for feature extraction process.*

Step-3: *Specify the role for a healthy masking range for HSV image parameters, lower and upper green color variations.*

Step-4: *Initiate the lower brown values from the array variable generated by the extraction process.*

Step-5: *Identify the safe masking range feature to follow the image HSV, the lower and the upper color differences in parameters.*

Step-6: *Define the disease masking range with regard to the color matching scheme, both for green and brown variations.*

Step-7: *Concatenate the final masking results and store them in the finale mask variable.*

Step-8: *Return to the classification principles the final masking result.*

Pseudocode:

```
define img_segment (rgb_img,hsv_img):
Lower_Green+ Lower_Brown←array([25,0,20]);
Upper_Green+ Upper_Brown← array([100,255,255]);
h_mask←cvt.Range(hsv_img, Lower_Green, Upper_Green, , Lower_
Brown, Upper_Brown);
r1←cvt.bitwise_and(rgb_img,mask ❼ h_mask);
result←cvt2.bitwise_and(r1, mask=final_mask);
return result;
```

Step-9: *Return the final results accuracy and subsequent prediction values.*

```
Acc(Result)←array{result};
return Acc(Result);
```

4 Result and Discussions

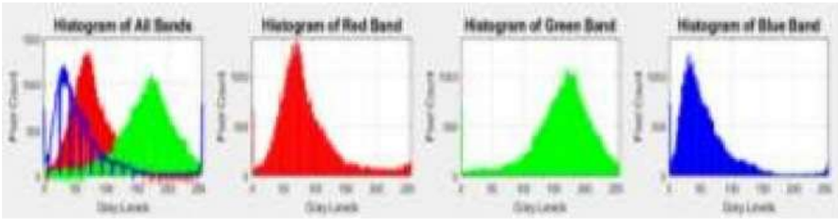
In this paper a novel Modified Convolutional Neural Scheme (MCNS) is introduced, in which it appends the machine learning strategies to provide the high accuracy result estimations in association with Internet of Things enabled agriBOT principles. The agriBOT design is completed based upon the structural view of block diagram in figure, Fig. 6. The resulting section process the inputs accumulated from the agricultural field based on the data as well as the plant leaf. The details such as soil irrigation level and temperature conditions are estimated with respect to the prediction logics and the leaf estimations are processed with respect to the digital image processing principles, in which the classification and segmentation schemes are applied to extract the affected content from the leaf area and identify the disease to do a proper protections against that. The following figure, Fig. 7 illustrates the sample leaf images acquired from the agriBOT in various dimensions. The figure portrays the leaf with disease as well as the leaf without disease specifications. These leaves are not only belonging to the unique plants, instead these leaves are accumulated from different farm lands and agricultural fields for processing.

Fig. 7. Plant leaf images gathered from agriBOT

The following figure, Fig. 8 illustrates the plant leaf image RGB feature details extraction process resulting perception of the proposed approach MCNS, in which it shows the masking portion of green color ratio segmentation and masking portion of brown color ratio segmentation from input images and the outcome proof, is displayed further. The general segmentation process splits the affected portion alone from the leaf image, but in this proposed MCNS process based image segmentation scheme split out the green masking portion and the brown masking portions separately and concatenate the final resulting masked images for classification procedures, in which it also leads a way to attain high accuracy results in outcome.

Fig. 8. Features extraction based on RGB color bands

The following figure, Fig. 9 (a) illustrates the histogram view of extracted features based on the plant leaf image RGB color variations as well as the basic image color perceptions acquired from the agriBOT. These histogram values are used to estimate the color variation ranges in pixel values as well as this is useful for easy understanding of the color ratios of the plant leaf image. Similarly the figure, Fig. 9 (b) illustrates the mask viws of the color bands in grayscale format.



(a)

(b)

Fig. 9. (a) Histogram view of RGB color bands and (b) color masking view of the plant leaf images

The following figure, Fig. 10 shows the image classification portion of the input image, in which the plant leaf image acquired from agriBOT is analyzed with the help of proposed MCNS classification logic to attain the following outcome with better value predictions. The diseased portion boundaries are identified and marked clearly with red line specifications.

The following figure, Fig. 11 illustrates the agricultural data collection accuracy levels of the proposed approach of MCNS. The agriBOT collects the field data with the help of associated sensor units presented into the device. Those data will be passed to the server unit for manipulations with respect to the Internet of Things strategies. The

Fig. 10. Disease portion extraction from the leaf image

following figure, Fig. 11 portrays the view of data collection levels with respect to the data sent from agriBOT for a particular time period intervals.

The following figure, Fig. 12 illustrates the error ratio analysis of the proposed approach, in which the data collected from the agricultural field is processed with respect to the principles of Modified Convolutional Neural Scheme (MCNS). This figure portrays the processing time accuracy estimation range in association with the respective bit error ratio occurred while processing the agricultural data. In which the x-axis indicates the time in milliseconds and the y-axis indicates the error ratio with accuracy levels. For better understanding the resulting accuracy ratio is divided by 100 to show the error ratio in clear manner over the following graphical view.

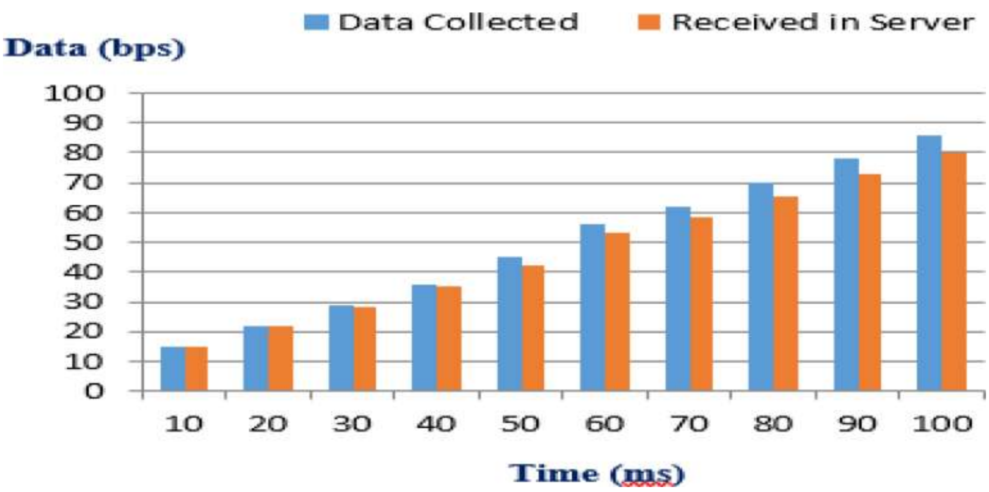


Fig. 11. Data collection vs. data received accuracy ratio

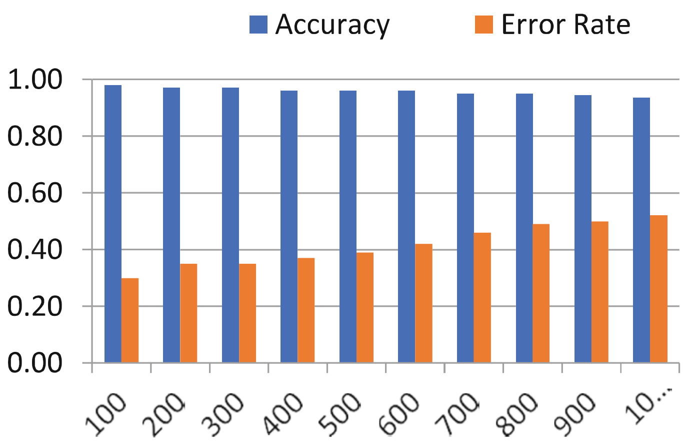


Fig. 12. Accuracy ratio vs. error rate estimation

The following figure, Fig. 13 (a) and (b) illustrates the temperature level and the rainfall ratio of the agriculture field with respect to the surveillance of 30 days continuously by using the designed agriBOT as well as the resulting efficiency are proved with the help of the following graphical results.

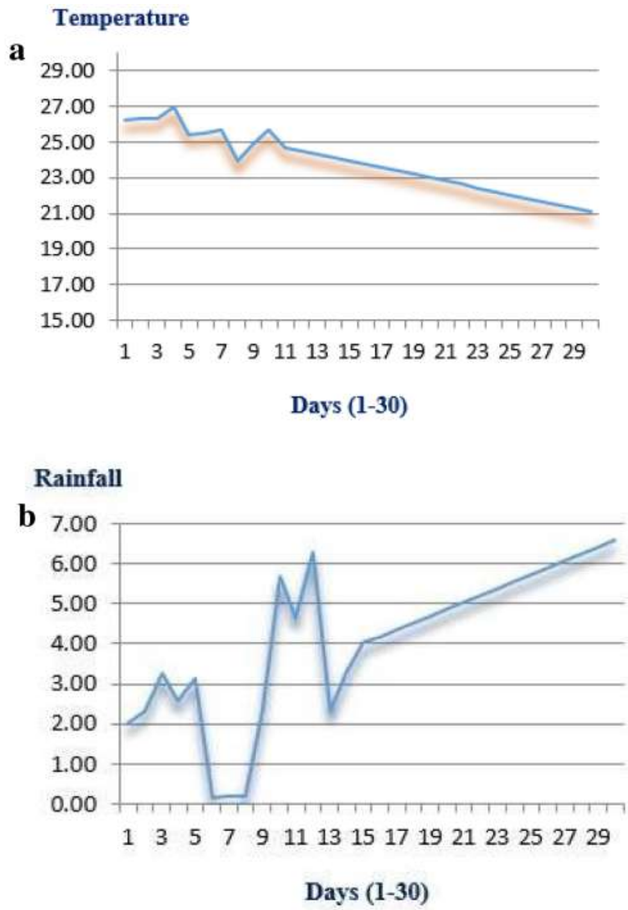


Fig. 13. (a) Temperature level estimation (b) rainfall level estimation

5 Conclusion and Future Scope

In this paper a new robotic structure is designed to provide support to the agricultural field and the farmers, in which it is designed with the association of smart sensors and the associated gadgets. The robot called agriBOT is operated with the nature of Artificial Intelligence and accumulates the temperature ranges and soil moisture levels in correct proposition as well as the resulting details are transferred to the remote server with the help of Internet of Things provisions. The outcome accuracy of the mentioned things are presented on the resulting section figures, Fig. 11 and Fig. 12. The proposed agriBOT acquire the agricultural information and pass it to the server end to manipulation, in which the server end receives the data and process it based on a novel machine learning procedure called Modified Convolutional Neural Scheme. This scheme identifies the climate changes and the associated water supplies to the crops are managed properly with the help of such approach in clear manner. The resulting section figure, Fig. 13 (a) and (b) illustrates the agricultural field temperature level and rainfall level indications in clear manner for the data of 30 days surveillance. The resulting section proves the proposed approach efficiency in terms of both image processing outcome wise as well as the machine learning processed basis also, so that the proposed approach presented into the paper is well and good to proceed and it is really useful for agricultural field monitoring environments.

In future the work can further be extended by means of adding some deep learning procedures on the server side to improve the training model accuracy ratio from 96% to 98%, so that the prediction accuracy will improve automatically. The agriBOT can be improvised by means of adding some lithium battery units instead of using the other expensive battery backups. These features will provide the best accuracy pattern with cost efficiency on the proposed approach.

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