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Internet of Things Based Intelligent System for Monitoring and Improving the Crop Growth Rate Using Deep Learning Technique

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ABSTRACT

As we all know, agriculture is an essential commodity in India. A lot of India's economy comes from the agriculture sector therefore the growth of agriculture field based on technology is necessary in all the agricultural fields. In the current situation, the agriculture sector has been going through a very distressful phase. During the last three decades, India saw a whole lot of natural calamities that affected the overall crop production. The major one being the draught of 1986-1987 and 1987-1988. Due to the deficit rains, the farmers saw a reduced production. Farmers facing Currently, the demand for agriculture products are increasing exponentially and Farmers are facing more challenges to predict natural calamities on environmental factors like moisture, light,Water distribution and healthiness of crops. Recent days Internet of Things inevitable technology in all the fields, now integrated with agricultural lands for provide knowledge about the environmental factors. This research study helps to address the issues of a forementioned factors, provides the intelligent decision system based on the environmental conditions. In this research, Intelligent Decision Support System (IDSS) designed for monitor the Crop healthiness and various sensors are used for collect the information from the fields accurately and instantly feed to the Intelligent Decision Support System. Crop's moisture status on the basis of moisture sensor, rain sensor, and light status via LDR, crop health is monitored with the help of image processingunit in IDSS.

Keywords : IoT,Rain sensor,Moisture sensor,Water level sensor,LDR Sensor and IDSS

1.Introduction

In the current situation, the agriculture sector is going through a very distressful phase. During the last three decades, India saw a whole lot of natural calamities that affected the overall crop production [1]. The major one being the draught of 1986-1987 and 1987-1988. Due to the deficit rains, the farmers saw a reduced production. This research work helps to minimize difficulties faced by farmers in real time and improve the agriculture and farming sector.

Agriculture all over the world mainly depends on monsoon [2,3],Result of the yield changes year to year, depending on the kind of rain received. A year with sample rain and crop production normally is followed by a year of dry soil and low or no production [4]. This, in turn, leads to income and employment fluctuations for the farmers as well as other agriculture-related departments. The research work used various sensors including rain sensor to accurately determine predictions and make changes accordingly.

+Traditional methods of irrigation exhaust land and in turn lead to bad produce. Farming in India has not seen any growth in terms of technological development, farmers are still using old methods of cultivation and irrigation. Not only is that inaccurate but it also sometimes results in failure due to human error. It is only recently that farmers in India have started implementing newer methods including steel plows, seed drills, barrows, hoes, etc., but to a limited extent only. Most of the farmers still prefer to use the old and orthodox wooden

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plows. Such a stubborn adoption of old methods leads to low production of crops and inaccurate prediction of rain and other such phenomena.

1.1 Internet of things

When we need a network of physical devices, buildings and vehicles that need to be embedded along with actuators, sensors and an internet connectivity, Internet of Things is used. It is a mechanism which helps us collect the data that is provided by the various devices and perform exchanging of data. These devices can be monitored as well as various operations can be performed on them [5,6]. Thus, IOT helps us create a blueprint of the physical world into the computing world. This technology is an instance of physical devices with cyber incorporated facilities that can be used such as smart grids, efficient transportation and intelligent cities. This project uses this technology to perform the various operations that need to be performed. It is basically the skeleton of the project.

2. Intelligent IoT System Architecture

The enhanced irrigation systemuses ARDUINO MEGA micro controller is the used as main component as it controls the working of each device connected to it [7]. This is because the full code and instructions of the system are stored in it. Moisture sensor and image processing technique used here to identify the the wet status of the crops so that the pump motor can work automatically to irrigate trees. Water level sensor, Rain sensor to monitor the water level at the ring as well as the tank to refill the tank automatically and detection of rain stop the working of the pump motor. LDR sensor to check the percentage of intensity of light use for photosynthesis, which can be displayed on the output display which is the LCD. All the data are fetched from the sensors stored in the controller for feed the IDSS for immediate operations in the field.

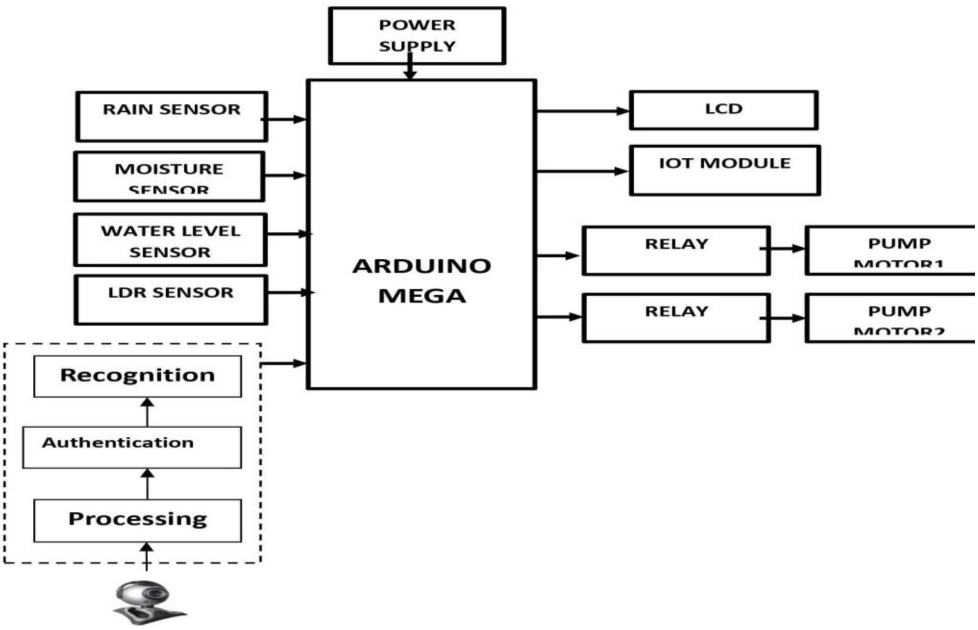

Figure 1: Intelligent IoT Architecture

The system architecture gives us a brief idea about the working of the project. The Arduino is the core component of this system. It monitors the different sub-components connected to it. Based on the information provided by the different components the pump motors are switched on/off accordingly. The various sensors are Rain, Moisture, Water level(tank), and Light Sensors. An additional component is added to the system to optimize the results, which is the image processor using MATLAB. A camera is fitted which will capture pictures of the field at specified intervals. This picture will then be analyzed using its features and dimensions. The analyzed report is learned and trained using algorithms hence optimizing the result.

Arduino Mega

The MEGA 2560 is required for projects large and more complex requirements.it contains 54 digital input-output pins along with 16 analogue pins. This provides the project with a larger space to work with and adding new components is also simplified.
The ATmega2560 supports the microcontroller board i.e. The Arduino Mega 2560. It consists of fifty-four ‘digital input/output’ pins (15 out of which are for PWM output processes), sixteen analog inputs, four hardware serial ports, a USB connection, a sixteen MHz quartz oscillator, an influence jack etc. the microcontroller is connected to the adapter via a USB cable and to the sensors with the help of jumper cables.it is the backbone of the project. It acts like the controller that receives the data from the various sensors and is coded in a way that it decided automatically what actions need to be taken.

Rain Sensor

It is a switching device whose sates of on and off are altered by rainfall itself. Few applications of rain sensor involve, a conservation device attached to an automated irrigation system that causes the system to shut down in the event of rainfall, another notable application is that of a windscreen wiper which will switch on automatically when rainfall is detected to wipe of rain so that the driver can have a clear view

Soil Moisture Sensor

The soil water sensor is an essential sensor for this project as it determines the level of moisture in the soil, which in turn gives the IOT module a clear idea whether to switch on or switch off the pumps. By using the soil moisture sensor even individually, the requirement of water by the soil can be fulfilled. The soil moisture sends a signal to the controller which decides the replenishment of the soil. Soil moisture senses and measures the volumetric water level of the soil. The sensor uses the soil’s dielectric constant to calculate the amount of water in it. i.e. the ability of the soil to transmit electricity. As the level of water elevates, the power of the soil to transmit electricity also elevates. The dielectric constant gives a fair amount of result which helps in deciding if the soil needs more water or not.

$$AnalogOutput = \frac{ADCValue}{1023}$$

Moisture in percentage = 100 – (Analog output * 100)

Water Level Sensor

A water level sensor as the name signifies is used to find the quantity of water in the reservoir. The water level sensor in the project works to monitor the amount of water in the tank at any given point. When the water in the tank goes below the desired level, the pumps are activated to fill the tank. The sensor uses the principle of echo to calculate if the tank is empty or full. The process is hassle free as there are different pumps to fill the tank and to water the soil.

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Liquid Crystal Display

To display the output to the user a LCD screen is used which is an electronic display device which is used in a variety of applications. The one that we are using in the project is a 'sixteen cross two' LCD display. The main advantages of using such a device is that the programming of this device is very easy, the user can add any symbol to show the output and it is cheap compared to the other display devices[7].

We define a 16X2 LCD as the device can display at the most 16 characters in one line so since its16X2 it has two lines so the user can display a total of 32 characters in the device. The device has two registers which are used to store the data called Data and Command. As the name says, the command are the instructions that are provided by the user to the to the LCD which are stored and the Data Register stores the data on which the various instructions will be performed. The register stores ASCII value of characters that need storing. This way there is a universal distinction between all the characters and the user can find it easy to perform the tasks on the LCD module.

Relay

Every system requires a switching device to regulate the flow of electrical quantities. The electrical quantities include voltage and current. So the switching device that we are using in this project is relays. These devices change the state of the circuit that we are using. The main purpose of the relays is to provide power to the servo motors which are used to water the fields as well as fill the water tanks.

Light Dependent Resistor

An important form of energy for plants is sunlight which they use for photosynthesis. to ensure that the crops in the field are provided with sufficient amount of sunlight, we use a device known as Light Dependent Resistor. This device has resistance that changes based on the amount of sunlight falling on it. Through this device we can monitor if the crops are provided with enough sunlight and take the appropriate measures to ensure that the crops are healthy.

SERVO MOTOR

This device consists of an output shaft that can be programmed in such a way that the angular positions can be controlled. Based on the signal received the angular positions will be maintained. These motors are used in a lot of places like elevators and rudders. These devices are very convenient and easy to use. In our project, the servo motor takes power from the battery that is provided to it. This battery gives the desired output power to the two servo motors that are installed in the project. The power is directly proportional to the amount of distance it needs to travel basically how fast the motor will rotate. In our case, how fast water will be given out to the tanks as well as to water the fields.

IMAGE PROCESSING UNIT

In this system image processing unit playing vital role to identify the part of wet or dry condition in the irrigation field, we trained the model used CNN for get the proper outcome from the system. This system recognize the dry field and indicate immediately to operate the servo motors enable to feed the water in the region.

MATLAB

The additional module that we are using is the Image Recognition Sensor device. To program it we are using MATLAB which is a numerical computing environment and a 4^{th} generation programming language. Data manipulation is done using various techniques and formulas that are already available in the libraries. It gives us a brief idea on the input images that we are providing and classifies them on various grounds. Using this we can learn about the images and train the device so in the future we can easily decode if the image is wet or dry.

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3. Intelligent Decision Support System

3.1 Training Dataset

This research study process is started by capturing the images and importing them to MATLAB. Different data sets can be stored in different file formats. In this, the data that is given is stored in as binary files. This is done so that they can be easily manipulated and reshaped base on the program's needs.

3.2 Train The Dataset

The data set of images formulated from the various site in order to train the CNN model[8]. Generation of training and test data is a simple data division. In first stage dataset is divided in a typical 70-30 ratio, test & validation data. The data can be divided such that all classes have proportionate representation in both test and training. Feature vector in simple terms is just a collection of characteristics or features of an image. In case of images, they may be geometric features, texture features etc. In this work machine learning must provide the training data to the classifier so that it can build a model. This model can be validated and optimal kernel parameters can be selected. K-fold cross validation is the one of the simplest ways to choose the same. There are also several algorithms can explore for selecting good (mRmR) features. Once your features and model are built you can test the classifier with the data and evaluate the accuracy of classification.

3.3 Classification

For Image Classification[8,9], deep learning can be used which contains various algorithms to classify as well as manipulate the data. One such algorithm is Convolutional Neural Network[9]. The architecture of CNN mainly consists of three layers, that can be classified into convolutional layers, pooling layers, and connected layers. The CNN algorithm receives an input image that passes through the layers to identify features and recognize the image, and then it produces the classification result[10]. Output that is given out by each layer in the CNN is the input of the upcoming layer. The input of the CNN is a 3D image (width × height × depth), the width and the height are the dimensions of the images. The depth is the number of input channels and it is three color channels Red, Green, and Blue (RGB). The convolutional layers extract features from images. Each convolutional matrices weights that are called filters or kernels which slide over the input image to detect particular information from the image. The filters of the first layers of the CNN detect colors and simple patterns. Then in the next layers, they gradually detect more complex patterns. To find features, each filter applies a convolution operation to output a feature map. Here CNN as Convolutional Neural Network works on 2D matrix shaped input. Data is processed in a distinct neural network. In this system CNN used for the input picture classification and segmentation. The pictures are dividing as two-dimensional matrices of pixels to execute the algorithm to classify them such as wet, dry, color, shape etc..,.

3.4 CONVOLUTION:

A mathematical function specifies how one feature of an image is modified by another feature of the image. In this work considered a picture of a crop field (x) is a two-dimensional matrix of pixels with diverse color channels and also specified a feature detector for detects a specific feature of the images from the input image ,the output is given in the form of feature map.

$$S[t] = (x * w)[t] = \sum x[a]w[a + t] \quad (1)$$

$$\text{where} S[t] - -\text{featuremap}$$
$$x[t] - -\text{input}$$
$$w[t] - -\text{kernel}$$

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The extracted features to identify the ridges in the crop image capturing in the fields,so the convolution operation is evaluated details of all the ridges in the input picture. By applying this operation input image is filtered based the feature.

The convolution functions are always assumed to be zero but there area definite set for which we store the values. For summation of the number of elements in the array can used the infinite summation shown in the given formula.

$$S(i,j) = (I * K)(i,j) = \sum_m \sum_n I(m,n)K(i-m, j-n) \qquad (2)$$

In function (2) ‘I’ is ’2-dimensional array’ and ‘K’ is the ‘kernel-Convolution’ fn.

The above equation can be re-written as the formula shown below. This is done as convolution is commutative. To ease the implementation in the learning of the images we use the latter formula. This is used by a large number of neural networks.

$$S(i,j) = (K * J)(i,j) = \sum_m \sum_n I(i-m, j-n)K(m,n) (3)$$

3. 5 CNN - STAGES

At first stage Convolutional Layer.

The feature detection is done by the Convolution Layer ,it filters the features of the images from input set The features are provided in Kernel (K) is learned features. This is used as it is very efficient because it goes to the very depth of each image and no feature of it is left out. Kernel K, that is used to find the features in the image I,in this research work the kernel is used to form various feature maps used to classify wet or dry. Various feature detectors include edge detection, shape identification, bends, ridges and colors.

To illustrate feature detector using a 5X5 matrix with three RGB channels, and a feature detector matrix of 3X3 also with three RGB channels. The feature detector is then scanned over the image by one stride left top to right .

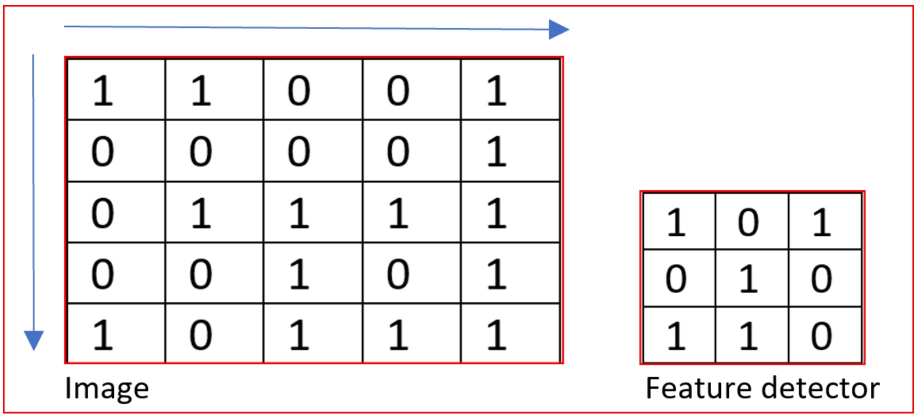

Figure 2: Feature Detector

A function of the dimension of the feature image can be given as,
Dimension = (4)

$$\text{Where}W - -\text{Inputimagesize}$$
$$F - -\text{Featuredetectorsize}$$
$$S - -\text{Stride}$$
$$P - -\text{ZeroPaddingonimage}$$

In our case the Image Size = 5 ,Feature detector = 3, Stride (S) = 1. Zero Padding=0 Thus feature map dimension output is 3*3 matrix with three RGB channels. This can be demonstrated below in the following steps:

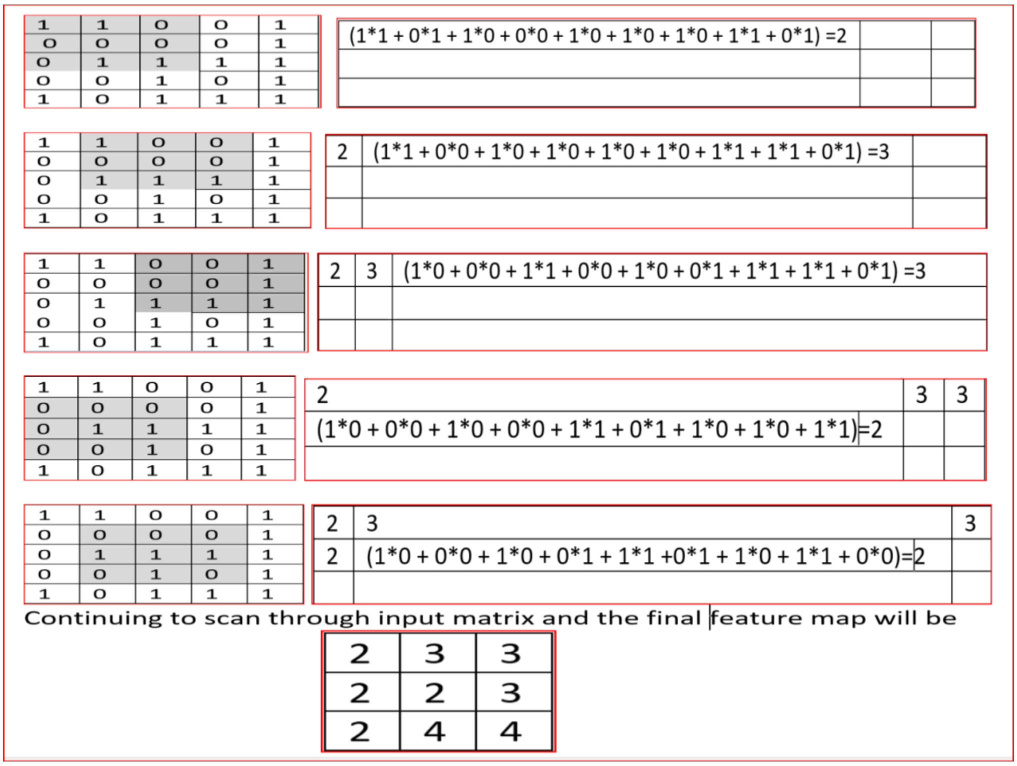

Figure 3: Feature map

A cross correlation function is done on the input image and feature detector so that the depth and channels of the image stays the same. This ensures there is no modification of the image. A number of feature detectors is used to find the edges of the image. The image also sharpened or made blur to get a better understanding of the image. The dimensions of the image size maintained same by use padding of zeros which is shown below.

0	0	0	0	0	0	0
0	1	1	0	0	1	0
0	0	0	0	0	1	0
0	0	1	1	1	1	0
0	0	0	1	0	1	0
0	1	0	1	1	1	0
0	0	0	0	0	0	0

Figure 4.10: Zero Padding

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In this work zero padding on 5X5 image So the formula now becomes,

(5)

With this the output image also be 5X5 with 3 RGB channels. A linear transformation is done if there is a single feature detector of 3X3. The transformation is given below

$$\text{Output} = \text{input} * \text{weight} + \text{bias}(6)$$

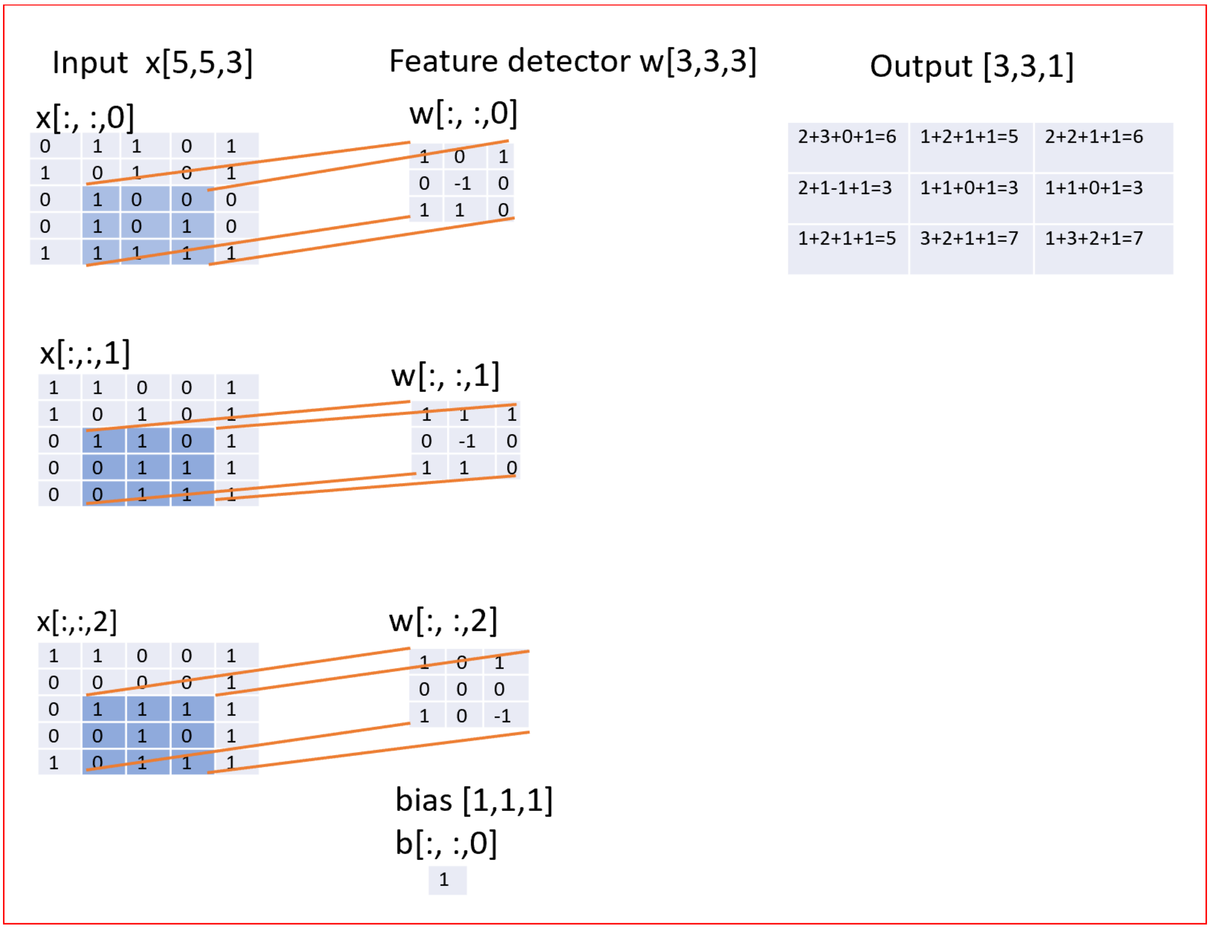

Figure 4.11: Input and Feature Detector

Input image= 5X5 with three RGB channel and a single feature detector of 3X3 with one bias unit and one stride ,so the Number of parameters =(3*3*3)+1=28.

A Relu Activation function is applied on the convolution operation[11] ,the main function of it is to introduce non-linearity in the layer. The pixels of a negative value is substituted with zero. The following diagram depicts the map after the application of the ReLu function on the convolution.

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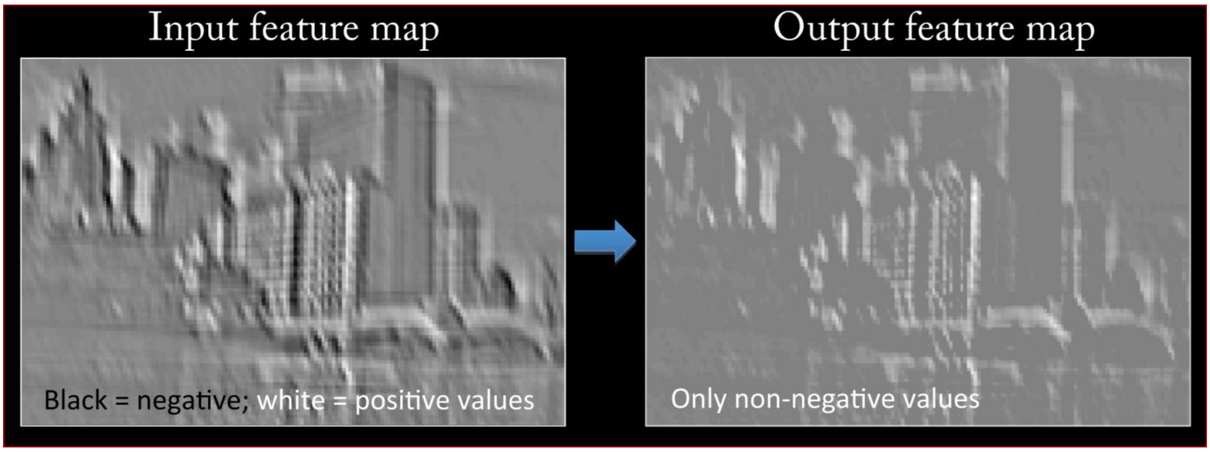

Figure 4.12: ReLU transformation feature map

After the features detected, again formed the picture by combining all of these features.

Pooling:

Translational Invariance is gained using Pooling ,it is done to combine the common characteristics and features of the image. In this research work applied max pooling, Max Pooling is more efficient and it pools the entire neighborhood thus minimizing the number of parameters and output of max pooling value shown in the figure .

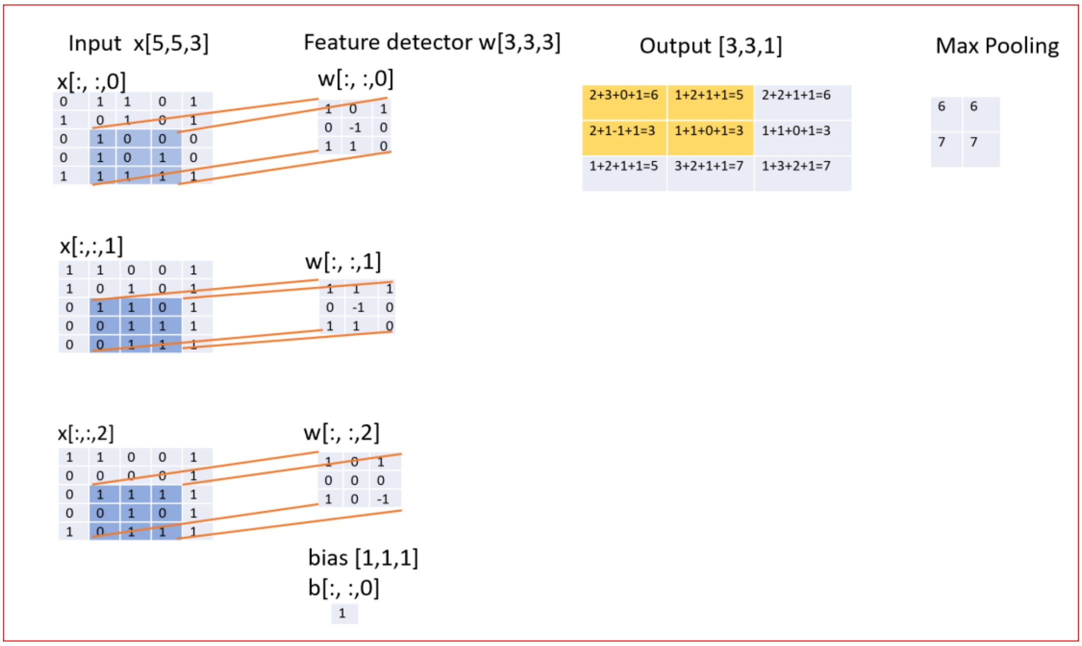

Figure 4.13: Max Pooling

The full convolutional neural network is formed by following layers shown in fig -

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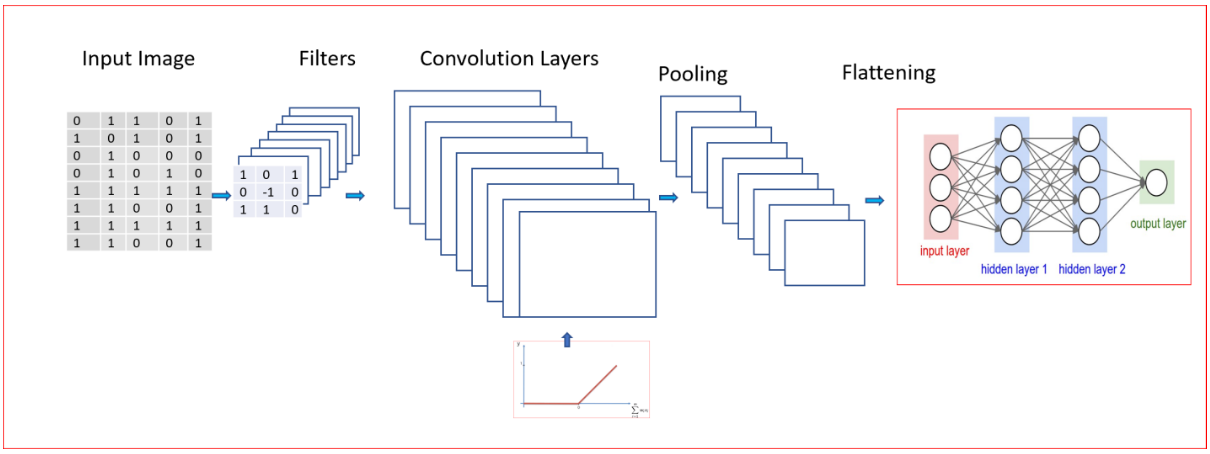

Figure 4.14: Full Convolutional Neural Network

4. Working Of Matlab According To Our Dataset

In this research work CNN algorithm is used in MATLAB for image recognition and training of a model to recognize certain features and aspects of an image. This CNN model trained the machine based on the dataset images of dry and wet crops as input shown in fig and fig .

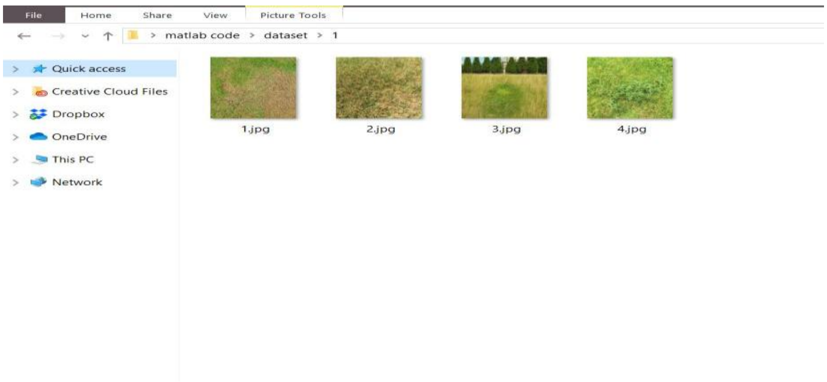

Figure 4.15: Dataset used for dry crops

Figure 4.16: Dataset used for wet crops

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5.EXPERIEMENTL RESULTS

Results For The Arduino Code

The research work tested with samples revolving around the Arduino and the various sensors aligned to it. The sensors send particular signals which is intercepted and based on these signals the output is displayed on the LCD. The sensors outcome samples are noted down by applying with prototype models show in table ,this sample values can be extended to the irrigation field. Moisture Sensor, the detection of moisture here is a change due to the electrical conductivity of the earth. There are two electrodes that measure the electrical resistance. Here define the limit which acts as a threshold. In this work assumed threshold value is 300. Sensor Value detected from sensor and compared with threshold value, field status is displayed as wet or dry shown in table . Sensor units Input voltage varies from 3.3 to 5 V,Output voltage 0 -4.2V. 3 Ultrasonic Sensor/ Water Level Sensor In the ultrasonic sensor for water level, the detection of water level occurs through SONAR which determines the distance of objects using ultrasonic waves. It has high accuracy and provides readings that are stable and convenient for use. In our sample test varied from minimum value 0 to maximum values tank capacity Threshhold assumed as 25 cm. In the light-dependent sensor, the detection of sunlight is a change in resistance when light falls on the surface of the component. The variable resistance is responsible for the detection of light and based on that various actions on the module are performed. A *luxmeter* is a device that measures illuminance and luminous emittance using the SI unit of *lux*.Table 1 : Sensors outcome samples

5.1.Intelligent Decision Support System

This system implemented with MAT lab research model input image of a crop is fed to the model, the machine analysed the image based on the CNN trained model, results in a dry or a wet crop. As it is trained with the help of a dataset dry crop identified , IDSS activate the servo motor. If wet crop the the valve remains shutoff. The training accuracy model shown in the fig- 5.5

5.2.3 GRAPHS:

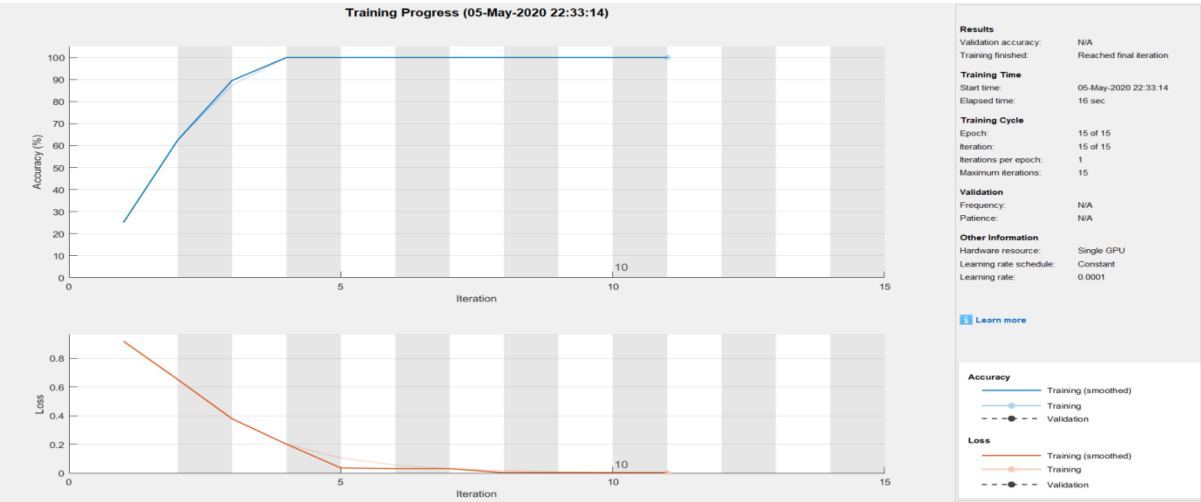

Figure 5.5: Dry-field image

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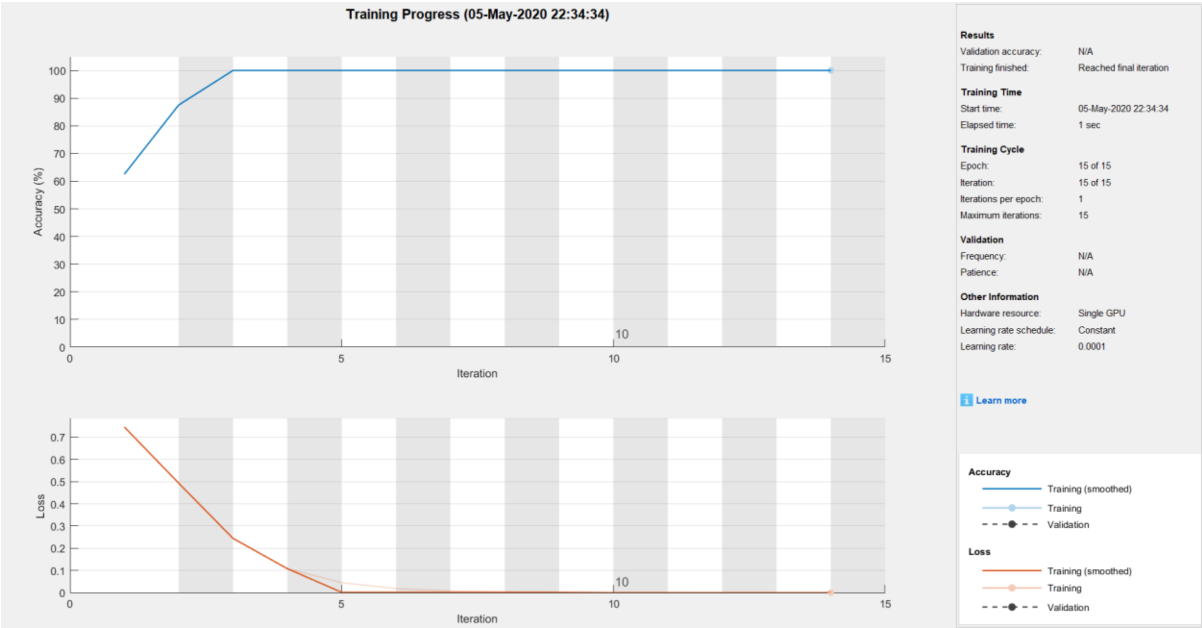

Figure 5.6: Wet-field image

The above graphs show accuracy and loss with iterations for every input image. The graphs show that the accuracy increases and loss decreases after a few iterations. When the graph shows a linear path, the system classifies the image into the result.

CONCLUSION

The project "Revolutionizing Automated Irrigation System' has been designed and tested successfully. The hardware, software, and the entire module has been placed out thoughtfully and neatly in a manner that the working of each element is clear. The system requires a negligible amount of human interference and works in an automated manner. The moisture sensor senses the level of moisture of the soil and sends the data to the module, the module combined with the image processor give a result. The result is for the pump to be ON when the soil is dry and OFF when the soil is wet. Once the desired water level is attained in the soil, the water pumps are switched off automatically. The working of the system has been determined to be successful. The system is almost automated and reduces manpower and the workforce required for the purpose of irrigation. Since the water is directly given to the soil in a form of sprinkler, there is minimum wastage of water, the pumps are switched off immediately after the desired moisture level is reached. Thus, the system is effectual and well-suited with the varying environment.

FUTURE ENHANCEMENTS

Considering the future, the first step would be to convert this project to a large scale. The results obtained would be precise and automated. A large-scale project would also require controlling of data via a cloud database instead of a wired connection. Further cost reduction can be done in this project by using renewable resources such as Solar power etc. Apart from that, we can enlarge the dataset by feeding it more images, this would make the results even more precise and make the project more adaptable.

The hardware part of the project can inculcate more sensors in it such a pH sensor to check the mineral levels in the soil and thus alert the farmer in case of any fluctuations,

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