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Research paper

Smart agriculture with big data

Kondapally Madhavi [1] *, Aarthi priya. R [1], K. Suresh [2], Deepa J [1]

[1] Department of IT, BVRIT, Narsapur, Medak, Telangana, India
[2-]Cyber Heights Software Technologies RTC X road, Telangana, India
**Corresponding author E-mail: madhavi.k@bvrit.ac.in*

Abstract

This paper presents the importance of smart agriculture, which is the revolution in traditional farming using new technologies such as big data, Hadoop, R programming and cloud computing. This paper covers the major areas of agriculture from seed to the marketing level. This schema contains mainly three layers. In the First Layer that is data collection layer, collecting data using sensors related to weather and environmental changes, identification of soil types, crop identification ,yield tracking, water availability in the soil . Not only sensor data, Here we will take Historical data i.e. past data, by this prediction will be easy. All this data will be stored in HDFS i.e. Hadoop distributed file system .In the second layer that is Analysis layer, the collected information is analysed using data mining algorithms. The most important part in data analysis is data acquisition; we extract knowledge from sensor data in real time and historical data. In the third layer i.e. data prediction layer predictions obtained from the analysis based on that we will get the answers for the questions what to plant, when to plant and where to plant for this purpose we use data mining algorithms. The prediction discovers relationship between independent variables and relationship between dependent and independent variables. Many classification and regression algorithms are available for data prediction. Some of them are Decision Trees, Artificial neural networks, Support Vector Machine, Bayesian classification and Regression and K-means clustering. Among these we are using Decision Trees and K means clustering for prediction.

Keywords: *Big Data; Smart Agriculture; Hadoop; R; Cloud Computing; Data Acquisition; Classification Data Analytics; Weather Forecast*

1. Introduction

There is nothing more important than food. Food has been driver for mass migrations in 1800's 2 million people died in Ireland with no food and rest all migrated to various places in the world. All migrations either animal or human taken place in the world because of this food. So with increase in population over the years and years food security is the major concern. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and fisheries accounted for 13.7% of the GDP (gross domestic product) in 2013, about 50% of the workforce (Wikipedia,2016). In worldwide the current population is 7.6 billion, In india itself the current population is 1.35 billion (135 crore), A big challenge is whether we can produce food for this population, if this is the current scenario what will be the challenges in future, other side all young generations are moving to urban areas for seeking employment, majority of farmers currently are old and middle aged people. So with the increase in population world-wide and to motivate the young generations, it is more important for the revolution in agriculture business. Smart agriculture is a development in the agriculture sector where new technologies like big data cloud computing and Hadoop and Internet of things has been incorporated. So with smart farming we are trying to make agriculture sector as a profitable sector.
Big Data in agriculture deals from the seed to the marketing level. It influences entire food supply system. There are certain challenges to be addressed such as where to plant, when to plant and what to plant. To address these challenges we should correctly predict the climate conditions time to time and we should have knowledge about soil condition, water level in the soil, before planting we should select high quality seeds, after planting there are major issues to be addressed like crop monitoring, irrigation. To address all these issues big data plays major role in improving the farm production. Sensors on fields and crops provide detailed information on soil conditions, wind, fertilizer requirements, water availability and pest infestations.
The First problem in the current agriculture system is difficult to predict climate conditions, in recent years weather conditions are not supportive to the farmers. Working in uncertain environment need to have much information about what will happen in next 24 hours and next 2 or 3 days, do I irrigate today or do I should hold off. Not only climate we need to measure the soil conditions based on that particular type of farming to be selected. In this scenario we need to use sensors for data collection, these sensors should be highly efficient they should track small changes also. Sensors should be placed in the field, using which we collect many types of data such as climate data, soil moisture data, yield monitoring, field monitoring. These sensors also used to identify pest affected area of crops i.e. crop monitoring using sensors we can easily manage irrigation as well. Sensors will produce huge volume of data, wide variety of data such as images and raw data mostly unstructured and high velocity of data where it changes time to time. One sensor will produce huge volume images nearly Peta bytes. Maintaining such data requires efficient storage device. HDFS (Hadoop distributed file system) is an efficient storage device which is a cloud based clustered environment. We need to refine this unstructured data, all the data we get such as images streaming data may not be use full whatever required data that we should collect this process is known as data acquisition. Not only data gathered from the sensors we also depend on historical data for weather forecasting and yield monitoring. We can also take feedback from the farmers about their past

experiences and also takes advices from scientists regarding crop selection and yield selection.

In the following, section II we brief out the big data , Hadoop and R, later in section III we are including our literature survey, then in section IV methodology in this we discuss detailed study of different phases of the big data analytics in smart farming , in section V Conclusion.

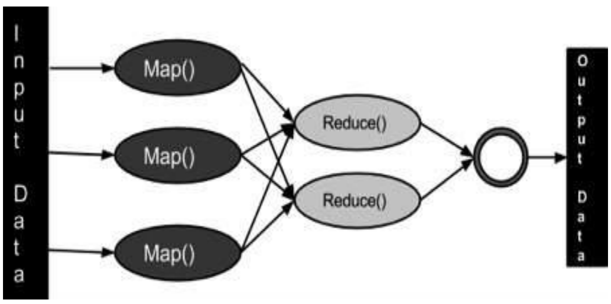
2. Technological review

a) Big data

Big data is large volume and complex type of data. Earlier data is represent in maximum tera bytes but now with invent of social media like Facebook , twitter and LinkedIn , internet retailers like amazon flipkart, paytm, search engines like Google , lot of data is generating. Radar's, satellites will produce more data. Latest planes like boeing 787 is produce Half a tera byte data per plane. With these effects in current era now data is measuring at max yotta byte which is 1024. The data which is produced by these sources is real time data and it is not traditional data, variety of data is produced structured data like transactional data and relational data, unstructured data like audio, video images, semi structured data like xml data and quasi structured data like click stream data.

b) Hadoop

The data which generated by these sources is difficult to store and retrieve and process. To solve the problem of big data Hadoop was introduced. Big data like agriculture data will be stored in HDFS (Hadoop Distributed File System). This data will be cleaned to remove noisy and duplicate data or to fill up missing values. To process the data MapReduce programming will be used. MapReduce is a processing technique and a program model for distributed computing based on java. The MapReduce algorithm contains two important tasks, namely Map and Reduce. Map takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key/value pairs). Secondly, reduce task, which takes the output from a map as an input and combines those data tuples into a smaller set of tuples. As the sequence of the name MapReduce implies, the reduce task is always performed after the map job.



Hadoop framework is based on a simple programming model (MapReduce) and it enables a computing solution that is scalable, flexible, fault-tolerant and cost effective. But processing speed is low. Spark was introduced by Apache Software Foundation for speeding up the Hadoop computational computing software process.

c) R programming

R is a programming language and software environment for statistical analysis, graphics representation and reporting. R was created by Ross Ihaka and Robert Gentleman at the University of Auckland, New Zealand, and is currently developed by the R Development Core Team. R is freely available under the GNU General Public License. In our case studies, we use R programming.

d) Global position system

It is a global navigation satellite system that provides geo location and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.[3] Obstacles such as mountains and buildings block the relatively weak GPS signals (Wikipedia). GPS is used for real time soil and crop measurement.

e) Remote Sensing

Sensors plays major role in smart farming for collecting in field data like yield growth, soil moisture, pest detection, measuring humidity and temperature. Sensors capture data and send image data to the servers; at server side data analysis will be done. These sensors should be highly efficient.

3. Literature survey

We have gone through several papers related to big data in smart farming among these I'm giving review of 4 papers which are influenced me in writing this paper

a) Hybrid Machine Learning Approach to Automatic Plant Phenotyping for Smart Agriculture [1]

Tough we have many approaches for plant phenotyping[paper count no], they implemented modern approach for finding the plant and seedpods by using the methodology called SLIC(simple linear iterative clustering) and CNN(Convolution neural networks). Apparently the flowers count and seedpods count play major role in final crops of the plant. Here, the steps followed Flower Detection, Flower Counting, and Seedpod Detection. While detecting the flowers and seedpods, have to differentiate the stem, leaves and other unrelated things from the image. For implementing the SLIC they used find out the distance between the pixels they segregated (2sx2s).In this study, CNN consists of [5] convolution layers, 3 pooling layers, 2 normalization layers and 3 full-connect layers. In this paper, we proposed CCNN (cross convolution neural networks) for the better results with the default layers and finally change the layer count for the good throughput.

PAID: Predictive Agriculture of data integration in India [2]

Discussion about big data, data integration for finding the crops density relates to area which crop been cultivated. The related data's are production of principal crop, average yielding, average annual yielding and gross area cultivated. The data from the dataset speaks the integration of the mentioned parameters for the crops. Algorithm used here for finding the results is regression analysis curve estimation with help of SPSS. The regression curve helps us to find the relation between the crop and land area under cultivation. In this paper, the rice and wheat crops depend on the soil testing and weather conditions of the place where the crop is cultivated.

Big Data in Precision Agriculture: Weather Forecasting for Future Farming [3]

Discussed on additional insights from precision agriculture through big data approach. With the help of ICT (information and communication technology) services like GPS, RS (remote sensing), GIS (geographic information system), VRT (variable rate fertilizer), drones taking changes in the sector of agriculture. Used map reduce for processing the bigdata, linear regression for predictive analytics. Using these models predicted rainfall and temperature values for the year 2013 near ahmednagar, India.

Research on intelligent acquisition of smart agriculture big data [4]

Used technologies such as geographic information system, cloud computing, IOT, Big data and sensing technologies for solving one of the major challenge of big data, Data acquisition. In this paper author gave detailed discussion on different phases in data acquisition. Zig bee network, GPRS used as communication channels. Conducts simple threshold value analysis on receiving data and then chooses automatic control orders according to the requirement. Performed experimental analysis on farmland in yanzhou distict, jining municipality, Shandong province.

4. Methodology and case study

Our model contains three layers

1) Data collection layer

To make agriculture as a profitable sector we need to collect lot of data. The sources for data collection are Remote Sensors, satellites, GPS, Historical data i.e. past data, for weather forecast historical

data will be useful for us. We establish sensors on fields to monitor each and every activity on the farm to monitor yields, soil, and climate. Establishing sensors on fields is a challenge for this we can tie up with companies like john deere and fix the sensors to the tractors or other agriculture machinery.
John deere is a manufacturing company manufacture agriculture machinery .Suppose water availability in the soil is below the threshold level, Sensor capture the data and it will send to the servers. Server side analysis will be done, and the related information is send to the farmers via gadgets and the farmer will react accordingly.
GPS is used for correctly locating the sensor, sensor data is transmitted via network, transmitting data over the network is a challenge generally villages will be having low internet connection; high speed internet is needed to collect the data. After collecting the data, removing the noisy data and cleaning the data is very important, even missing values we need to correctly fill up. next data acquisition, agriculture big data acquisition includes many factors , cultivation, irrigation, fertilization, crop protection, soil moisture data, temperature, yield tracking marketing , for this we need to integrate multiple sensors.In this scenario first we capture the data, then we store the data into HDFS, we transfer the data, we transform the data into the required format means some time data need to be converted from numerical to categorical, then In this paper we collected the past weather data of India and United States and performed data analysis and in analysis phase we analyse the data. Not only sensor data, we collect the historical data. The agriculture big data is huge volume and various types both structured and non-structured. This huge volume is stored in HDFS. In HDFS data will be stored under data nodes under different clusters. Name node will be having metadata about data nodes. They will keep monitor working nature of data nodes. Fig 1 shows the simple structure of data nodes and name node.

2) Data analysis layer

Data analysis is the process of examine the data to uncover hidden patterns .The data collected from different sources like Sensor data, historical data is raw data, we should transform this data into understandable format, because the real world data is inconsistent and incomplete and may have erroneous data, this transformation is known as data pre-processing, and after pre-processing we should train the data by including different conditional attributes. Fig.2 gives you the algorithmic approach for predictive maintenance.
For analysis we have taken weather data of Telangana from 1870 to 2016 and performed k-means clustering. K-means clustering is a simple unsupervised learning algorithm, classifies data set into k number of clusters. We have taken weather data because it is easily available and weather influences agriculture in a big way, weather prediction is used for decision making in farming. Agriculture data is the data without data analytics it is of no value. Using technologies like IOT and cloud computing used for generating the data. Big data analytics changes the state of agriculture in a drastic manner; it is used for getting intelligence from the data. There are different challenges of modelling and deploying big data applications Fig.3 will give this in detailed manner.

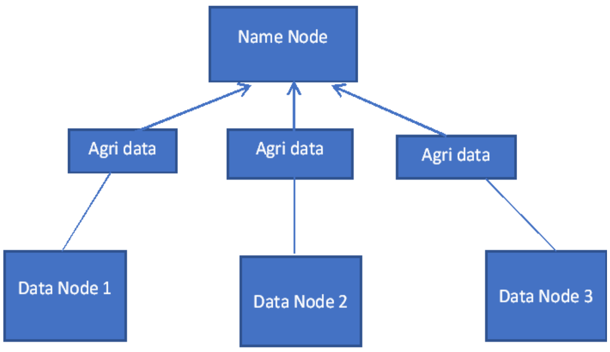


Fig. 1: Simple Structure of HDFS.

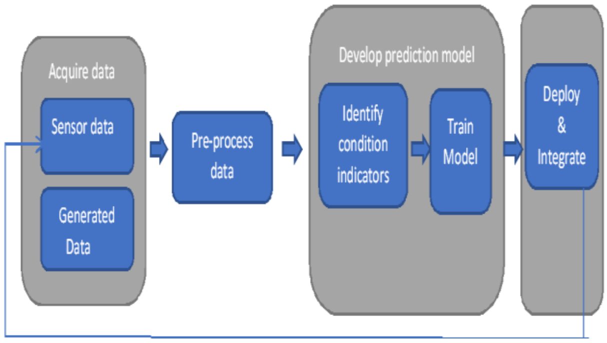


Fig. 2: Predictive Maintenance Algorithm.

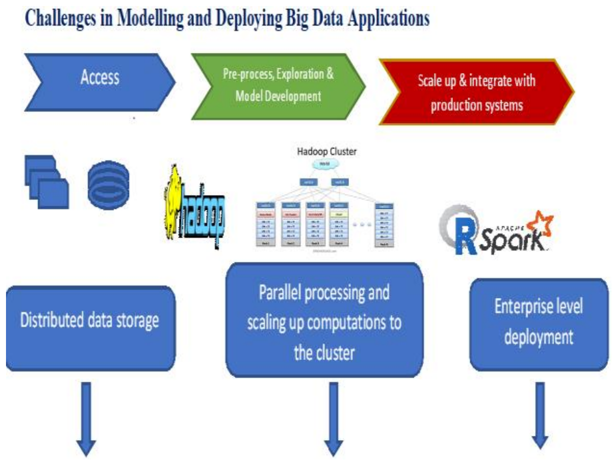


Fig. 3: Challenges in Modelling and Deploying Big Data Applications.

For analysing the big data In Hadoop ,we have map reduce programming as we discussed in earlier section map reduce having two main phases mapper and reducer , but the problem of map reduce is getting data from secondary storage to main memory for analytics it will take some time so map reduce is a slow processes, now a days time is an important factor in terms of computation. So apache spark is introduced for in memory analytics. Not only mapreduce and Spark even R is better for statistical modelling. Mat Lab expo, python are also giving better results for Data Analytics.
For our case study now we are using R studio because R is the open source framework, which has been traditionally used in academics and research because of its open source nature now it is rapidly expanding to other areas. It is of learning and having data handling capabilities. R is having great features for data visualization and many features of R programming come from C programming so it is easy to understand.
We have taken rain fall data from year 1871 to 2016 and we applied time series, K-means clustering for data analytics, Decision tree for predictive analytics. We have taken rain fall data because of failure of monsoon agriculture is facing tremendous problems. The variability of monsoon rains in India affecting agriculture system and giving losses for Indian economy. Large parts of the country are severely affected due to less rainfall. The main source of monthly rainfall data of the 306 stations is National Data Centre, IMD Pune. Number of researchers are analysing the rainfall data. Even though data collected from rain gauge stations but There are some missing values. These missing values are replaced by mathematical techniques.
Table.1 gives past rain fall data in Telangana from 1871 to 2016. Figure 4 gives time series analysis of summer monsoon data of Telangana. For India as a whole, the monsoon months June, July, August and September are main rainy months. The mean rainfall of June, July, August and September is 163.1, 272.5, 242.2 and 170.3 mm respectively. The rainfall of July month is the highest and contributes 25 % of annual rainfall (1085.9 mm, Percentage to Annual: P-Ann.). The August rainfall is slightly less than that of July and contributes 22.3 % of the annual rainfall. The June and September rainfalls are almost same and they contribute 15.1 % and 15.7 % of the annual rainfall respectively. The year has been divided into four

seasons: winter (jan+feb:JF), pre-monsoon (mar+apr+may:MAM). Southwest Monsoon (June to September: JJAS) and Post Monsoon (October +November+December: OND) and the mean seasonal rainfall are 23.2 mm, 94.4 mm, 848.1 mm and 120.1 mm respectively. The winter, Pre-Monsoon, Monsoon and Post-monsoon season contribute 2.1%, 8.7%, 78.1% and 11.1% of annual rainfall respectively. The CV is low in monsoon season 9.8 % and the highest in winter season 49.9%. Fig.6 gives week by week monsoon rainfall for the year 2017.

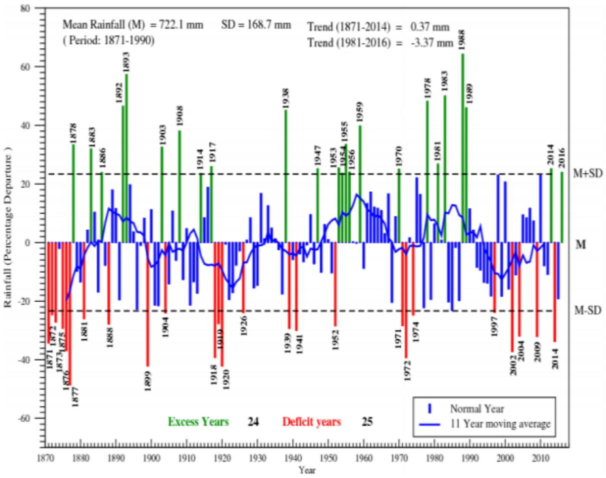


Fig. 4: Telangana Summer Monsoon (JJAS) Rainfall (1871-2016).

We have applied K-means clustering for the above data using R language. The data we obtained different mean values. Fig 5 shows the plot

K-means clustering with [3] clusters of sizes 48, 41, 57

Cluster means:

sno year JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV

1 66.45833 1935.458 66.54167 78.33333 93.2500 199.0208 258.4792 1011.521 1550.812 1418.104 1412.646 639.8750 192.7917

2 80.58537 1949.585 69.21951 116.36585 135.2439 128.8049 353.3659 1640.707 2655.951 2518.415 2282.878 1160.9268 206.5122

3 76.89474 1945.895 40.89474 68.52632 123.7719 216.2281 219.7719 1234.912 2337.105 1948.368 1700.614 676.3509 270.0702

DEC JF MAM JJAS OND ANN

1 48.72917 144.8333 550.6875 5393.021 881.2917 6969.854

2 63.48780 185.5854 617.3902 9097.951 1430.8293 11331.683

3 53.59649 109.4211 559.7544 7220.912 999.9825 8890.158

Clustering vector:

[1] 1 1 1 3 1 1 1 2 3 1 1 3 2 3 3 2 3 1 2 3 1 2 2 2 3 1 3 3 1 3 1 1 2 1 1 3 3 2 1 3 1 1 1 2 2 2 2 1 1 1 3 1 1 3 3 1 3 3

[59] 1 1 2 3 2 3 3 2 3 2 1 3 1 3 3 3 3 3 2 3 3 3 3 1 2 2 2 2 3 3 2 3 2 2 3 3 3 3 3 1 2 2 1 1 3 1 2 3 1 2 1 3 2 3 2 1 1 3

[117] 3 2 2 2 3 3 3 3 2 1 1 2 1 2 1 1 3 1 2 3 3 3 1 2 3 3 2 1 1 2

Within cluster sum of squares by cluster:

[1] 139801736 238438108 188479281

(between_SS / total_SS = 59.2 %)

Fig. 5: K-Means Clustering to Analyse Summer Monsoon Data from 1871 to 2016.

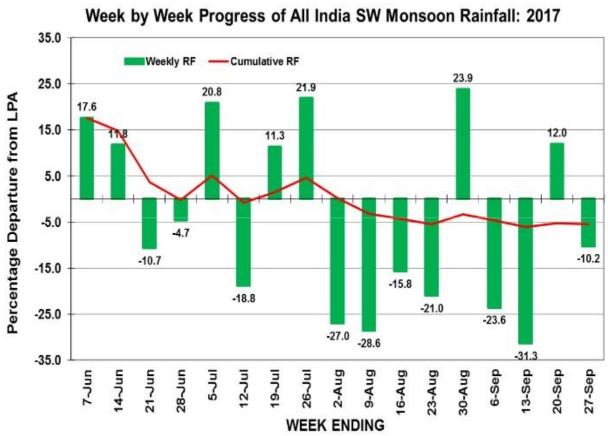


Fig. 6: Week - By - Week Progress of the All India Weekly and Cumulative Weekly Monsoon Rainfall Anomalies during the 2017 Southwest Monsoon Season. the Rainfall Anomalies are Expressed as the Percentage Departure From Long Period Average (LPA).

3) Data Prediction Layer

The analytics which we discussed before are descriptive analytics. Now we are discussing predictive analytics for agriculture data. Prediction is the most important technique of data mining which employs a set of pre-classified examples to develop a model that can classify the data and discover relationship between independent and dependent data. To predict future data we have taken a classification algorithm called decision tree. In classification learning, a classifier is presented with a set of examples that are already classified and from these examples; the classifier learns to assign unseen examples. A decision tree also called as prediction tree is a tree structure to specify sequence of decisions. The goal is to obtain an output variable or class label from the input variables. Internal nodes of a decision tree are test points, each internal node is a input variable and leaf nod is a output variable. Decision tree is having many advantages over other classification mechanisms it can be used for both numerical and categorical attributes, as it is pictorial representation; it is easy to understand the algorithm. Naive Bayes classifier is also good but compared with this prediction will be accurate when data is large. Random forest is another algorithm if we take huge data set like agriculture data; it removes the challenges of decision tree like pruning and over fitting.

Now for yield forecasting using decision tree we have taken other data set. Climate data of march 2017 North Carolina, USA, which includes maximum minimum

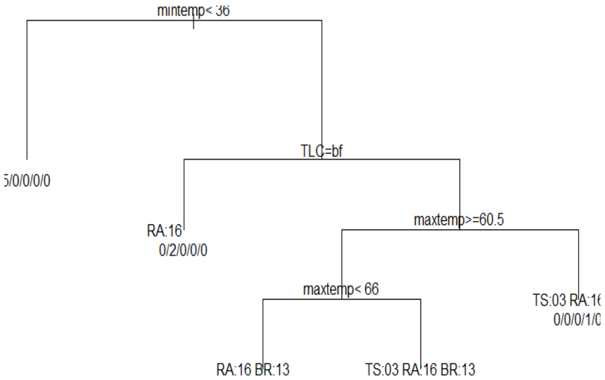


Fig. 7: Decision Tree for first to 10th March Climate Data of NC, USA.

temperature, Humidity, wind speed and wind direction sustainable speed and sustainable direction, sunset, sun rise, for sample we have taken only 10 days data of that month.

Depends on the above parameters using existing data, how to predict future rainfall, depending on rain fall which crop is to be selected, for example if rain fall is low we can suggest the farmers instead of rice , they can go for millets and cotton, if it moderate or high they can go for rice and wheat.Fig.7 gives classified example using decision tree the data for above example is mentioned in table.1.

Yield Forecasting

Like weather forecasting remote sensing forecasting can be done with classification and regression techniques. This forecast is done at crop growth stage, when crop growth is visible for the coverage by the remote sensors SAC Ahmedabad developed remote sensing based methods for selected crops. According to FASAL report [9].So far RS methodology for forecasting in national level developed for Wheat(Rabi), Rice(kharif), Jute Potato(Winter), Rapeseed & Mustard.

Algorithm for yield Forecasting

1) Collect the data from different sources
2) Generate the Database using Hadoop Hbase
3) Conduct field experiments for evaluation of data
4) Observe initial soil conditions at planting time
5) Coordinate with AgroMet Field Units(AMFUs) for crop yield forecasting
6) Generate season wise crop yield forecasts for 14 major crops during kharif and Rabi
7) Apply Data analytics using R and generate statistical models and crop growth simulation models for various crops
8) Depending on the models Take the decision making policies
9) Educate the Farmers about using Technologies for using forecast data

Under Gramin Krishi Mausam Sewa (GKMS) scheme of IMD(Indian Meteorological Department), a network of 130 Agromet Field Units (AMFUs) and 23 State AAS Units of IMD are functioning in the country. These centers are located at different State Agricultural Universities, IITs in each Agro climatic zones. We can make use for these AMFUs for yield forecasting, will performs necessary actions such as i) sends weather data to the IMD. ii) Provide in season Crop yield forecast using statistical models.

Table 1: 1st to 10th March 2017 NC, USA Climate Data

date	maxtemp	mintemp	avg	dep	heat	cool	sunrise	set	weather	TLC	SF	SD	AVgstn	Avgspd	peakspeed	peakdir	sustspeed	sustdir
1	71	48	60	16.6	5	0	659	1826	TS:03 RA:1	0.18	0	0	27.69	14	44	340	32	340
2	51	35	43	-0.6	22	0	658	1827		0	0	0	27.82	16.5	44	330	36	330
3	48	28	38	-5.8	27	0	656	1828		0	0	0	28.08	10.5	35	340	29	340
4	59	28	44	-0.1	21	0	655	1829		0	0	0	28.2	4.2	22	350	17	350
5	58	26	42	-2.3	23	0	654	1830		0	0	0	28.17	4.1	20	160	14	120
6	59	42	50	5.4	15	0	652	1831	RA:16	0.01	0	0	28.12	5.6	30	210	23	200
7	61	51	56	11.2	9	0	651	1832	RA:16 BR:	0.09	0	0	27.99	11.4	30	210	22	210
8	64	38	51	6	14	0	650	1832	RA:16	T	0	0	27.95	10.4	38	340	28	350
9	72	29	50	4.7	15	0	648	1833		0	0	0	27.94	3.1	22	210	17	210
10	60	37	48	2.5	17	0	647	1834	TS:03 RA:1	0.2	0	0	27.74	13.6	41	340	33	330

Yield Tracking

Yield tracking is done by analysing captured images of sensors. Following is an algorithm to finding the image and dropouts

Algorithm: Finding the image and dropouts

Step 1: Define the CNN architecture with the layers (number of layers we can define-here we used 3 layers).

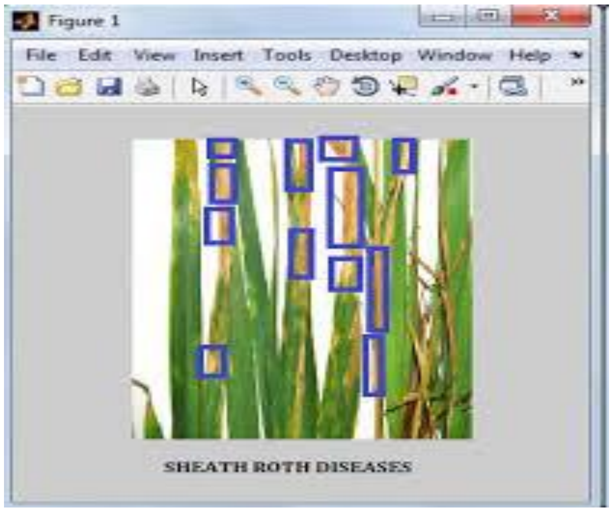
Step 2: Create empty dictionary for loading the points (end points)

Step 3: Collect outputs for conv2d and max_pool2d for Layer-1, Layer-2, Layer-3 mention the scope.

Step 4: Last layer which is the logits for classes

Step 5: Return the collections as a dictionary (check the dropouts)

Step 6: Squeeze spatially to eliminate extra dimensions.



By implementing the this algorithm, image is read and classifier algorithm will segregate the image want to read rice and extra (dropouts-leaves) which can be neglected.

5. Conclusion

In this paper we covered how big data will be used in differ areas of agriculture, first we focused mainly on weather forecast because agriculture production is highly depends on environmental conditions. We have taken dataset and applied clustering and classification techniques for analytics. Later we focused on how yield forecasting and yield tracking will be done, algorithms specified for the both. More research should be done on yield tracking and yield monitoring and on automated irrigation; many open challenges are to be addressed in future.

Acknowledgement

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