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AI BASED SMART IRRIGATION SYSTEM USING HYBRID ENSEMBLE MODEL

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Abstract

Irrigation is planned across the world based on farmers' eye assessment of crops, and as a result, traditional irrigation systems waste around 50% of water. Sprinkle irrigation, drip irrigation, and furrow irrigation are examples of controlled irrigation methods that minimise water waste by 30% to 70%. However, because to the open-loop structure, these techniques fail to maintain precise water content in the soil, resulting in worse crop quality and quantity when soil nutrients are depleted by under or over-irrigation. As a result, input on integrated precision irrigation strategies is required in order to properly use water without compromising crop development. Precision irrigation uses soil moisture, climatic data, and crop type to determine whether or not water is required. As a result, farmers' labour expenses are reduced. In this study, we will determine if agricultural land requires water or not. Using a hybrid machine learning approach known as Hybrid Random Forest and Linear Model, we can determine if we need to apply fertiliser or not. Precision agriculture has recently received a lot of attention as a result of the ever-increasing global population demands for food and water.. As a result, farmers will require water as well as arable land to satisfy this demand. Farmers require a solution that alters the way they work due to the restricted availability of both resources. Precision irrigation is the way to get greater, better, and more lucrative yields with less effort and money. To make better use of water, several machine learning-based irrigation models have been developed. These models are not well adapted to variable climates due to their weak learning capabilities. For precision agriculture, our study offers a deep learning neural network-based Internet of Things (IoT)-enabled intelligent irrigation system. The sensor's data was saved in order to use it to estimate the content and control the water supply motors. In addition, the fertiliser motor must be switched. The projected findings show that the system in the experimental agricultural region utilises water more wisely than prior models.

CHAPTER-I

INTRODUCTION

Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labor time, and ensure the effective management of fertilizers and irrigation processes. It uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops (Mulla, 2013). PA is an advanced innovation and optimized field level management strategy used in agriculture that aims to improve the productivity of resources on agriculture fields. Thus PA is a new advanced method in which farmers provide optimized inputs such as water and fertilizer to enhance productivity, quality, and yield (Gebbers and Adamchuk, 2010). It requires a huge amount of information about the crop condition or crop health in the growing season at high spatial resolution. Independently of the data source, the most crucial objective of PA is to provide support to farmers in managing their business. Such support comes in diverse ways, but the end result is typically a decrease of the necessary resources.

1.1 Prediction

"Prediction" refers to the output of an algorithm after it has been trained on a historical dataset and applied to new data when forecasting the likelihood of a particular outcome, such as whether or not a customer will churn in 30 days. The algorithm will generate probable values for an unknown variable for each record in the new data, allowing the model builder to identify what that value will most likely be.

The word "prediction" can be misleading. In some cases, it really does mean that you are predicting a future outcome, such as when you're using machine learning to determine the next best action in a marketing campaign. Other times, though, the "prediction" has to do with, for example, whether or not a transaction that already occurred was fraudulent. In that case, the transaction already happened, but you're making an educated guess about whether or not it was legitimate, allowing you to take the appropriate action.

Why are Predictions Important?

Machine learning model predictions allow businesses to make highly accurate guesses as to the likely outcomes of a question based on historical data, which can be about all kinds of things – customer churn likelihood, possible fraudulent activity, and more. These provide the business with insi .

ghts that result in tangible business value. For example, if a model predicts a customer is likely to churn, the business can target them with specific communications and outreach that will prevent the loss of that customer.

What are Prediction Explanations in Machine Learning?

Prediction explanations in machine learning explain how or why an AI platform arrived at an outcome. In the past, these models did not explain how a decision was made. This lack of clarity causes the "black box" syndrome, where you have predictions but are unsure of which feature variables affect a model's outcomes.

Machine learning models learn how to make decisions based on rules that it created while analyzing the training dataset. Prediction explanations allow us to understand these rules and how they are applied to new data, as well as what features are the most valuable considerations in determining the output.

The prediction explanation assigns each input value a measure of importance, and if you take the sum of all of them, it will add up to 100%.

For decision tree models, the prediction explanation follows the prediction path. Still, for others like regression, it is calculated based on aggregating the results of many predictions that use random variations of input data.

Why are Prediction Explanations Helpful?

Understanding how your AI platforms interpret feature variables to arrive at predictions is essential to making data-driven decisions. By learning what inputs most contribute to the outcomes, you can gain insights into what is driving things like consumer trends or revenue growth.

Prediction explanations are required by regulations when machine learning models are used in industries like finance. Loan issuers must explain how they arrived at a credit decision so that they can prove it was fair – and provide support for why they declined a loan application.

They are also crucial in healthcare, as medical professionals must provide explanations for diagnosis. This is the only way that doctors can be confident enough to make a life-or-death decision, and so that they can convey that decision path to the patient and their family.

1.2 Precision Agriculture

Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labor time, and ensure the effective management of fertilizers and irrigation processes. It uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops (Mulla, 2013). PA is an advanced innovation and optimized field level management strategy used in agriculture that aims to improve the productivity of resources on agriculture fields. Thus PA is a new advanced

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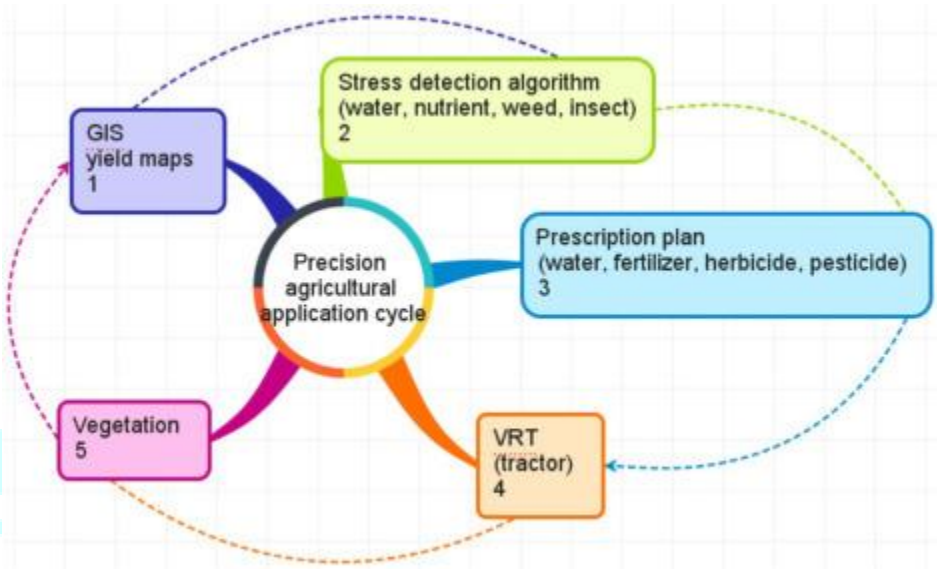


Modern agricultural production relies on monitoring crop status by observing and measuring variables such as soil condition, plant health, fertilizer and pesticide effect, irrigation, and crop yield. Managing all of these factors is a considerable challenge for crop producers. The rapid enhancement of precise monitoring of agricultural growth and its health assessment is important for sensible use of farming resources and as well as in managing crop yields (Nigam et al., 2019). Such challenges can be addressed by implementing remote sensing (RS) systems such as hyperspectral imaging to produce precise biophysical indicator maps across the various cycles of crop development.

RS is a rapidly expanding technology implemented in various agricultural applications. In particular, imaging spectroscopy in large continuous narrow bands provides significant information for understanding the biophysical and biochemical properties of agricultural plants. It is also useful to identify the changes in various physical processes, which can be better identified using multispectral RS (Sahoo et al., 2015). Advanced techniques of RS have been used for large scale crop inventory and yield predictions (Mulla, 2013). RS applications are used in agriculture studies that are based on the interaction between electromagnetic radiation and soil or plant material on the Earth's surface (Atzberger, 2013). RS combined with geographic information systems (GISs) and/or global positioning systems (GPSs) are often used in PA. This allows farmers and other agriculture producers to reduce inputs and maximize cost benefits using modern technologies rather than traditional field approaches. Nowadays, variable rate technology (VRT) is introduced to increase precision

farming practices. VRT is a vital component for PA and is becoming more prevalent for large land holders. In VRT, collections of field variable information and other input data are helpful in defining suitable quantities of chemical inputs required for the fields. Hence the demand of precision agricultural techniques, valuable products, fine RS information as well as VRT has grown tremendously (Brisco et al., 1998).

This chapter describes the latest developments in Earth Observation (EO) techniques and platforms for PA with particular emphasis on the use of hyperspectral sensors for this purpose. As part of this, it provides useful information regarding the identification of research challenges, limitations, and advantages of different platforms and sensors for PA with specific emphasis placed on hyperspectral sensors.

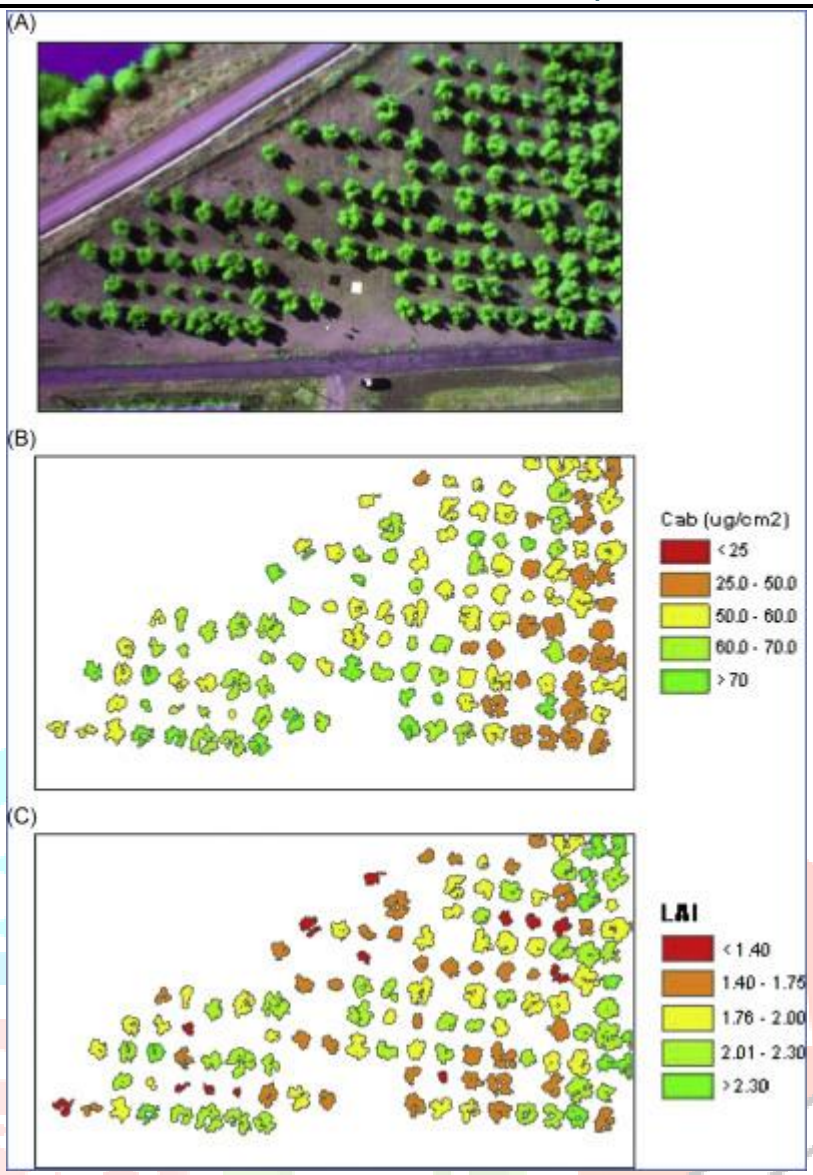
Precision agriculture employs data from multiple sources to improve crop yields and increase the cost-effectiveness of crop management strategies including fertilizer inputs, irrigation management, and pesticide application. While definitions of precision agriculture are somewhat inconsistent, the term is generally applied to tools and strategies that are relevant locally at subfield scales (i.e., < 5 m). Remote sensing has been promoted as a key source of information available in support of precision agriculture for decades, but adoption has been slow for a variety of reasons. Recent technological developments, specifically the availability of high-resolution satellite imagery, and more recently, rapid development of unmanned aerial vehicle technology (UAV), suggest that adoption of remote-sensing data sources in precision agriculture is likely to rapidly increase in the coming decade.

Satellite- and UAV-based applications of remote sensing in precision agriculture generally use multispectral measurements to estimate high-spatial resolution information related to soil properties, plant health, and crop yields. Reflectance spectra from soils provide information related to a variety of soil properties including soil moisture and organic matter content (Ben-Dor et al., 2008). Depending on the spectral resolution of the instrument, specific constituents including clay minerals, calcium carbonates, and iron oxides that affect soil fertility and moisture holding capacity can also be measured (Thomasson et al., 2001; Rossel et al., 2006). Each of these soil constituents have specific spectral regions where reflectance (or absorption) is strongest (Ben-Dor, 2002; Ben-Dor et al., 2008), and narrowband or hyperspectral imagery, in combination with techniques such as spectral unmixing algorithms (Huete and Escadafal, 1991) or derivative spectra (Demetriadesshah et al., 1990; Li et al., 1993) are often required to identify these soil constituents. A key challenge in exploiting this capability is that current space-based instruments have limited spectral bands and resolution relative to the narrow and hyperspectral imagery used in many of the studies described earlier.

Until recently, efforts use satellite-based imagery for applications in precision agriculture used Landsat imagery (Liu et al., 2010). However, aside from relatively conventional characterizations of crop type, detection of large-scale pathogens, and crude estimates of crop yield, the 30 m spatial resolution of the Landsat Thematic Mapper has imposed limits on the utility of Landsat imagery for most applications in precision agriculture. In the last two decades, high-spatial resolution (i.e., < 1–5 m) from commercial image providers such as Ikonos, RapidEye, Digital Globe, and AirBus has partly resolved this issue. Unfortunately, however, increases in spatial resolution afforded by these commercial sources are partly (and in many cases

entirely) offset by lack of temporal coverage and the cost of imagery—simply put, the data are too expensive and infrequent to be useful. The recent emergence of private companies launching constellations of low cost small satellites (so-called cubesats) has the potential to help resolve some of these challenges by providing much higher observation frequencies and driving down the cost of imagery. In the short term, however, the spectral and radiometric quality of these data sources is currently well below that required for precision agriculture. In the long run, solutions will be required that exploit a combination of high-quality medium resolution imagery from traditional sources such as Landsat and Sentinel 2, high-quality high-resolution vendors such as Digital Global and AirBus, and high-frequency lower quality imagery from Cubesats will be required to make satellite-based remote sensing truly useful for applications in precision agriculture. For a recent and comprehensive survey of traditional remote-sensing techniques, including ground-based remote sensing, which is not discussed here, the reader is referred to Mulla (2013).

Perhaps the most important recent technological development, which is already starting to transform the use of remote sensing in precision agriculture, is the emergence of low cost UAVs and associated imaging technology (Berni et al., 2009; Calderon et al., 2013; Gevaert et al., 2015; Jeong et al., 2016; Zarco-Tejada et al., 2013) (**Fig. 10**). UAVs come in a number of different forms, but the two most common configurations are multirotor systems, which typically have 4–8 rotors, and fixed wing systems, both of which use conventional (but sophisticated) remote-controlled aircraft technology. Multirotor UAVs provide substantial flexibility in terms of their deployment options but are able to image relatively limited areas because their flight times tend to be quite limited (typically less than 30 min) by battery life. Fixed wing UAVs, on the other hand, provide longer flight times and are able to cover larger areas, but require runways for take-off and landing, which are often not available. In either case, combined UAV-sensor configuration are complex and varied. Options include simple and inexpensive (<$1000) configurations that use low cost digital cameras, to much more sophisticated and expensive (>$100,000) configurations with hyperspectral cameras, thermal sensors, or LiDAR systems.



CHAPTER-II

LITERATURE SURVEY

1) Title: Design and Implementation of an IoT System for Smart Energy Consumption and Smart Irrigation in Tunnel Farming

Author name: M. Safdar Munir, Imran Sarwar Bajwa

Year: 2018

Content:

Efficient and cost effective ways of irrigation have emerged as the need of the hour due to limited sweet water resources, especially the countries that are seriously hit by a lack of sweet water reservoirs. The majority of the water is wasted due to inefficient ways of watering plants. In this project, we propose an intelligent approach for efficient plant irrigation that has a database of daily water needs of a type of plant and decides the amount of water for a plant type on the basis of the current moisture in soil, humidity, and time of the day. This approach not only saves sweet water by efficient utilization, but also supports smart consumption of energy. Our approach employs IoT and a set of sensors to efficiently record plant data and their watering needs

and the approach is implemented with a mobile phone application interface that is used to continuously monitor and control the efficient watering system. The results of this study are easy to reproduce as the sensors used are cheap and easy to access.

2) Title: A Systematic Review on Monitoring and Advanced Control Strategies in Smart Agriculture

Author name: SYEDA IQRA HASSAN, MUHAMMAD MANSOOR ALAM

Year: 2021

Content:

Automation in agriculture nowadays is the main focus and area of development for various countries. The population rate of the world is increasing rapidly and will be double in upcoming decades and the need of food is also increasing accordingly. To meet this rapid growth in demand, agriculture automation is the best solution. Traditional strategies employed by farmers are not ef_cient enough to ful_ll the rising demand. Improper use of nutrients, water, fertilizers and pesticides disturbs the agricultural growth and the land remains barren with no fertility. This research paper presents different control strategies used to automate agriculture such as: IoT, aerial imagery, multispectral, hyperspectral, NIR, thermal camera, RGB camera, machine learning, and arti_cial intelligence techniques.

3) Title: Design and Development of Precision Agriculture System Using Wireless Sensor Network

Author name: S. R. Nandurkar, V. R. Thool, R. C. Thool

Year:

Content:

Crop farming in India is labour intensive and obsolete. Farming is still dependent on techniques which were evolved hundreds of years ago and doesn't take care of conservation of resources. The newer scenario of decreasing water tables, drying up of rivers and tanks, unpredictable environment present an urgent need of proper utilization of water. We have the technology to bridge the gap between water usage and water wastage. Technology used in some developed countries is too expensive and complicated for a common farmer to understand. Our project is to give cheap, reliable, cost efficient and easy to use technology which would help in conservation of resources such as water and also in automatizing farms. We proposed use of temperature and moisture sensor at suitable locations for monitoring of crops. The sensing system is based on a feedback control mechanism with a centralized control unit which regulates the flow of water on to the field in the real time based on the instantaneous temperature and moisture values. The sensor data would be collected in a central processing unit which would take further action. Thus by providing right amount of water we would increase the efficiency of the farm. The farmer can also look at the sensory data and decide course of action himself. We have made the interface of our project keeping in view the educational and financial background of average Indian farmer. In this projects we are proposed a low cost and efficient wireless sensor network

technique to acquire the soil moisture and temperature from various locations of farm and as per the need of crop controller take the decision to make irrigation ON or OFF.

4) Title: Smart Farming System Using Sensors for Agricultural Task Automation
Author name: Chetan Dwarkani M, Ganesh Ram R
Year: 2015

Content:

Agriculture is the broadest economic sector and plays an important role in the overall economic development of a nation. Technological advancements in the arena of agriculture will ascertain to increase the competence of certain farming activities. In this paper, we have proposed a novel methodology for smart farming by linking a smart sensing system and smart irrigator system through wireless communication technology. Our system focuses on the measurement of physical parameters such as soil moisture content, nutrient content, and pH of the soil that plays a vital role in farming activities. Based on the essential physical and chemical parameters of the soil measured, the required quantity of green manure, compost, and water is splashed on the crops using a smart irrigator, which is mounted on a movable overhead crane system.

5) **Title:** Providing Smart Agricultural Solutions to Farmers for better yielding using IoT
Author name: M.K.Gayatri, J.Jayasakthi, Dr.G.S.Anandha Mala
Year: 2015

Content:

The field of Cloud computing is helping in leaps and bounds to improvise our age old business - Agriculture. Practical applications can be built from the economic consumption of cloud computing devices that can create a whole computing ecosystem, from sensors to tools that observe data from agricultural field images and from human actors on the ground and accurately feed the data into repositories along with their location as GPS co-ordinates. In reality, sensors are now able to detect the position of water sources in a subject that is being investigated. Issues related to farmers are always hampering the course of our evolution. One of the answer to these types of problems is to help the farmers using modernization techniques. This paper proposes an approach combining the advantages of the major characteristics of emerging technologies such as Internet of Things(IoT) and Web Services inorder to construct an efficient approach to handle the enormous data involved in agrarian output.The approach uses the combination of IoT and cloud computing that promotes the fast development of agricultural modernization and helps to realize smart solution for agriculture and efficiently solve the issues related to farmers.

6) Title: Solar Based Plant Irrigation System

Author name: Dr.M. Janakiranimathi, G Alex

Year: 2016

Content:

Solar energy has emerged as viable source of renewable energy over the past few decades and is now used for various applications such as emergency lighting, water heaters, and industrial application. It is a cheap source of energy. Unlike hydroelectricity it does not cause national or any conflicts because sun is the only renewable source which is available to everyone. This paper proposes a solar based automatic irrigation system. The main objective is to design an low cost and time based irrigation system with the help of microcontroller. Irrigation Scheduler measures various parameters such as humidity, temperature and soil moisture. In this project the new type of solar panel is used i.e.. Spin Cell, which produces 20 times more current than the traditional flat panels and also in the irrigation system the irrigation pump controlled in two modes :- Automatic mode and GSM mode.

7) Title: Automated Irrigation System Using a Wireless Sensor Network and GPRS Module

Author name: Joaquín Gutiérrez, Juan Francisco

Year: 2014

Content:

An automated irrigation system was developed to optimize water use for agricultural crops. The system has a distributed wireless network of soil-moisture and temperature sensors placed in the root zone of the plants. In addition, a gateway unit handles sensor information, triggers actuators, and transmits data to a web application. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller-based gateway to control water quantity. The system was powered by photovoltaic panels and had a duplex communication link based on a cellular-Internet interface that allowed for data inspection and irrigation scheduling to be programmed through a web page. The automated system was tested in a sage crop field for 136 days and water savings of up to 90% compared with traditional irrigation practices of the agricultural zone were achieved. Three replicas of the automated system have been used successfully in other places for 18 months. Because of its energy autonomy and low cost, the system has the potential to be useful in water limited geographically isolated areas.

CHAPTER III

SYSTEM IMPLEMENTATION

3.1 EXISITING SYSTEM

In the existing system they used LSTM to predict the volumetric soil moisture of the field one day a head but they can't able to predict whether field needs water and fertilizer. But due to complex structure of LSTM their training time is high and their accuracy also low

3.2 PROPOSED SYSREM

In the proposed system we use a hybrid Random forest with linear model (HRFLM) algorithm for prediction works. We used ensemble voting Classifier for hybriding random forest and linear model. Due to the architecture of hybrid algorithm, we achieved high accuracy for predition. We get more than 96% of accuracy.

We have also implemented a scenario with a hardware for testing our perdition are true by using a microcontroller, pump motor and sensors.

CHAPTER IV

SOFTWARE IMPLEMENTATION

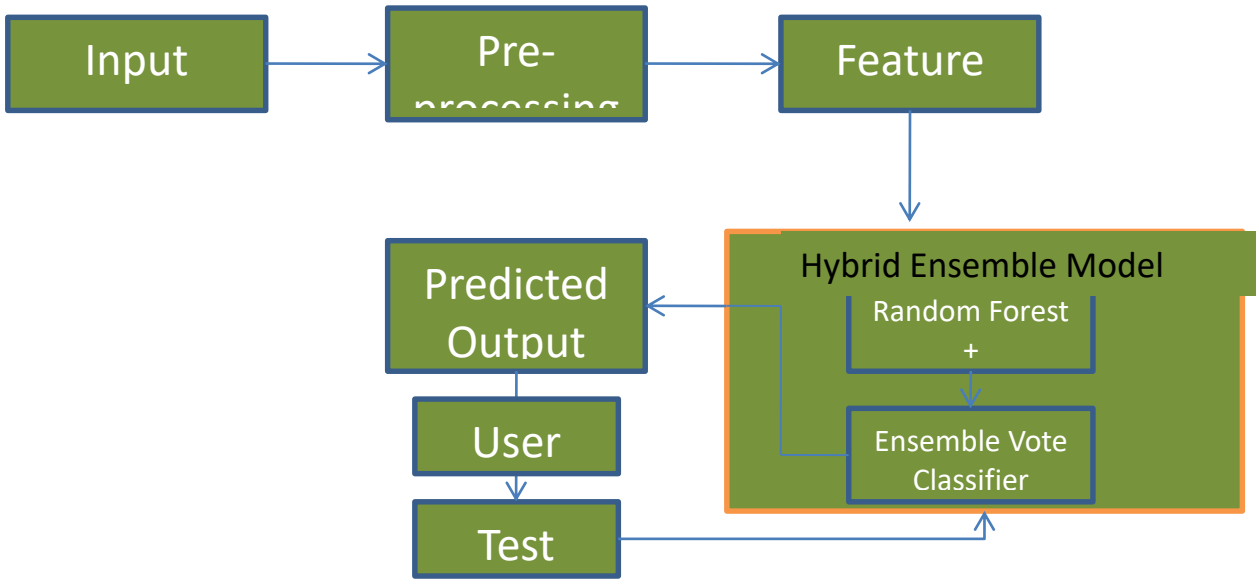
4.1 DATA COLLECTION

We collected the precision agriculture dataset from kaggle website. This data consists of over 5000 data's and has features such as soil moisture, temperature, humidity, wind speed, fertilizer and humidity

4.2 DATA PRE-PROCESSING

At first the dataset is fetched by using pandas library and then we save the datas inside a pandas dataframe, At first this dataset consists of lots of null values, then we drop all the null values, because our Machine learning model cannot able to process null values

Proposed system Architecture



Module Description

- At first the datas are getted from the input dataset by using pandas library. Then we preprocess the data by droping null values, then we make feature selection by selecting input features for feeding it in the Hybrid MACHINE Learning module, we design a Hybrid ensemble mchine learning model by using Random forest and linear model with voting classifier which can able to give high accuracy, the extracted features are inserted in to the Hybrid model and the machine gets trained. After training we predict the status of pump and fertilizer by feeding test datas into the model.

4. 3 MACHINE LEARNING

Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy. IBM has a rich history with machine learning. One of its own, Arthur Samuel, is credited for coining the term, “machine learning” with his research (PDF, 481 KB) (link resides outside IBM) around the game of checkers. Robert Nealey, the self-proclaimed checkers master, played the game on an IBM 7094 computer in 1962, and he lost to the computer. Compared to what can be done today, this feat almost seems trivial, but it’s considered a major milestone within the field of artificial intelligence. Over the next couple of decades, the technological developments around storage and processing power will enable some innovative products that we know and love today, such as Netflix’s recommendation engine or self-driving cars. Machine learning is an important component of the growing field of data science. Through the use of statistical methods, algorithms are trained to make classifications or predictions, uncovering key insights within data mining projects. These insights subsequently drive decision making within applications and businesses, ideally impacting key growth metrics.

As big data continues to expand and grow, the market demand for data scientists will increase, requiring them to assist in the identification of the most relevant business questions and subsequently the data to answer them.

4.3.2 LOGISTIC REGRESSION

Logistic regression is a statistical analysis method used to predict a data value based on prior observations of a data set. Logistic regression has become an important tool in the discipline of machine learning. The approach allows an algorithm being used in a machine learning application to classify incoming data based on historical data. As more relevant data comes in, the algorithm should get better at predicting classifications within data sets. Logistic regression can also play a role in data preparation activities by allowing data sets to be put into specifically predefined buckets during the extract, transform, load (ETL) process in order to stage the information for analysis. A logistic regression model predicts a dependent data variable by analyzing the relationship between one or more existing independent variables. For example, a logistic regression could be used to predict whether a political candidate will win or lose an election or whether a high school student will be admitted to a particular college. The resulting analytical model can take into consideration multiple input criteria. In the case of college acceptance, the model could consider factors such as the student's grade point average, SAT score and number of extracurricular activities. Based on historical data about earlier outcomes involving the same input criteria, it then scores new cases on their probability of falling into a particular outcome category.

Purpose and examples of logistic regression

Logistic regression is one of the most commonly used machine learning algorithms for binary classification problems, which are problems with two class values, including predictions such as "this or that," "yes or no" and "A or B." The purpose of logistic regression is to estimate the probabilities of events, including determining a relationship between features and the probabilities of particular outcomes. One example of this is predicting if a student will pass or fail an exam when the number of hours spent studying is provided as a feature and the variables for the response has two values: pass and fail. Organizations can use insights from logistic regression outputs to enhance their business strategies so they can achieve their business goals, including reducing expenses or losses and increasing ROI in marketing campaigns, for example. An e-commerce company that mails expensive promotional offers to customers would like to know whether a particular customer is likely to respond to the offers or not. For example, they'll want to know whether that consumer will be a "responder" or a "non responder." In marketing, this is called *propensity to respond modeling*. Likewise, a credit card company develops a model to decide whether to issue a credit card to a customer or not will try to predict whether the customer is going to default or not on the credit card based on such characteristics as annual income, monthly credit card payments and number of defaults. In banking parlance, this is known as *default propensity modeling*.

Uses of logistic regression

Logistic regression has become particularly popular in online advertising, enabling marketers to predict the likelihood of specific website users who will click on particular advertisements as a yes or no percentage.

Logistic regression can also be used in:

- Healthcare to identify risk factors for diseases and plan preventive measures.
- Weather forecasting apps to predict snowfall and weather conditions.
- Voting apps to determine if voters will vote for a particular candidate.
- Insurance to predict the chances that a policy holder will die before the term of the policy expires based on certain criteria, such as gender, age and physical examination.
- Banking to predict the chances that a loan applicant will default on a loan or not, based on annual income, past defaults and past debts.

Logistic regression vs. linear regression

The main difference between logistic regression and linear regression is that logistic regression provides a constant output, while linear regression provides a continuous output.

In logistic regression, the outcome, such as a dependent variable, only has a limited number of possible values. However, in linear regression, the outcome is continuous, which means that it can have any one of an infinite number of possible values.

Logistic regression is used when the response variable is categorical, such as yes/no, true/false and pass/fail. Linear regression is used when the response variable is continuous, such as number of hours, height and weight.

For example, given data on the time a student spent studying and that student's exam scores, logistic regression and linear regression can predict different things.

With logistic regression predictions, only specific values or categories are allowed. Therefore, logistic regression can predict whether the student passed or failed. Since linear regression predictions are continuous, such as numbers in a range, it can predict the student's test score on a scale of 0 -100.

4.3.3 RANDOM FOREST

Random forest is a ***Supervised Machine Learning Algorithm*** that is ***used widely in Classification and Regression problems***. It builds decision trees on different samples and takes their majority vote for classification and average in case of regression.

One of the most important features of the Random Forest Algorithm is that it can handle the data set containing ***continuous variables*** as in the case of regression and ***categorical variables*** as in the case of classification. It performs better results for classification problems.

Real Life Analogy

Let's dive into a real-life analogy to understand this concept further. A student named X wants to choose a course after his 10+2, and he is confused about the choice of course based on his skill set. So he decides to consult various people like his cousins, teachers, parents, degree students, and working people. He asks them varied questions like why he should choose, job opportunities with that course, course fee, etc. Finally, after consulting various people about the course he decides to take the course suggested by most of the people.

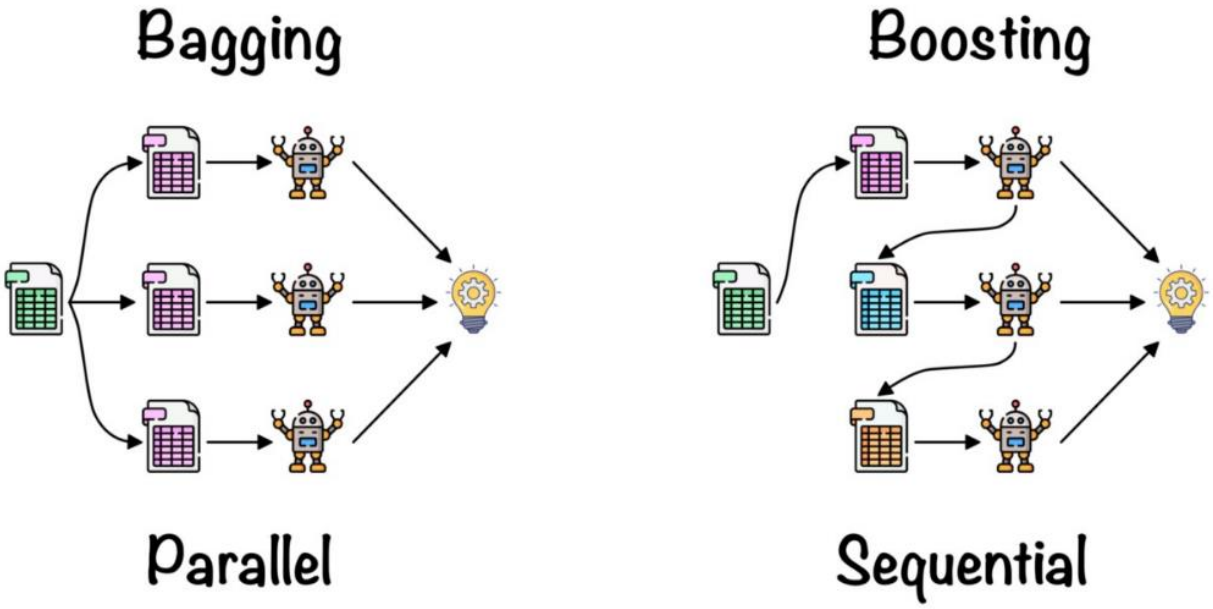
Working of Random Forest Algorithm

Before understanding the working of the random forest we must look into the ensemble technique. ***Ensemble*** simply means combining multiple models. Thus a collection of models is used to make predictions rather than an individual model.

Ensemble uses two types of methods:

1. **Bagging**– It creates a different training subset from sample training data with replacement & the final output is based on majority voting. For example, Random Forest.

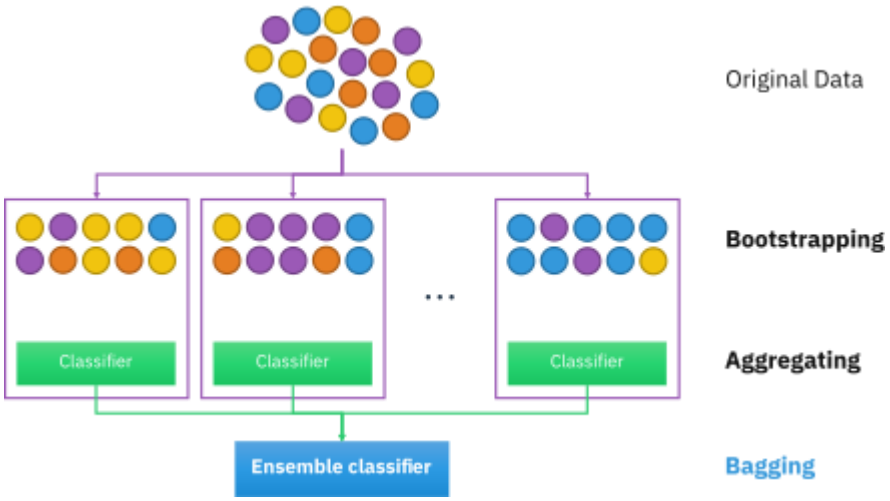
2. **Boosting**– It combines weak learners into strong learners by creating sequential models such that the final model has the highest accuracy. For example, ADA BOOST, XG BOOST



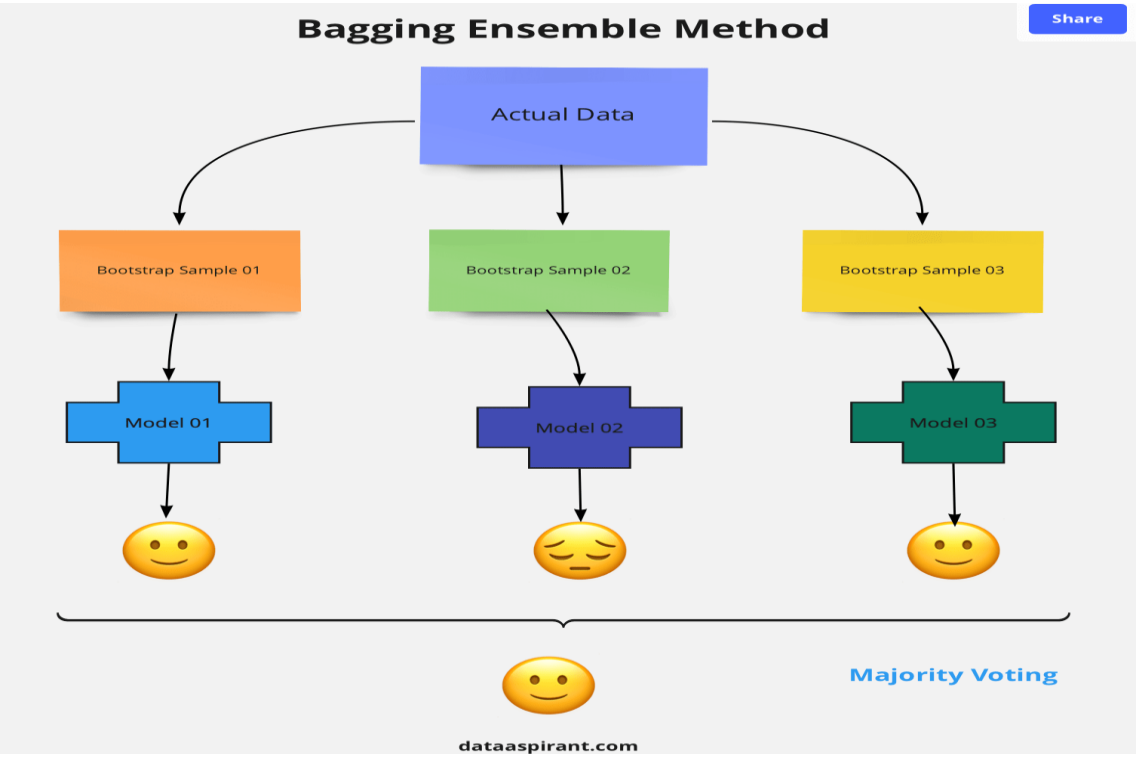
As mentioned earlier, Random forest works on the Bagging principle. Now let's dive in and understand bagging in detail.

Bagging

Bagging, also known as ***Bootstrap Aggregation*** is the ensemble technique used by random forest. Bagging chooses a random sample from the data set. Hence each model is generated from the samples (Bootstrap Samples) provided by the Original Data with replacement known as ***row sampling***. This step of row sampling with replacement is called ***bootstrap***. Now each model is trained independently which generates results. The final output is based on majority voting after combining the results of all models. This step which involves combining all the results and generating output based on majority voting is known as ***aggregation***.



Now let's look at an example by breaking it down with the help of the following figure. Here the bootstrap sample is taken from actual data (Bootstrap sample 01, Bootstrap sample 02, and Bootstrap sample 03) with a replacement which means there is a high possibility that each sample won't contain unique data. Now the model (Model 01, Model 02, and Model 03) obtained from this bootstrap sample is trained independently. Each model generates results as shown. Now Happy emoji is having a majority when compared to sad emoji. Thus based on majority voting final output is obtained as Happy emoji.



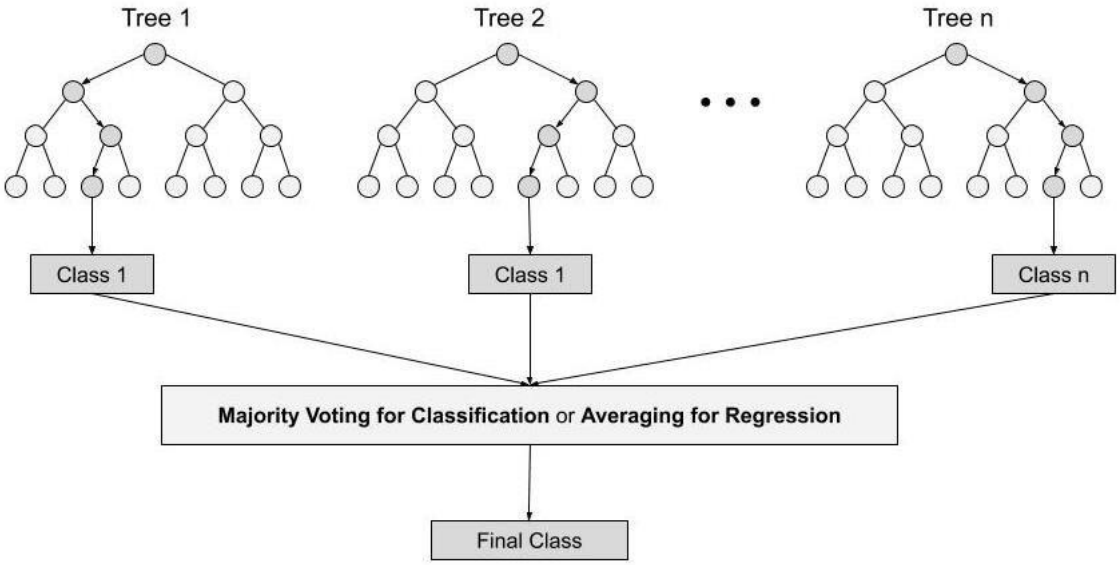
Steps involved in random forest algorithm:

Step 1: In Random forest n number of random records are taken from the data set having k number of records.

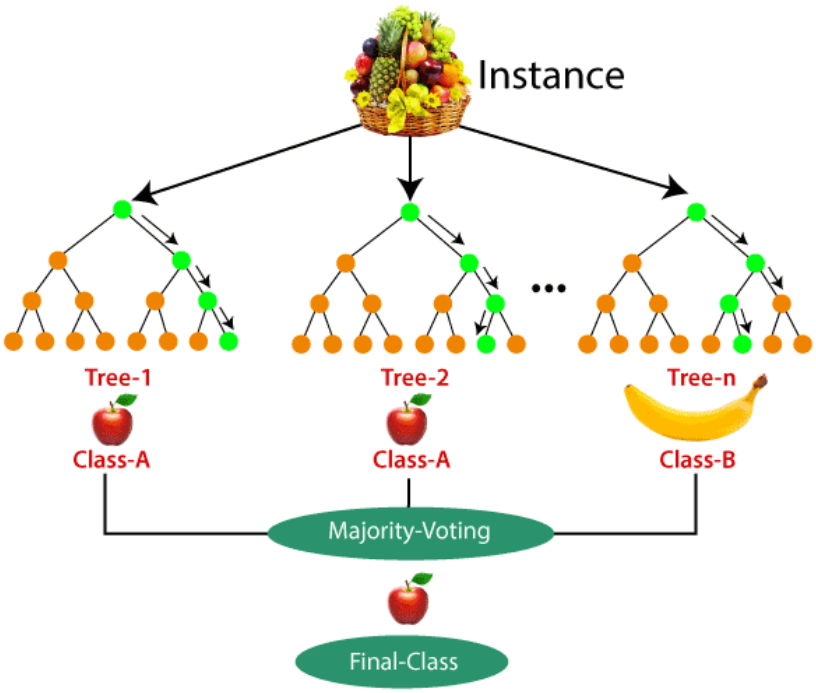
Step 2: Individual decision trees are constructed for each sample.

Step 3: Each decision tree will generate an output.

Step 4: Final output is considered based on ***Majority Voting or Averaging*** for Classification and regression respectively.



For example: consider the fruit basket as the data as shown in the figure below. Now n number of samples are taken from the fruit basket and an individual decision tree is constructed for each sample. Each decision tree will generate an output as shown in the figure. The final output is considered based on majority voting. In the below figure you can see that the majority decision tree gives output as an apple when compared to a banana, so the final output is taken as an apple.



Important Features of Random Forest

1. Diversity- Not all attributes/variables/features are considered while making an individual tree, each tree is different.

2. Immune to the curse of dimensionality- Since each tree does not consider all the features, the feature space is reduced.

3. Parallelization-Each tree is created independently out of different data and attributes. This means that we can make full use of the CPU to build random forests.

4. Train-Test split- In a random forest we don't have to segregate the data for train and test as there will always be 30% of the data which is not seen by the decision tree.

5. Stability- Stability arises because the result is based on majority voting/ averaging.

Difference between Decision Tree & Random Forest

Random forest is a collection of decision trees; still, there are a lot of differences in their behavior.

Decision trees	**Random Forest**
1. Decision trees normally suffer from the problem of overfitting if it's allowed to grow without any control.	1. Random forests are created from subsets of data and the final output is based on average or majority ranking and hence the problem of overfitting is taken care of.
2. A single decision tree is faster in computation.	2. It is comparatively slower.
3. When a data set with features is taken as input by a decision tree it will formulate some set of rules to do prediction.	3. Random forest randomly selects observations, builds a decision tree and the average result is taken. It doesn't use any set of formulas.

Thus random forests are much more successful than decision trees only if the trees are diverse and acceptable.

Important Hyperparameters

Hyperparameters are used in random forests to either enhance the performance and predictive power of models or to make the model faster.

Following hyperparameters increases the predictive power:

1. **n_estimators**– number of trees the algorithm builds before averaging the predictions.

2. ***max_features***– maximum number of features random forest considers splitting a node.

3. ***mini_sample_leaf***– determines the minimum number of leaves required to split an internal node.

Following hyperparameters increases the speed:

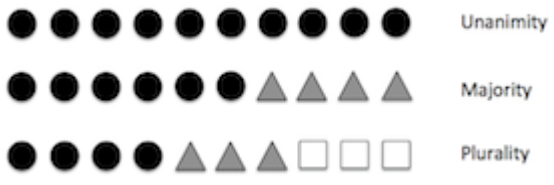
1. ***n_jobs***– it tells the engine how many processors it is allowed to use. If the value is 1, it can use only one processor but if the value is -1 there is no limit.

2. ***random_state***– controls randomness of the sample. The model will always produce the same results if it has a definite value of random state and if it has been given the same hyperparameters and the same training data.

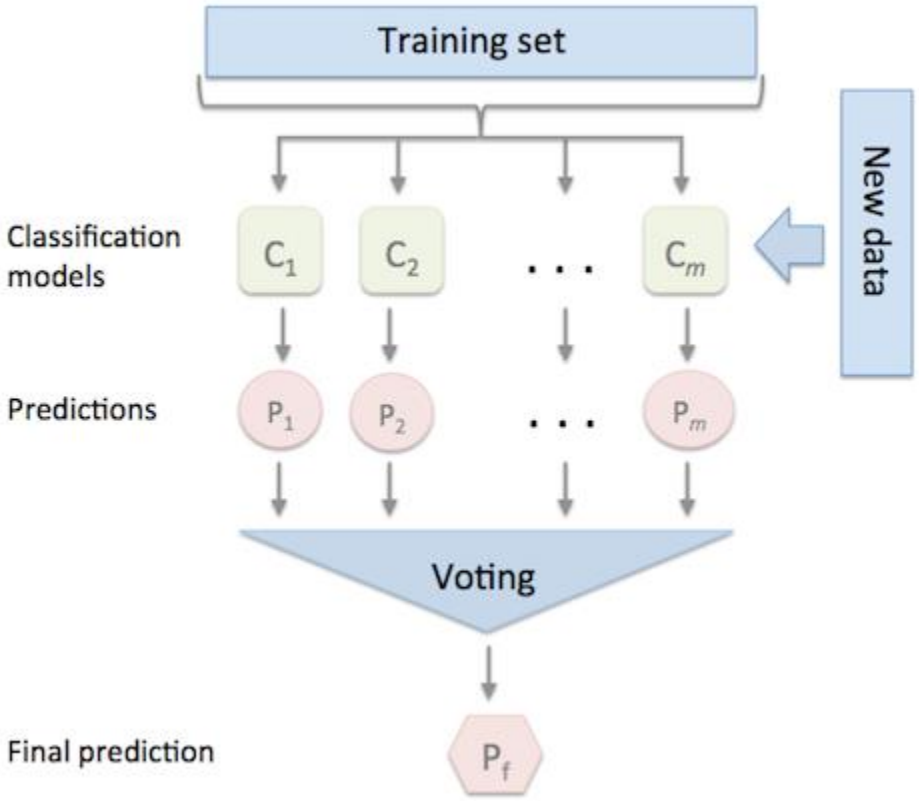
3. ***oob_score*** – *OOB* means out of the bag. It is a random forest cross-validation method. In this one-third of the sample is not used to train the data instead used to evaluate its performance. These samples are called out of bag samples.

4.4 ENSEMBLE VOTING CLASSIFIER

- The Ensemble Voting Classifier is a meta-classifier for combining similar or conceptually different machine learning classifiers for classification via majority or plurality voting. (For simplicity, we will refer to both majority and plurality voting as majority voting.)



- The EnsembleVoteClassifier implements "hard" and "soft" voting. In hard voting, we predict the final class label as the class label that has been predicted most frequently by the classification models. In soft voting, we predict the class labels by averaging the class-probabilities (only recommended if the classifiers are well-calibrated).



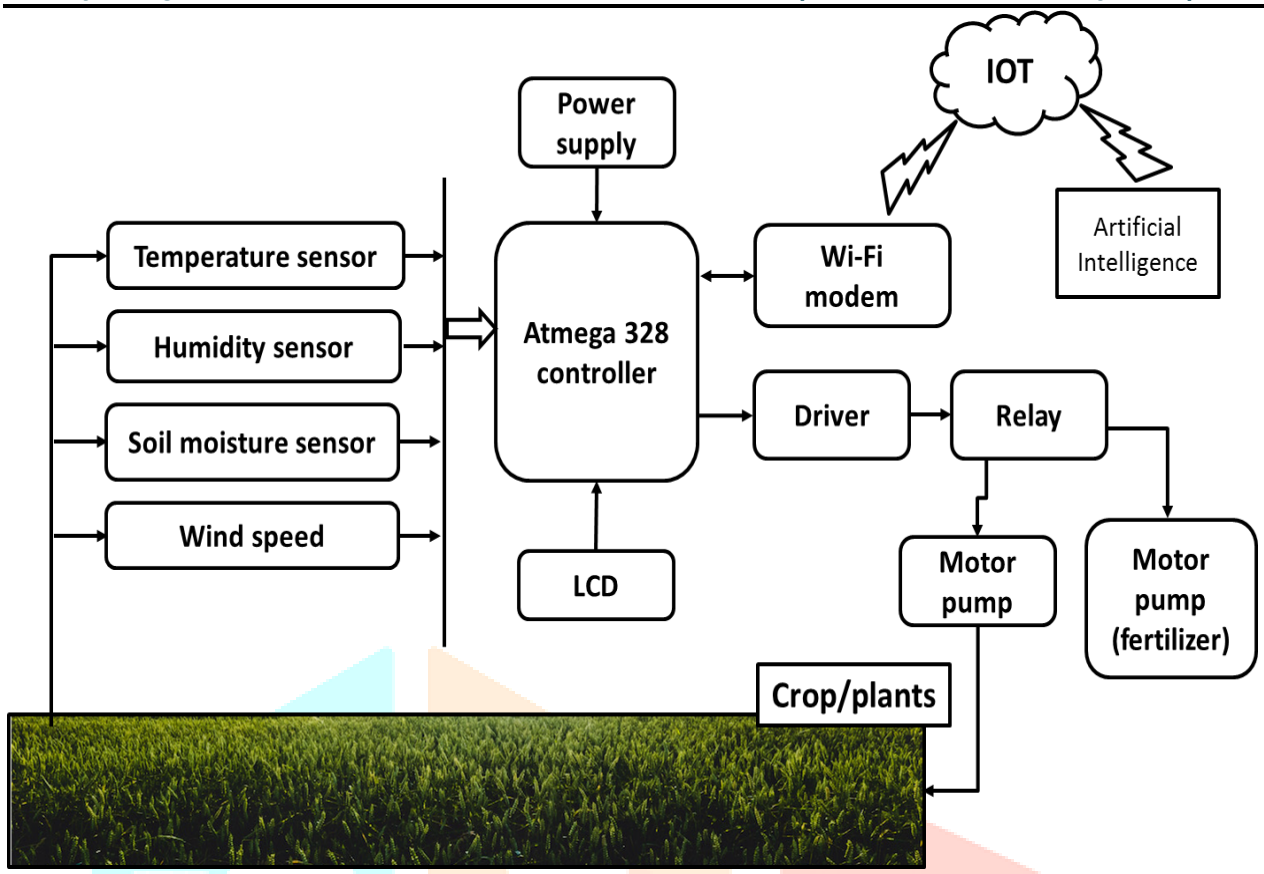
HARD VOTING

- Hard voting is the simplest case of majority voting. Here, we predict the class label y^y^ via majority (plurality) voting of each classifier CjCj:
- y^=mode{C1(x),C2(x),...,Cm(x)}

CHAPTER V

HARDWARE IMPLEMENTATION

5.1 BLOCK DIAGRAM



Block Description

Atmega328p microcontroller

This microcontroller is used for doing all the operation that are intertied for the microcontroller to be performed. In our case we have connected various sensor to this microcontroller. The sensed values will be analog. This microcontroller has inbuilt ADC i.e. analog to digital converter so no need of any external ADC circuits to be implemented. And also this Atmega IC has a Transmission/Reception serial communication port using this port we can connected wireless communication device. The port of this microcontroller can be utilized for connecting and controlling the load. In our project load are the two 12v Pump motor for water supply and fertilizer.

LCD

The LCD are connected to the microcontroller for display the reading of the sensor and to show the operation that is performed.

Wi-Fi modem

The Wi-Fi modem is a wireless communication device which is used for sending the data to the IoT server. The Wi-Fi modem is connected to the microcontroller using serial port pin Tx and Rx. These data can be view using a web portal.

Drivers and Relay

The driver is used for controlling the load motor using a switching mechanism. That is known as relay. Here in our project we are using a 12v relay and driver IC is ULN2003A. The relay becomes active whenever microcontroller send a pulse signal to the driver IC. The load of that particular terminal become active.

Temperature Sensor

The temperature sensor is used for sensing the temperature of the surround. We use LM35 sensor for our experiments.

Humidity Sensor

The Humidity Sensor is used for sensing the moisture levels in the air in the surroundings in our case it is agricultural field. We have used DHT11.

Soil Moisture Sensor

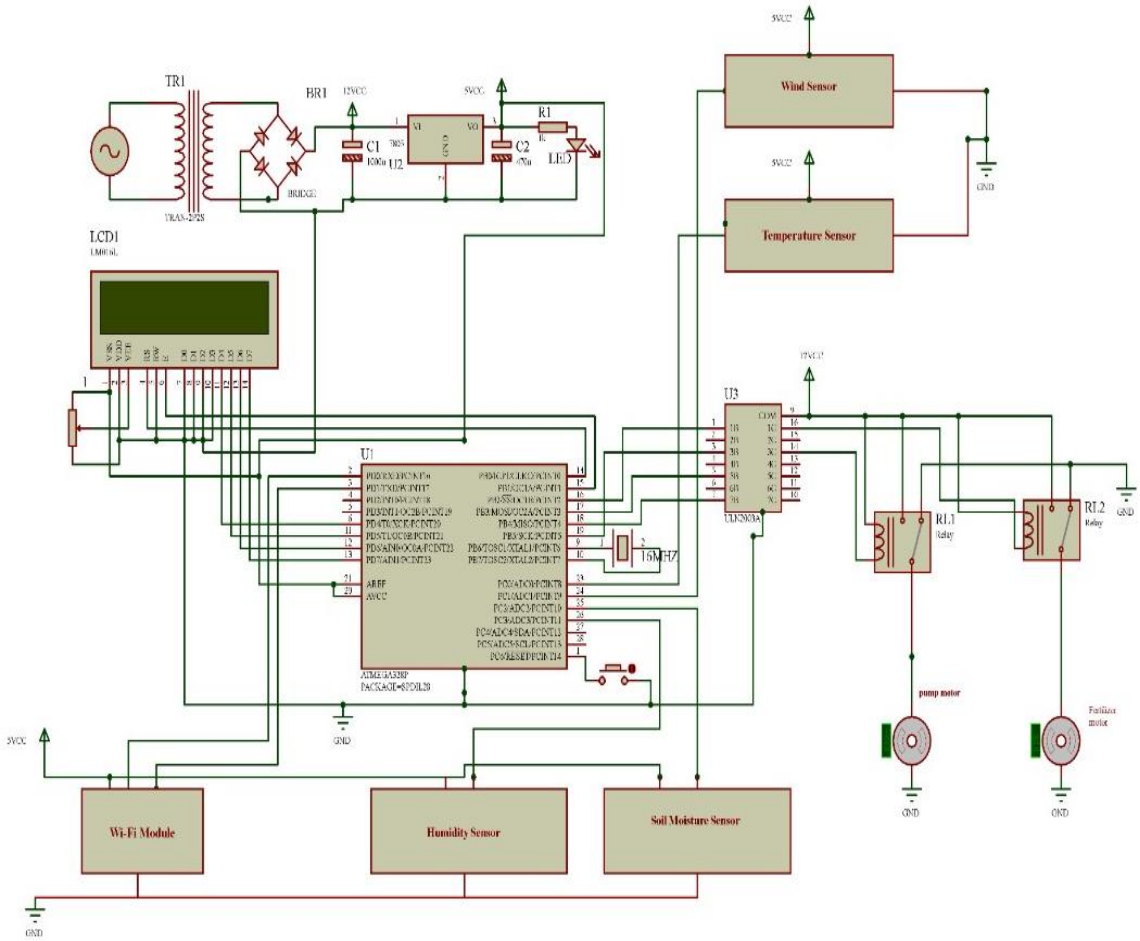
This sensor is used for sensing the moisture content in the soil using a conductivity.

For sensing wind we have used a variable pot for giving a variable wind source generated value to the microcontroller. These value are used for analysis also.

Power Supply unit

A power supply unit is used for giving supply to all the components of our project design.

5.2 Circuit Diagram



5.2 Hardware Description

1. ATMEGA 328

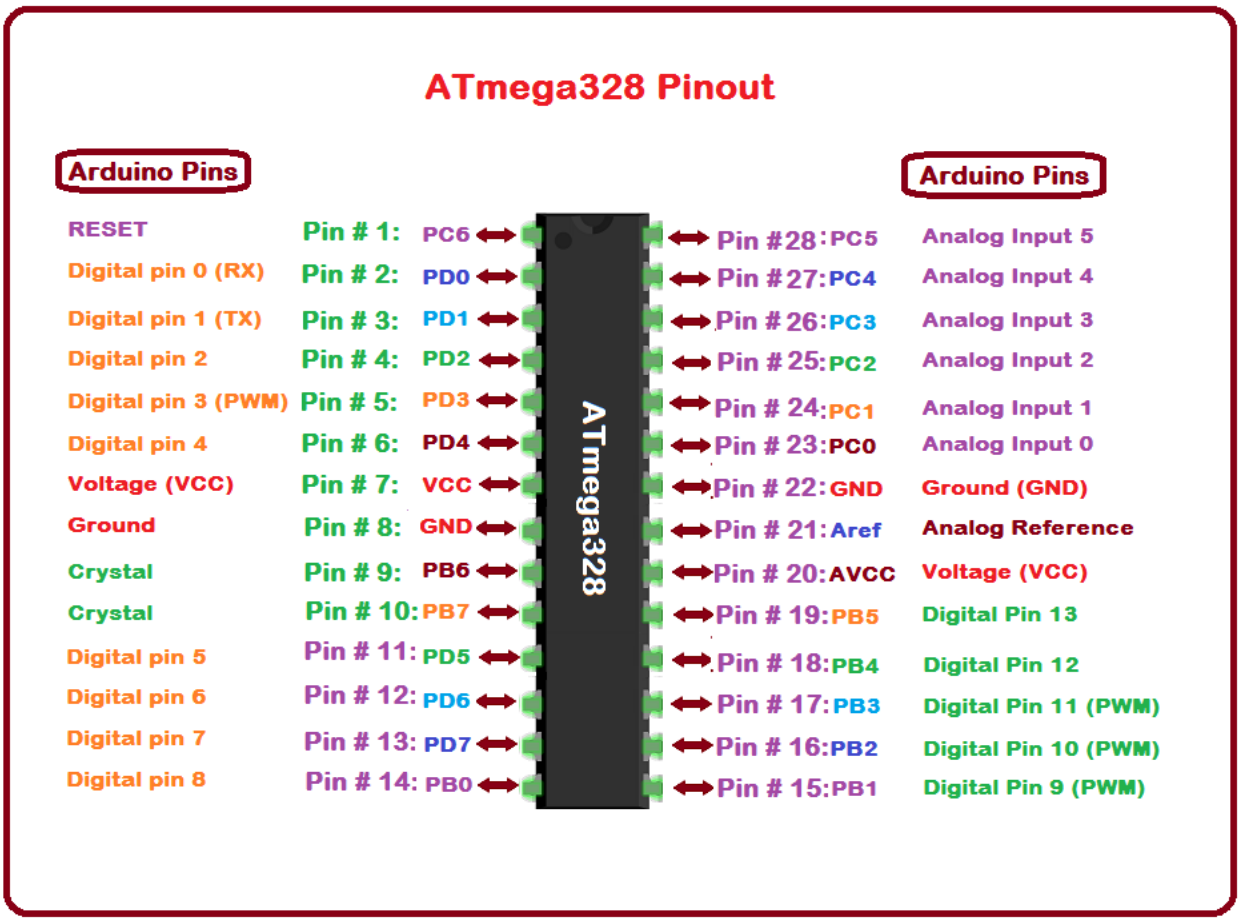
ATmega328 is an 8-bit and 28 Pins AVR Microcontroller, manufactured by Microchip, follows RISC Architecure and has a flash type program memory of 32KB. It has an EEPROM memory of 1KB and its SRAM memory is of 2KB. It has 8 Pin for ADC operations, which all combines to form PortA (PA0 – PA7). It also has 3 builtin Timers, two of them are 8 Bit timers while the third one is 16-Bit Timer. You must have heard of Arduino UNO, UNO is based on atmega328 Microcontroller. It's UNO's heart. It operates ranging from 3.3V to 5.5V but normally we use 5V as a standard. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, and real timer counter with separate oscillator. It's normally used in Embedded Systems applications.

Atmega328 pin out:

Through pinout diagram we can understand the configurations of the pins of any electronic device, so you are working on any Engineering Project then you must first read the components' pinout.

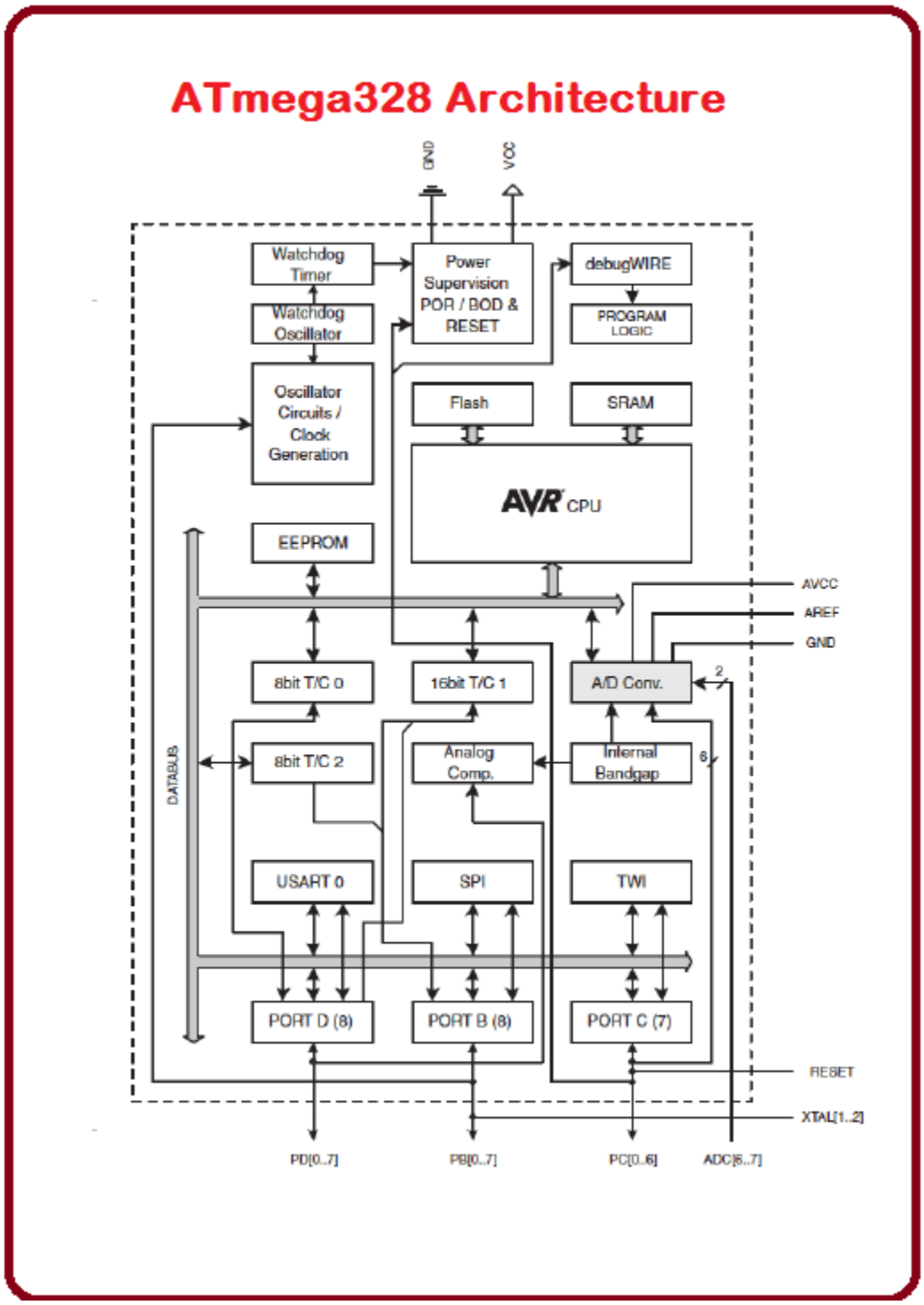
- Functions associated with the pins must be known in order to use the device appropriately.

- ATmega-328 pins are divided into different ports which are given in detail below.
  - VCC is a digital voltage supply.
  - AVCC is a supply voltage pin for analog to digital converter.
  - GND denotes Ground and it has a 0V.
  - Port A consists of the pins from PA0 to PA7. These pins serve as analog input to analog to digital converters. If analog to digital converter is not used, port A acts as an eight (8) bit bidirectional input/output port.
  - Port B consists of the pins from PB0 to PB7. This port is an 8 bit bidirectional port having an internal pull-up resistor.
  - Port C consists of the pins from PC0 to PC7. The output buffers of port C has symmetrical drive characteristics with source capability as well high sink.
  - Port D consists of the pins from PD0 to PD7. It is also an 8 bit input/output port having an internal pull-up resistor.



ATmega-328 architecture

An architecture of a device presents each information about the particular device.



Memory:

- ATmega 328 has three types of memories e.g. EEPROM, SRAM etc.
- The capacity of each memory is explained in detail below.

Flash Memory has 32KB capacity. It has an address of 15 bits. It is a Programmable Read Only Memory (ROM). It is non volatile memory.

SRAM stands for Static Random Access Memory. It is a volatile memory i.e. data will be removed after removing the power supply.

EEPROM stands for Electrically Erasable Programmable Read Only Memory. It has a long term data.

Registers:

- ATmega-328 has thirty two (32) General Purpose (GP) registers.
- These all of the registers are the part of Static Random Access Memory (SRAM).

Applications:

- A complete package including ATmega 328 and Arduino can be used in several different real life applications.
- It can be used in Embedded Systems Projects.
- It can also be used in robotics.
- Quad-copter and even small aero-plane can also be designed through it.
- Power monitoring and management systems can also be prepared using this device.

Features:

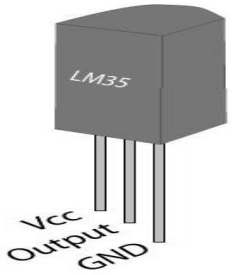
- High Performance, Low Power Design
- 8-Bit Microcontroller Atmel® AVR® advanced RISC architecture
  - 131 Instructions most of which are executed in a single clock cycle
  - Up to 20 MIPS throughput at 20 MHz
  - 32 x 8 working registers
  - 2 cycle multiplier
- Memory Includes
  - 32KB of of programmable FLASH
  - 1KB of EEPROM
  - 2KB SRAM
  - 10,000 Write and Erase Cycles for Flash and 100,000 for EEPROM
  - Data retention for 20 years at 85°C and 100 years at 25°C
  - Optional boot loader with lock bits
  - In System Programming (ISP) by via boot loader
  - True Read-While-Write operation
  - Programming lock available for software security
- I/O and Package
  - 23 programmable I/O lines
  - 28 pin PDIP package
- Operating voltage:1.8 - 5.5V
- Operating temperature range:40°C to 85°C

- Speed Grades:
  - 0-4 MHz at 1.8-5.5V
  - 0-10 MHz at 2.7-5.5V
  - 0-20 MHz at 4.5-5.5V
- Low power consumption mode at 1.8V, 1 MHz and 25°C:
  - Active Mode: 0.3 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.8 µA (Including 32 kHz RTC)
- Package: Lead Free PDIP 28

2) TEMPERATURE SENSOR- LM35

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4˚C at room temperature and ±3⁄4˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available pack aged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Pin Diagram:



Pin Description:

Pin No	Function	Name
1	Supply voltage; 5V (+35V to -2V)	Vcc
2	Output voltage (+6V to -1V)	Output
3	Ground (0V)	Ground

Features

- Calibrated directly in ˚ Celsius (Centigrade)
- Linear + 10.0 mV/˚C scale factor
- 0.5˚C accuracy guarantee able (at +25˚C)
- Rated for full −55˚ to +150˚C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08˚C in still air
- Nonlinearity only ±1⁄4˚C typical
- Low impedance output, 0.1 Ω for 1 mA load

3) SOIL MOISTURE SENSOR

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.

Water is needed for the fundamental growth of plants. When sufficient amount of water is not present at the time of plant needs, then eventually the plant can prompt lessened quality or demise. Since it is very hectic for human to look after plants all the time, engineers designed soil moisture sensors to lessen the burden. Now using the sensor system designer can build any types of system that can look after the water needs of plant.

Sensor description:

This DFRobot soil moisture sensor has two probes through which current passes in soil, then read the resistance of soil for reading moisture level. We know that water make the soil more prone to electric conductivity resulting less resistance in soil where on the other hand dry soil has poor electrical conductivity thus more resistance in soil. Using these properties of electricity the sensor is designed. Inside the sensor there are circuitry for measuring the resistance and converting it into voltage as output.

Features:

1. Supply voltage: 3.3v – 5v
2. Output voltage: 0- 4.2 v
3. Current: 35mA
4. Low power consumption

WIRING:

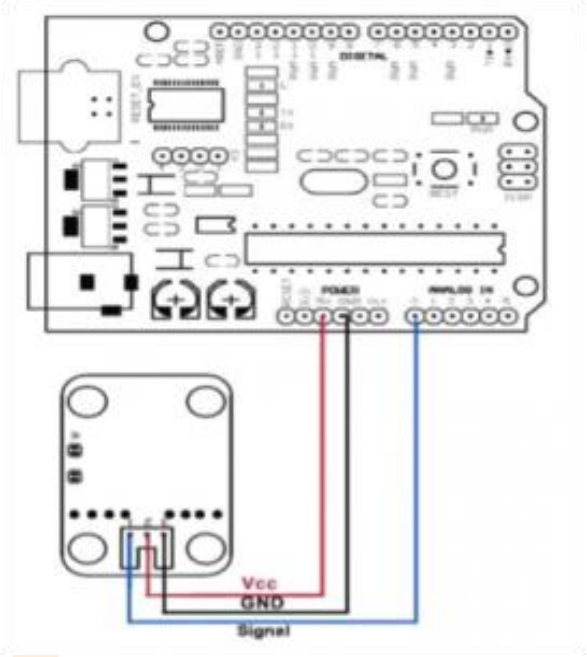


Figure 2: soil moisture sensor interfacing with Arduino Uno

Arduino	Soil Moisture sensor
A0	S (pin 3)
5V	VCC (pin 1)
GND	GND (pin 2)

For this sensor no extra circuit is not required to construct so the data pin of soil moisture sensor which is pin 3 is directly connected with Arduino Uno's analog I/O pin. In this project this pin is connected with Arduino Uno's analog pin A0. However the question arises as to why analog pin? The reason behind using analog I/O pin is because the sensor provides analog voltage as output. Since Arduino Uno has analog-to-digital converter (ADC), it saves the hobbyist from hassles. Arduino Uno do all the task using **analog Read ()** function and show analog value.

Applications

Agriculture

Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

Landscape irrigation

In urban and suburban areas, landscapes and residential lawns are using soil moisture sensors to interface with an irrigation controller. Connecting a soil moisture sensor to a simple irrigation clock will convert it into a "smart" irrigation controller that prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event.

Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground.

Research

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

Simple sensors for gardeners

Relatively cheap and simple devices that do not require a power source are available for checking whether plants have sufficient moisture to thrive. After inserting a probe into the soil for approximately 60 seconds, a meter indicates if the soil is too dry, moist or wet for plants

4) DTH11 - Humidity Sensor

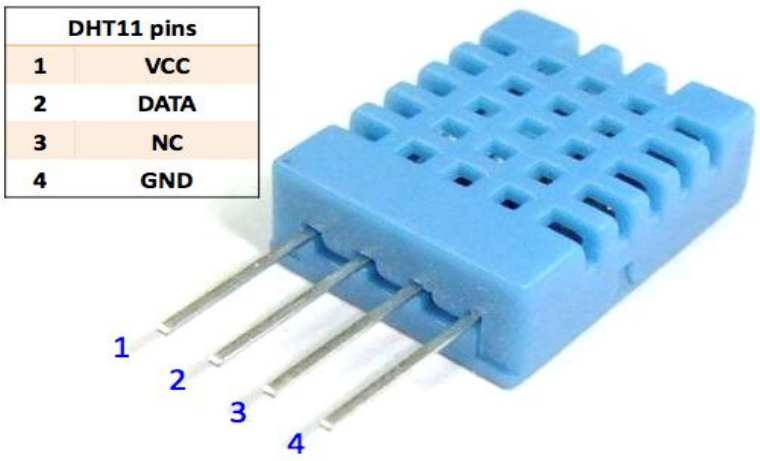
The DHT11Temperature & Humidity Sensor features a temperature& humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability.

This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

Each DHT11 sensor is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy.

Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according tousers' request.

Pin diagram

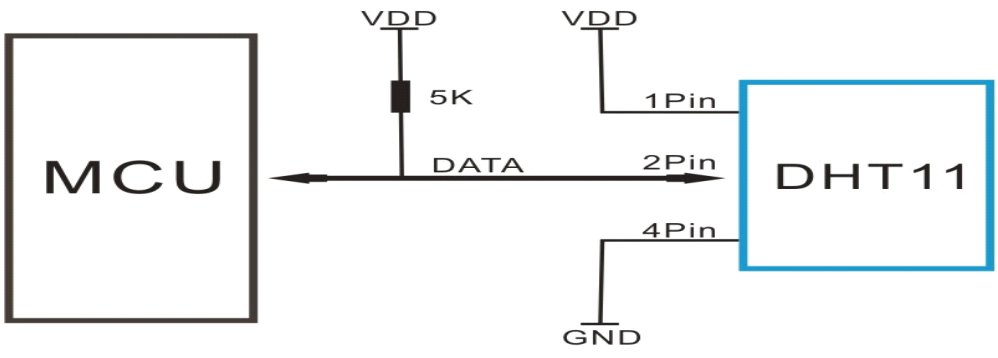


Simply ignore pin 3, its not used. You will want to place a 10K resistor between VCC and the data pin, to act as a medium-strength pull up on the data line. The Arduino has built in pull-ups you can turn on but they're very weak, about 20-50K.

Technical Specifications:

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5％RH	±2℃	1	4 Pin Single Row

Typical Application



3Pin – Null; MCU = Micro-computer Unite or single chip Computer

When the connecting cable is shorter than 20 meters, a 5K pull-up resistor is recommended; when the connecting cable is longer than 20 meters, choose a appropriate pull-up resistor as needed.

Power and Pin

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

Communication Process: Serial Interface (Single-Wire Two-Way)

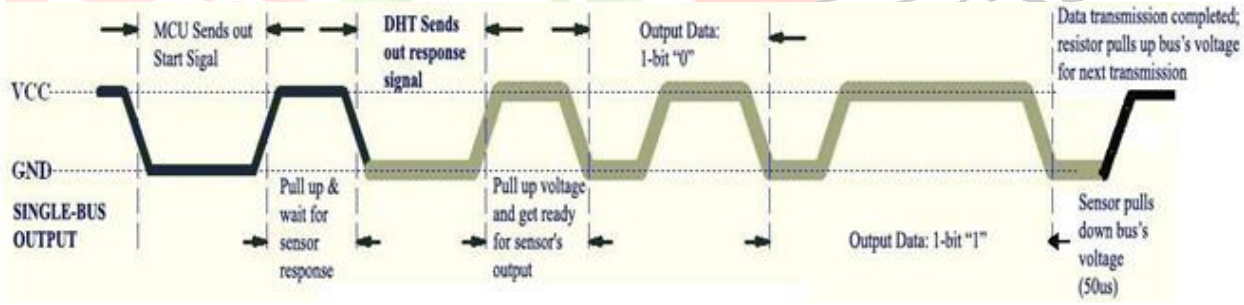
Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms. Data consists of decimal and integral parts. A complete data transmission is **40bit**, and the sensor sends **higher data bit** first.

Data format:

8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is right, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data".

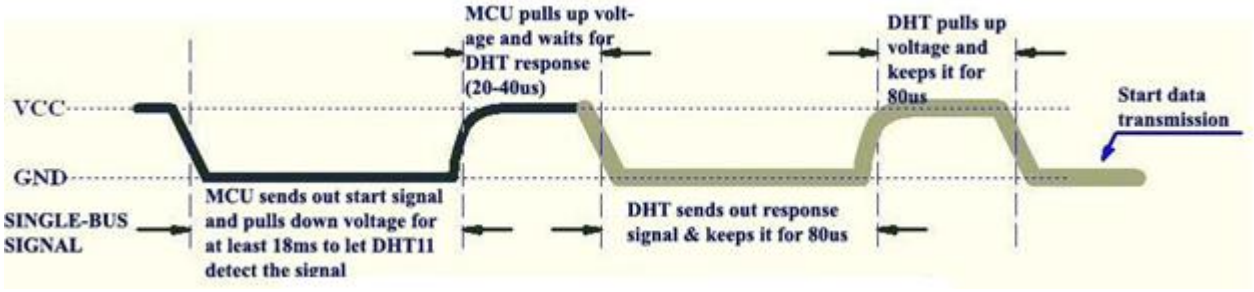
Overall Communication Process

When MCU sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for MCU completing the start signal. Once it is completed, DHT11 sends a response signal of 40-bit data that include the relative humidity and temperature information to MCU. Users can choose to collect (read) some data. Without the start signal from MCU, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the low-power-consumption mode until it receives a start signal from MCU again.



MCU Sends out Start Signal to DHT (Figure 3, below)

Data Single-bus free status is at high voltage level. When the communication between MCU and DHT11 begins, the programme of MCU will set Data Single-bus voltage level from high to low and this process must take at least 18ms to ensure DHT's detection of MCU's signal, then MCU will pull up voltage and wait 20-40us for DHT's response.

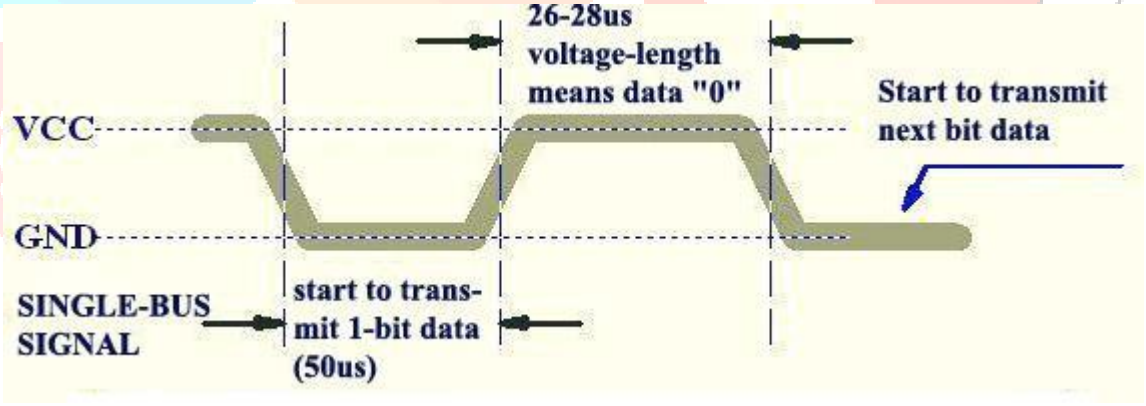


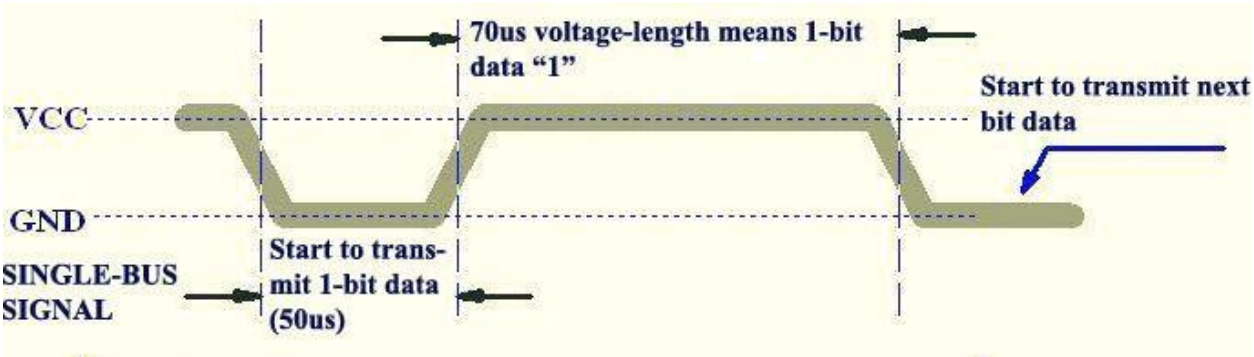
DHT Responses to MCU

Once DHT detects the start signal, it will send out a low-voltage-level response signal, which lasts 80us. Then the programme of DHT sets Data Single-bus voltage level from low to high and keeps it for 80us for DHT's preparation for sending data.

When DATA Single-Bus is at the low voltage level, this means that DHT is sending the response signal. Once DHT sent out the response signal, it pulls up voltage and keeps it for 80us and prepares for data transmission.

When DHT is sending data to MCU, every bit of data begins with the 50us low-voltage-level and the length of the following high-voltage-level signal determines whether data bit is "0" or "1" (see Figures 4 and 5 below).





If the response signal from DHT is always at high-voltage-level, it suggests that DHT is not responding properly and please check the connection. When the last bit data is transmitted, DHT11 pulls down the voltage

level and keeps it for 50us. Then the Single-Bus voltage will be pulled up by the resistor to set it back to the free status.

Electrical Characteristics

VDD=5V, T = 25℃ (unless otherwise stated)

	Conditions	Minimum	Typical	Maximum
Power Supply	DC	3V	5V	5.5V
Current Supply	Measuring	0.5mA		2.5mA
	Average	0.2mA		1mA
	Standby	100uA		150uA
Sampling period	Second	1		

Note: Sampling period at intervals should be no less than 1 second.

Applications

- HVAC,
- dehumidifier,
- testing and inspection equipment,
- consumer goods,
- automotive,
- automatic control,
- data loggers,
- weather stations,
- home appliances,
- humidity regulator,
- Medical and other humidity measurement and control.

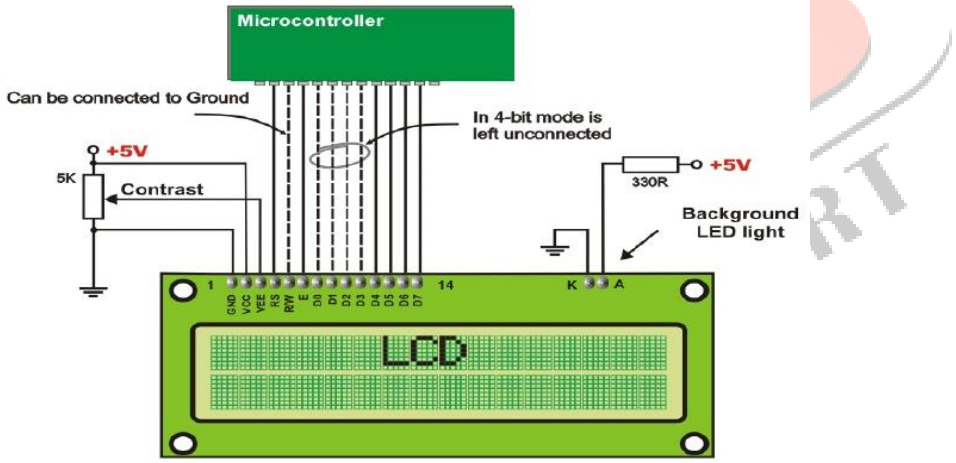
Features

- Low cost,
- long-term stability,
- relative humidity and temperature measurement
- excellent quality,
- fast response,
- strong anti-interference ability,
- long distance signal transmission,

- digital signal output, and precise calibration

5. LCD DISPLAY

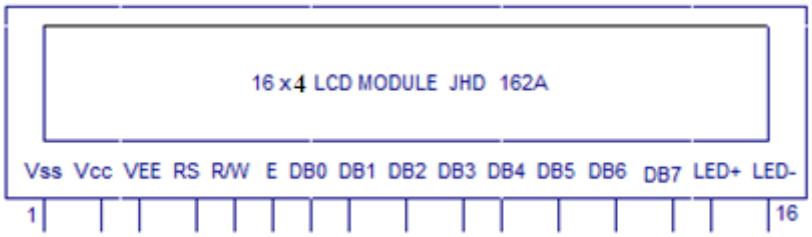
Liquid Crystal Displays (LCDs) have materials, which combine the properties of both liquid and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarizer are pasted outside the two glass panels. This polarizer would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarizer and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction.



The LCDs are lightweight with only a few millimeters thickness. Since the LCD's consume power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD does don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size of the layout size is relatively simple which makes the LCD's more customers friendly. The LCD's used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

LCD module 16×4

It has 16 pins and can be operated in 4-bit mode or 8-bit mode. Here we are using the LCD module in 4-bit mode. Before going in to the details of the project, let's have a look at the JHD162A LCD module.



Pin of the JHD162A LCD module is given below.

Pin1 (Vss): Ground pin of the LCD module.

Pin2 (Vcc):+5V supply is given to this pin.

Pin3 (VEE): Contrast adjustment pin. This is done by connecting the ends of a 10K potentiometer to +5V and ground and then connecting the slider pin to the VEE pin. The voltage at the VEE pin defines the contrast. The normal setting is between 0.4 and 0.9V.

Pin4 (RS): Register select pin. The JHD162A has two registers namely command register and data register. Logic HIGH at RS pin selects data register and logic LOW at RS pin will select command register. If we make the RS pin HIGH and put a data on the data lines (DB0 to DB7) it will be recognized as a data. If we make the RS pin LOW and put a data on the data lines, then it will be taken as a command.

Pin5 (R/W): Read/Write modes. This pin is used for selecting between read and write modes. Logic HIGH at this pin activates read mode and logic LOW at this pin activates write mode.

Pin6 (E): This pin is meant for enabling the LCD module. A HIGH to LOW signal at this pin will enable the module.

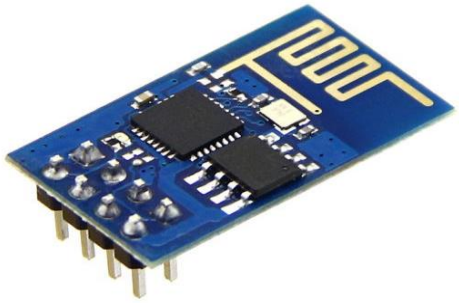
Pin7 (DB0) to Pin14 (DB7): These are data pins. The commands and data are put on these pins.

Pin15 (LED+): Anode of the back light LED. When operated on 5V, a 560 ohm resistor should be connected in series to this pin. In arduino based projects the back light LED can be powered from the 3.3V source on the arduino board.

Pin16 (LED-): Cathode of the back light LED.

6. Wi-Fi Module

ESP8266 is Wi-Fi enabled system on chip (SoC) module developed by Espressif system. It is mostly used for development of IoT (Internet of Things) embedded applications.



ESP8266-01 WiFi Module

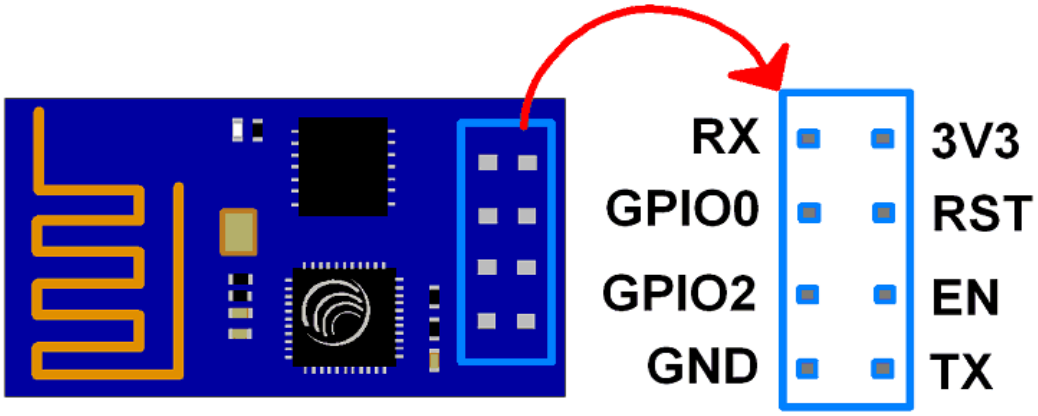
ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
- general-purpose input/output (16 GPIO),
- Inter-Integrated Circuit (I^2C) serial communication protocol,
- analog-to-digital conversion (10-bit ADC)
- Serial Peripheral Interface (SPI) serial communication protocol,
- I^2S (Inter-IC Sound) interfaces with DMA(Direct Memory Access) (sharing pins with GPIO),
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and
- Pulse-width modulation (PWM).

It employs a 32-bit RISC CPU based on the Tensilica Xtensa L106 running at 80 MHz (or overclocked to 160 MHz). It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

ESP8266 module is low cost standalone wireless transceiver that can be used for end-point IoT developments. To communicate with the ESP8266 module, microcontroller needs to use set of AT commands. Microcontroller communicates with ESP8266-01 module using UART having specified Baud rate.

Module Pin Description



ESP8266-01 Module Pins

- **3V3**: - 3.3 V Power Pin.
- **GND**: - Ground Pin.
- **RST**: - Active Low Reset Pin.
- **EN**: - Active High Enable Pin.
- **TX**: - Serial Transmit Pin of UART.
- **RX**: - Serial Receive Pin of UART.
- **GPIO0 & GPIO2**: - General Purpose I/O Pins. These pins decide what mode (boot or normal) the module starts up in. It also decides whether the TX/RX pins are used for Programming the module or for serial I/O purpose.

To program the module using UART, Connect GPIO0 to ground and GPIO2 to VCC or leave it open. To use UART for normal Serial I/O leave both the pins open (neither VCC nor Ground).

7. **DRIVER:**

Driver is used for drive the relay. ULN2003A IC is used as driver. This IC has some special features

- Seven Darlington's per package
- output current 500ma per driver (600ma peak)
- output voltage 50v
- integrated suppression diodes for inductive loads
- outputs can be paralleled for higher current
- ttl/cmos/pmos/dtl compatible inputs

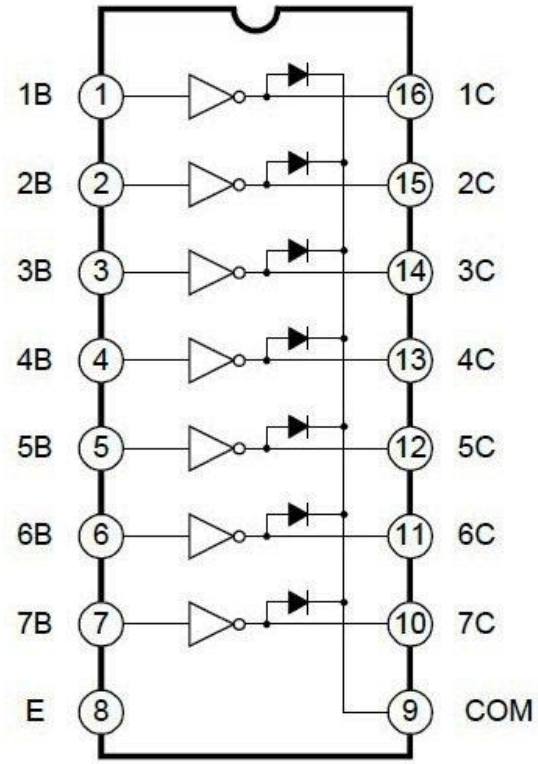
DESCRIPTION

The ULN2001A, ULN2002A, ULN2003 and ULN2004Aare high voltage, high current Darlington arrays each containing seven open collector dar-lington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. The four versions interface to all common logic families

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors; LED displays filament lamps, thermal print-head sand high power buffers ULN2001A/2002A/2003Aand 2004A is sup-plied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

Pin Diagram – ULN 2003



The ULN2003A is a high voltage, high current, Darlington Arrays each containing seven open collection Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite to outputs to simplify layout. It is a 5V TTL, CMOS. This versatile device is useful for driving a wide range of loads including solenoids, relays, DC motors, LED displays, and high power buffers. Outputs can be paralleled for higher current.

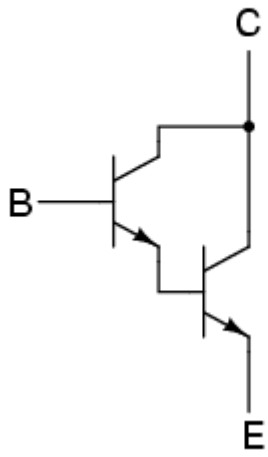
The output of MC is applied to the input of relay driver transistor at its phase terminals. When the input base voltage is reduced so that the relay is de-energized, the collector current falls to zero abruptly. This sudden switching off the relay current induces a very high back emf in the relay coils, which may be high enough to puncture the collector-emitter junction at the transistor and damage it. A large capacitor connected in parallel with the relay coil absorbs this transient and protects the transistor. However large capacitor connected in parallel with the relay coil absorbs this transient, protects the transistor and sluggish the relay operations.

In an alternative method, a diode is connected in parallel with relay coil instead of the capacitor. During normal operation, the diode is reversed biased and has no effects on circuit performance, but, when the high back emf is induced, it has the proper polarity for the diode to conduct. The diode there after conducts heavily and absorbs all the transient voltage. The use of a diode is parallel with the relay coil is highly recommended.

Working of ULN2003 IC:

The ULN2003 IC consists of eight NPN Darlington pair which provides the proper current amplification required by the loads. We all know that the transistors are used to amplify the current but here Darlington transistor pairs are used inside the IC to make the required amplification.

An NPN "Darlington pair"



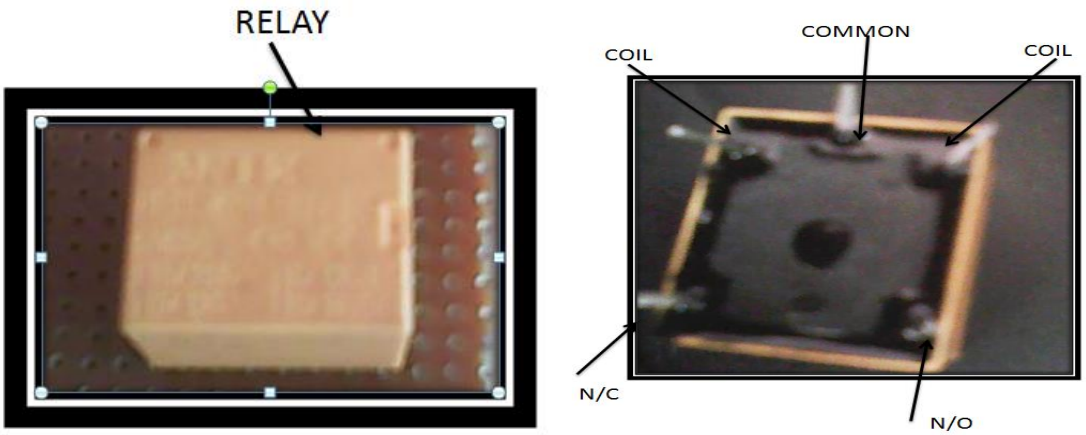
A Darlington pair is two transistors that act as a single transistor providing high current gain. In this pair the current amplified by the first transistor is further amplified by the next transistor providing high current to the output terminal.

When no base voltage is applied that when no signal is given to the input pins of the IC, there will be no base current and transistor remains in off state. When high logic is fed to the input both the transistors begin to conduct providing a path to ground for the external load that the output is connected. Thus when an input is applied corresponding output pin drops down to zero there by enabling the load connected to complete its path.

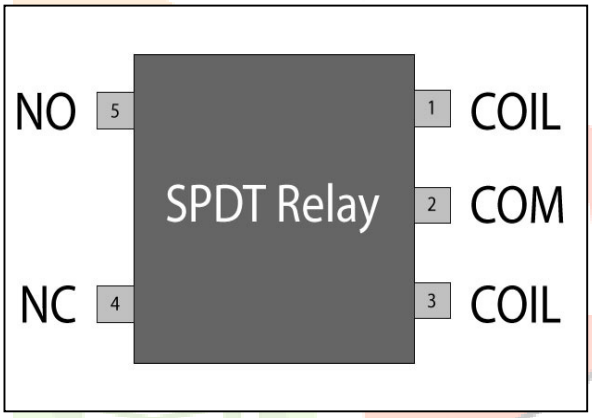
Features:

- Output Voltage: 50 V
- Input Voltage (for ULN2002A/D - 2003A/D - 2004A/D): 30 V
- Continuous Collector Current: 500 mA
- Continuous Base Current: 25 mA
- Operating Ambient Temperature Range: – 20 to 85 °C
- Storage Temperature Range: – 55 to 150 °C
- Junction Temperature: 150 °C

RELAY



Relay Pin Diagram

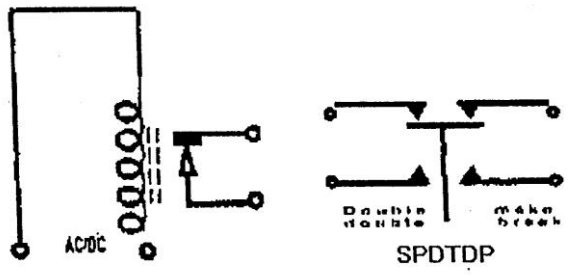


Relays are switching devices. Switching devices are the heart of industrial electronic systems. When a relay is energized or activated, contacts are made or broken. They are used to control ac or dc power. They are used to control the sequence of events in the operation of a system such as an electronic heater, counter, welding circuits, and X-ray equipment, measuring systems, alarm systems and telephony. Electromagnetic relays are forms of electromagnets in which the coil current produces a magnetic effect. It pulls or pushes flat soft iron armatures or strips carrying relay contacts. Several relay contact can be operated to get several possible ON/OFF combinations.

OPERATION OF ELECTROMAGNETIC RELAY

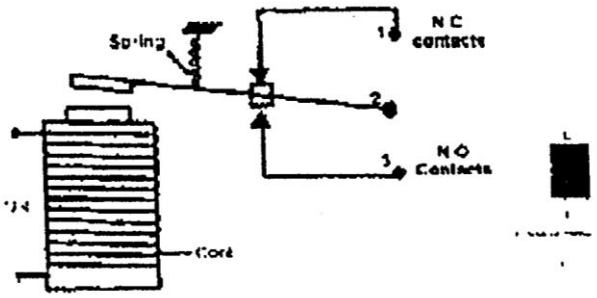
Relays are usually dc operated. When dc is passed to the coil, the core gets magnetized. The iron armature towards the core contacts 1 and 2 open and contacts 2 and 3 close. When coil current is stopped, the attraction is not there and hence the spring tension brings 1 and 2 to closed position, opening the other set 2 and 3.

Fig (28)



Electromagnetic Relay

Fig (29)



Relay Contacts and Identification

The heart of the relay is the 'junction' of the contact points. The relay contact points may be flat, spherical, pointed and combination of all these. Flat contacts require more pressure for perfect contact closing. Half round contacts are better because the surface contamination will be minimum. The twin contacts give reliable operation.

Relay contacts are made of silver and silver alloys in small power applications. For large relays, contacts are made up of copper. Certain relays use silver – palladium of platinum – ruthenium alloys for contacts. The special types mentioned above give long life, carry moderate currents and keep shape for long time.

To identify relay contacts, some important contact arrangements must be remembered.

SPST - Single Pole Single Throw

SPDT - Single Pole Double Throw

NO - Normally Opened

NC - Normally Closed

Break - Relay action opens or breaks contacts

Make - Relay action makes or closes contacts

Relays are electromagnetic device by which operation of one or more circuits can be controlled by the operation of some other circuit. Relay is a type of switch where switching completely depends upon the electromagnetism. When winding of insulted wire is made on soft iron rod and apply is given across its end then magnetic field develops around the rod and due to this magnetic field, magnetism also becomes magnet. In this way, can be said that on giving supply to the coil winded over a core, it becomes magnet. This magnet is known as electromagnet.

Relay is a device which can turn ON/OFF any external circuit in some special circumstances. The principal relay is a one pole 2 way switch. The difference is that simple switch is manual switch where as relay is an automatic switch to some extent. It has a coil in it.

When this coil gets enough supply then it becomes electromagnet and attracts the strip of pole towards itself and changes the position of switch. When supply cuts off then coil demagnetizes and thus switch comes in its normal position. In telephony, the relays are used widely. The relay that we used in this circuit has two states.

- Normally closed state (NC)
- Normally opened state (NO)

The control circuit of the relay transistor is shown in figure. When the input to transistor is logic 0, the transistor will be open. So the relay will be holding +12 and which will be in normally closed state.

Relays are electro mechanical switches and are electrically operated power switches. A relay consists of an electromagnet which when energized pulls the armature. The armature carries heavy electrical contacts that make or break an electric circuit. General purpose relays can handle current of five or ten amperes. Relays that have contact ratings of about 25A or more are known as contactors. A single relay can make or break a number of contacts simultaneously.

The amount of electrical power required to drive a relay is very small. Most Voltage stabilizers use relay coils of 720mw.It means that 12v relay coil will have resistance of 200 ohms and operated up to 60mA.The same relay with 450 ohms coil will operate on 18v with 40mA.Transistor circuits can easily supply this much of power and this much of power and thus control large amount of power through relay contacts.

When the relay is not activated (ie.) in the reenergized state, NC contacts are closed and NO connections are opened. When the relay is activated (ie.)in the energized state, NC contacts broken and NO contacts are made. When the relay is de energized the original states of the contacts are returned. The Above relays are single contact relays. This means that the relays have one common point, one NO contact and one NC contact.

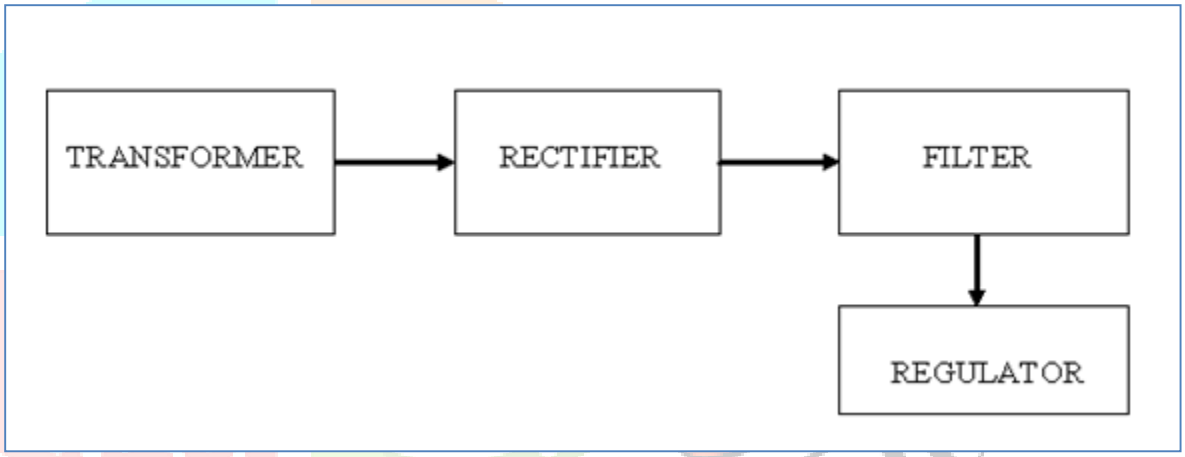
Double contact relays are also present. These relays have a set of common points, a set of NO contacts and set of NC contacts. In single contact relay, only one relay independent load or a series of different loads can be connected.

In double contact relay, two independent loads can be connected at two different contacts and these two different and these two loads can be operated as desired.

POWER SUPPLY

Most electronic circuits require DC voltage sources or power supplies. If the electronic device is to be portable, then one or more batteries are usually needed to provide the DC voltage required by electronic circuits. But batteries have a limited life span and cannot be recharged. The solution is to convert the alternating current lose hold line voltage to a DC voltage source.

BLOCK DIAGRAM FOR POWER SUPPLY



Block diagram of AC to DC power Supply consists,

1. Transformer: Steps the household line voltage up or down as required.

2. Rectifier: Converts ac voltage into dc voltage.

3. Filter: Smooth the pulsating DC voltage to a varying DC voltage.

4. Regulator: Fix the output voltage to constant value.

Brief Introduction to an Electrical Transformer

A Transformer is an electrical device that takes electricity of one voltage and changes it into another voltage. In AC circuits, AC voltage, current and waveform can be transformed with the help of Transformers. Transformer plays an important role in electronic equipment. AC and DC voltage in Power supply equipment are almost achieved by transformer's transformation and commutation. Figure 1 shows the Transformer.

Basically, a Transformer changes electricity from high to low voltage or low to high voltage using two properties of electricity. In an electric circuit, there is magnetism around it. Second, whenever a magnetic field changes (by moving or by changing strength) a voltage is made.

A Transformer takes in electricity at a higher voltage and lets it run through lots of coils wound around an iron core. ". A single-phase Transformer can operate to either increase or decrease the voltage applied to the primary winding. Because the current is alternating, the magnetism in the core is also alternating. Also around the core is an output wire with fewer coils. The magnetism changing back and forth makes a current in the wire. Having fewer coils means less voltage. When it is used to "decrease" the voltage on the secondary winding with respect to the primary it is called a **Step-down Transformer**. When a Transformer is used to "increase" the voltage on its secondary winding with respect to the primary, it is called a **Step-up Transformer**.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to input. This type of Transformer is called an **"Impedance Transformer"** and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

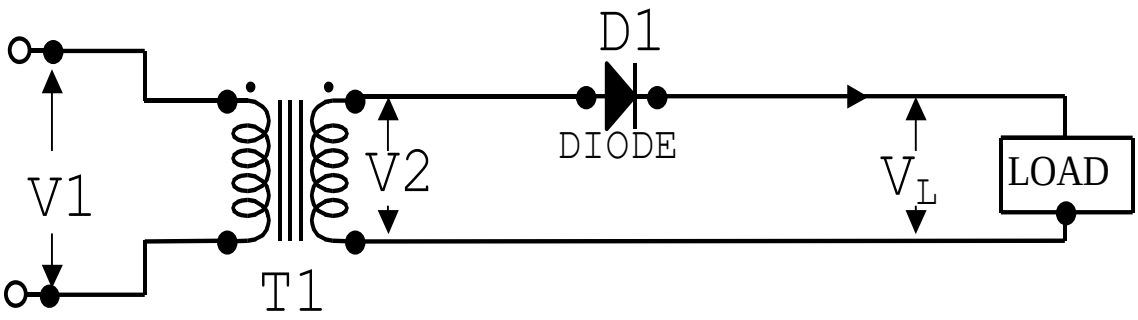
Rectifiers

A rectifier circuit converts an AC voltage into a pulsating DC voltage. This is accomplished by using one or more diodes because diodes conduct current in only one direction.

Types of Rectifiers:

- Half-wave Rectifier
- Full-wave Rectifier
- Full-wave bridge rectifier

Half-wave Rectifier



The transformer (T1) isolates the household voltage and also steps down the household voltage to a more useful voltage level. The diode lets current flow into the load in only one direction. The load current is unidirectional; therefore, it has a significant dc component (or average value).When V2 is positive, diode D1 conducts and V_L=V2. When V2 is negative, diode D1 blocks the current flow and V_L=0volts. The load voltage consists of dc voltage along with ripple voltage. In a half-wave rectifier circuit, the ripple component is larger than the DC component, which is undesirable.

CONCLUSION

In our project we used Hybrid Random forest and linear model algorithm for predicting the load status such as fertilizer and pesticide. We used precision agriculture dataset which holds over 5000 datas for training purpose. After training we predict the load status by using test data's using Hybrid Random forest with Linear model. Our Model Archives more than 96% accuracy during testing and training. The predicted results by our hybrid algorithm is accurate and stable, its patterns are also matched with the existing dataset patterns. And hence our model is perfectly trained and it can able to predict the Load status with high stability. Our future work is to improve the accuracy by using other deep learning techniques.

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