International Journal of Grid and Distributed Computing
Vol. 14, No. 1, (2021), pp. 1539–1547

Smart Cultivation and Prediction System for Agriculture

Ms Sarita Dnyaneshwar Sapkal[1], Ms.Pradnya Samit Mehta[2] ,Ms Geetha Chillarge[3]
MMCOE,Pune,India
[1]sapkalsarita@gmail.com ,[2]pradnyamehta@mmcoe.edu.in, [3]geethasb@mmcoe.edu.in

Abstract

Agriculture is a vital sector for overall economy of India. Identification of crop to cultivate based on soil type its nutrients, disease detection are the vital roles for agriculture. Crops getting infected with diseases is the common thing but to improve product quality, quantity and productivity, proper care should be taken. The automation is crucial as it is beneficial in making crop monitoring simpler and faster Smart farming. In this paper, we propose a smart prediction system for identifying suitable crop for cultivation and plant pathology .The proposed system implements soil testing using the various sensors such as soil temperature, soil moisture, NPK, pH are used for monitoring temperature, humidity, soil moisture . This system lowers the probability of soil degradation and helps to maintain crop health. Plant pathology is carried out through convolutional Neural Network. The farmers can use this smart farming model to help them in selecting suitable crop for their field and make timely decisions to control diseases.

Keywords: *Smart farming,Convolutional Neural Network,Disease Diagnosis,Internet of Thing,Plant Pathology*

1. Introduction

India is Diversified country with various physical and cultural features. In India, Agriculture is one of the major source for basic needs of people. Majority of the population relies on Agriculture for their Occupation. Technologies such as IoT, machine learning can be used in agriculture for solving issues such as lack of soil nutrient knowledge, water irrigation issues and plant pathology etc. Educating farmers in recommending crop suitable for field, predicting disease in advance so that farmer can take precautions and get prevented from loss. With all the above mentioned techniques the farmer is able to maximize profits[22].

With the advancement in the field of IoT, the farmer can continuously monitor the field using various hardware components and in turn yield better results.Due to the Global Warming, Earth Environment is changing continuously which is damaging the crops and causing the adverse effect of suicidal cases of the farmers. With the growing population the farmers are using more pesticides and fertilizers to increase productivity in short period and also to maximize the profit which also leads to the soil impotent, decreasing the water retention ratio of the soil and increases noxiousness of soil.

Growing industrialization mainly needs land for development,which increases the percentage of the soil contamination and in turn make difference to grade of the plants. Agriculture contributes to the overall economic growth of the country. Agriculture is the backbone of Indian economy. Successful conduction of agricultural operations depends upon a proper use of fertilizers, water and weather conditions[23].Lack of a strategies in agriculture leads to over and under production of certain crops which impacts the demand of population.

The problem is more acute in case of perishable agriculture which outputs like vegetables and fruits where estimates of wastage are around 40%[25]. Disease Diagnosis and providing right solution on the disease for increasing productivity and quality of the crops is done through Convolutional Neural Network (CNN).Pesticides and fungicides affect the crop overall yield[24]. In addition environmental pollution and weather conditions also hamper the overall growth and productivity of crops.

Hence a the paper proposes a smart solution which can overcome the impact of the above mentioned factors and as well help farmer make early decisions to maintain the crops. Our contribution is to give smart solution to the farmers starting from sowing the seeds till the final yeild, suggesting suitable crop to their soil and monitoring the same till the final product.

In Section 2, related work of smart farming is explained. Section 3, will elaborate proposed methodology and system architecture. Section 4 -5 will share the conclusion and acknowledgement.

ISSN: 2005-4262IJGDC

2. Related Work

Now a days,an Image Processing with IoT is replacing manual work with automation in agriculture field. Its very beneficial to the farmers to get the quality of the product and ultimately the productivity by investing less money. Table 1 shows the literatur e survey for the Smart Cultivation and Prediction System for Agriculture.

Table 1 : Literature Survey

Name of the Author	Description	Crop Selected
Schor et al .[2]	Proposes robotic based disease detection system with PCA and CV based classification could achieve 90% and 85% accuracy respectively	Tomato
Anand et al.[5]	HSI model extracts texture features such as angular moment,intensity of covariance and entropy features which are divided into training and testing features	Brinjal
Mayuri Pawar et al [8]	Author focused on suggesting crop, fertility of soil,level of toxicity and water supply using sensors.Further disease detection is carried out through decision tree algoithm J48	Tomato
Rutu et al.[4]	uses Generative Adversarial Networks (GANs) to augment the limited number of local images available. Inception V3 and MobileNet CNN model experimented and compared and respective accuracies are 88.6% and 92%.	-
Nadia Jmour,IEEE 2018. [6]	Author worked on fine tuning techniue for reusing trained data of layered network.	-
Somesh et al.[10]	Deep Neural Network is used for training 120 samples.Resized to 256*256. Three Conv layer and one fully connected layer.Global accuracy 85.10% on test set.Tobacco	Tobacco
Rakesh Kumar et al. 2015[9]	Selection of appropriate crop for field using Machine learning methods	Any crop
Usama et al.[16]	Uses SVM algorithm.Powdery mildew and early blight are considered. 200 images in dataset where 150 for training and 50 for testing.99.5 % accuracy.	Tomato
Singh et al.[15]	SVM algoithm used for automatic detection and classification of infected leaves with 97.6% average accuracy	Rose,Beans Lemon, Banana leaf
Hemantkumar Wani et al. 2017[14]	Author suggested a method for early plant disease prediction and providing suggestions of appropriate pest by using Naive Bayes algorithm	Any Crop
Raheela Shahzadi et al., 2016[13]	IoT base system for guidance on water irrigation and plant pathology. Author used humidity, temperature sensors for implementation of the system.	Cotton

ISSN: 2005-4262IJGDC

Panchal et.al[3]	Author uses K-means clustering and HSV dependent classification for detecting diseases on plant leaf.98% accuracy achiebed with random forest classifier.	Tomato, Potato
Barbedo, *et.al[7]*	Proposes an algoithm to detect plant leaf disease from asymptomatic tissues through HSV technique for 19 spices of different plants	Various plants leaves

Based on literature survey it can be concluded that many authors have used various methods or algorithms such as KNN,SVM,CNN etc. on plant pathology.But none of the authors could attain bench mark for smart solution for the same.It is also found that very few papers have taken up a complete solution for smart cultivation by considering various hardware and sensors for detection of required fertilizers and identification of soil type.Hence a new and better system is proposed which provides complete solution to farming.

3. Proposed Methodology

3.1. Hardware used

To set up smart cultivation and prediction system for Agriculture the following Hardwares are used as shown below in table II.

TABLE 2 : Hardware Components required for system

Components	**Description**
Raspberry Pi Kit	Raspberry Pi 3 module
Raspberry Pi Camera	5MP, 15-pin MIPI Camera Serial Interface,for capturing real time images of crop in the field
Ph Sensor	To sense Ph value
Moisture Sensor	To sense moisture level of soil
Nano-tube Sensor	To determine and monitoring soil nutrients
Temperature Sensor	To sense temperature value of the environment

Overall architecture of the system shows three main modules. Crop suggestion,plant pathology and solution in the farming for suitable crop. Architecture of the smart Cultivation and Prediction system for Agriculture is shown below in Figure 1.

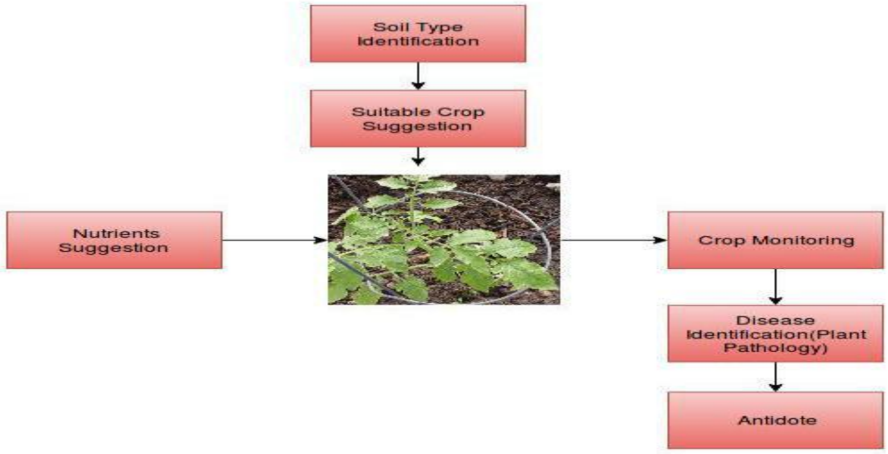


Figure 1.Proposed System Architecture

ISSN: 2005-4262IJGDC

3.2. Crop Suggestion

According to the soil type identified using Bulk density test[26] and its nutrient contents, the system suggests suitable crop to the farmer[1]. Crop cultivation is mainly dependent on major soil nutrients like Phosphorous, Potassium and Nitrogen which are essential for any type of farming.

Every crop requires less or more amount of nutrients for their entire life span. Nutrients can play a vital role for the fertility of the soil[1]. As per concentration level of the nutrients existing in the soil the right crop can be decided. Soil type and suitable crop for the same is as mentioned in the table 3[1].

TABLE 3 :TYPE OF SOIL AND SUITABLE PLANT

Sr. No.	Type of Soil	Suitable Crop
1	Halaki(Murmad)	Tamato
2	Madhyam,Nicharyachi,Poytyachi	Potato
3	Madhya to bhari,Nichryachi	Peas
4	Halaki To Retad, Madhyam, Nichryachi	Raddish
5	Madhyam Kali,Nichryachi	Bottle Gaurd
6	Madhyam Kali,Nichryachi	Ridge Gaurd

Suggesting crop to the farmer is referred from Krishidarshani 2017 -18, Published by Mahatma Krishi Vidyapeeth, Rahuri.Smart Cultivation and Prediction system will suggest major nutrients compositions suitable for crop for their overall growth.

Concentration of fertilizers to be given to the plant before and after cultivation is also suggested in the system. Table 4 shows soil type-crop-fertilizer(Nitrogen: Phosphorus :Potassium).

TABLE 4: CROP AND REQUIRE QUANTITY OF FERTILIZERS

Sr.No.	Type of Soil	Suitable Crop	Major Fertilizer N(Nitrogen): P(Phosphorus): K(Potassium)	
			Before Cultivation (in Kg)	After Cultivation (in Kg)
1	Halaki(Murmad)	Tomato	200:100:100 / 300:150:150	
2	Madhyam,Nicharyachi,Poytyachi	Potato	100:60:120	50 kg Nitrogen after one month
3	Madhaya to bhari,Nichryachi	Peas	100:60:120	10 kg Nitrogen after one month
4	Halaki To Retad, Madhyam,Nichryachi	Raddish	20:20:80	10 kg Nitrogen after one month
5	Madhyam kali, Nichryachi	Bottle Gaurd	50:50:50	50 kg Nitrogen after 30/45 days in two equal weeks
6	Madhyam Kali,Nichryachi	Ridge Gaurd	50:50:50	50 kg Nitrogen after30,45 and 60

ISSN: 2005-4262IJGDC

				days in three equal
				weeks.

3.3. Crop monitoring is done using Raspberry Pi camera module by taking images at run time in test bed of 10*10.

3.4. Disease Diagnosis

System will focus on monitoring the plant growth and will detect and notify the fungal disease at early stage, with suitable pesticide for the identified disease[20]. Steps in disease diagnosis are shown in Figure 2. Proposed system for disease diagnosis contains the following steps :

3.4.1.Image Acquisition: Input image can be captured by end user using android phone.

3.4.2.Image Pr-processing: a) Input image is preprocessed by removing background noise and distortions. Then this input image is resized to 128 * 128.

b)Segmentation :It partitions an image into different parts.

c) Feature Extraction:Describes the infected region.

3.4.3.Convolutional Neural Network: This resized image goes through three convolution layer and one fully connected layer and gives probable value for each class.

3.4.4.Classification: Among these probable values, the highest value is selected and classified in that category. Label and preventions are sent to user.

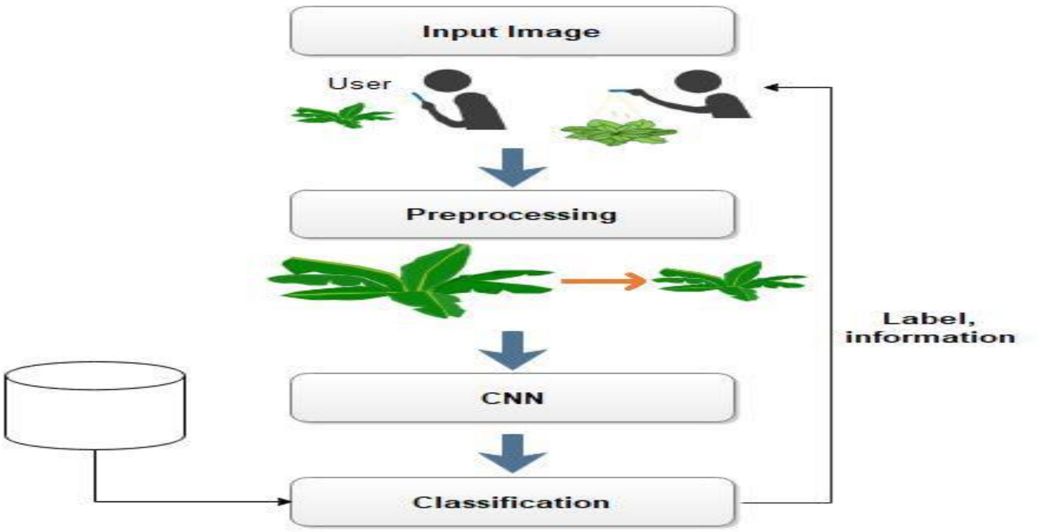


Figure 2. steps involved in disease diagnosis.

3.4.5.CNN:

Convolutional Neural Network achieved significant success in image recognition application which learns image features deeply at each convolution layer. Images are nothing but set of pixels represented in RGB i.e. 3 channel. CNN requires preprocessing as compared to other image classification algorithms.

Image Acquisition: The input image is reshaped to 128*128 and number of channels are 3 as R, G, and B i.e. 128* 128*3. Figure 3 shows an example of input snapshot.

What we see

2	3	1	0	0	0	9	8	8	7
4	5	6	7	8	0	0	3	2	1
7	8	9	0	0	7	5	2	1	0
7	8	5	5	5	5	5	4	3	2
1	0	0	0	0	8	6	5	4	9
5	6	7	8	9	6	4	3	2	1
0	9	8	7	6	5	4	3	3	4
2	3	4	5	0	0	0	1	1	1

Computer View

ISSN: 20

Figure 3. Example of input snapshot.

Convolution: Input snapshot is given to convolution layer which filters and extracts the features of input image. In this work, filter size is 3*3 and number of filters is 32, 32 and 64 at CONV1, CONV2 and CONV3 respectively as shown in Figure 4. The output is given to next layer.

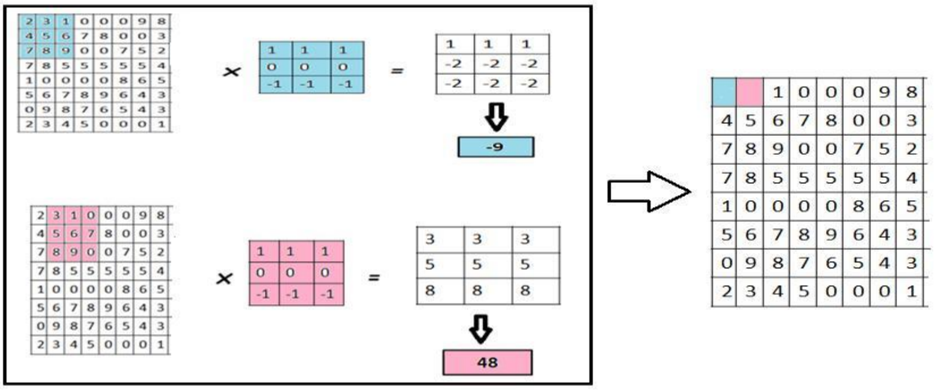


Figure 4. Example of convolution

Pooling : After obtaining features using convolution it is necessary to reduce space related size of depiction for decreasing the number of characteristics and computation cost of network. Max pooling is one of the commonly used technique which represents the max value of particular region over the image as shown in Figure 5.

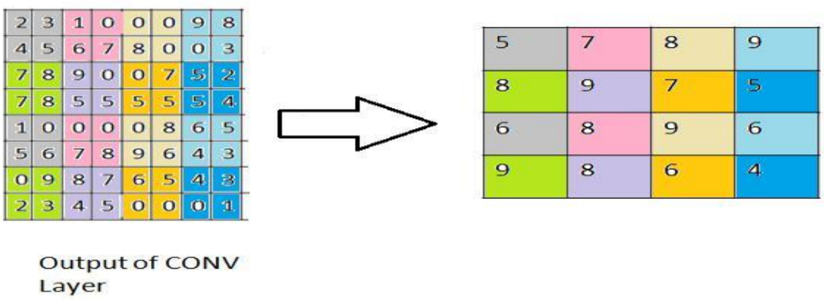


Figure. 5 Example of Max Pooling

ReLU: ReLU is used as activation function ( )=max (0,) used by neurons[19]. It adds non-linearity to the network.

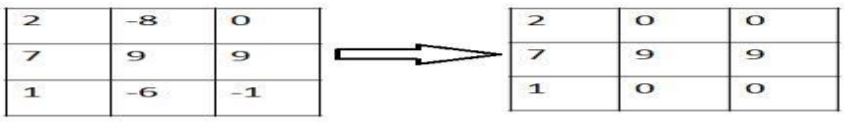
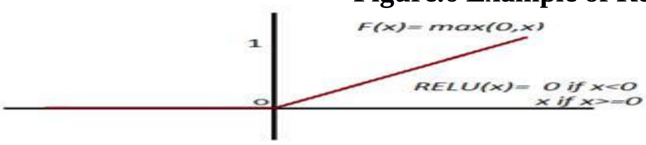


Figure.6 Example of ReLU



Weights: weights are useful to visualize smooth patterns without noise. In CNN, weights are generated by algorithm and tuned by hyper parameter to improve accuracy. There are three convolution layer followed by max pooling and ReLU activation function. The output size after every convolution layer is calculated as:

$$O=\frac{-F+2}{} + 1 \quad (1)$$

where O is output matrix size and N is no. of inputs, F is filter size and P is padding and S is strides that pixel moves with less overlapping[21].

After max pooling matrix changes which reduces matrix size which ultimately reduces storage space and calculation time and is calculated as[19]:

$$O=\frac{-}{} + 1 \quad (2)$$

4. Results

System provides information of pesticide based on detected disease. Figure 7 shows accuracy levels of diagnosed diseases.

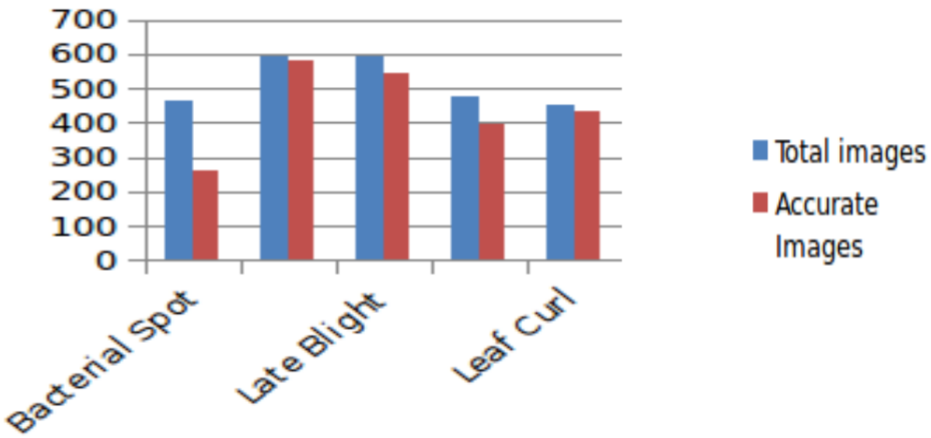


Figure 7 Accuracy levels of diagnosed diseases

4.1. Antidote

The last step of the system suggest pesticide to be used for an identified disease[1].The table 5 shows pesticides can be used for various types of crops. Suggestion of Pesticide is based on classification algorithm.

Table 5: Disease and Pesticide

Sr. No.	Crop	Disease Name	Pesticide
1	Potato, Tomato, Wheat, Maize	Late blight, early blight, buck eye rot	Mancozeb 75 WB
2	Chillies, Groundnut, Rice	Powdery Mildew, Tikka and Rust, Sheath Blight	Tabuconazole 25 EC
3	Citrus, Cardamom, Chillies, Betel, Banana, Coffee, Potato, Tobacco, Tomato, Grapes, Coconut	Leaf spot, Early and Late blight, Canker	Copper Oxichloride 50%
4	Grapes, Potato, Black Pepper, Mustard, Chilli	Bajara: Downy mildew, Potato: late blight , Mustard : white rust	Metalaxyl 8 % WP + Mancozeb 64 %
5	Maize, Pea, Cucumber, Brinjal and Beet	Leaf Spot, Blight and Powdery Mildew	Bavistin 50%WP-250gm

ISSN: 2005-4262IJGDC

4. CONCLUSION

Smart cultivation and prediction system shows very efficient way of farming. The proposed system enhances the yield of crop by timely identification of required nutrients through various sensors and notifying the early disease detection. The system also includes suggestion of crop for given soil, required amount of fertilizers and antidote. In future the system can be extended to perform checking the soil fertility for micro nutrients.

5. ACKNOWLEDGMENT

We would like to thank Plant Pathology Department ,College of Agriculture, Pune for providing information for the project.

References

[1] Kushidarshani 2017,Mahatma Phule Krushi Vidyapeeth,RahuriJ.

[2] Schor, N., Bechar, A., Ignat, T., Dombrovsky, A., Elad, Y., & Berman, S. (2016). *Robotic Disease Detection in Greenhouses: Combined Detection of Powdery Mildew and Tomato Spotted Wilt Virus. IEEE Robotics and Automation Letters, 1(1), 354–360*

[3] Panchal, P., Raman, V. C., & Mantri, S. (2019). *Plant Diseases Detection and Classification using Machine Learning Models. 2019 4th International Conference on Computational Systems and Information Technology for Sustainable Solution (CSITSS).*

[4] Rutu Gandhi Shubham Nimbalkar Nandita Yelamanchili Surabhi Ponkshe "Plant Disease Detection Using CNNs and GANs as an Augmentative Approach" 2018 IEEE International Conference on Innovative Research and Development (ICIRD) 11-12 May 2018

[5] Anand R,Veni S,Aravinth J "An Application of image processing techniques for Detection of Diseases on Brinjal Leaves Using K-Means Clustering Method" 2016 Fifth International Conference On Recent Trends In Information Technology

[6] Nadia Jmour, Sehla Zayen, Afef Abdelkrim "Convolutional Neural Networks for image classification" IEEE 2018

[7] Barbedo, J. G. A. (2016). *A novel algorithm for semi-automatic segmentation of plant leaf disease symptoms using digital image processing. Tropical Plant Pathology, 41(4), 210–224.*

[8] Pawar, M., & Chillarge, G. (2018). *Soil Toxicity Prediction and Recommendation System Using Data Mining In Precision Agriculture. 2018 3rd International Conference for Convergence in Technology (I2CT).* doi:10.1109/i2ct.2018.852975

[9] Rakesh Kumar, M.P. Singh, Prabhat Kumar and J.P. Singh " Crop Selection Method to Maximize Crop Yield Rate using Machine Learning Techniqu**e",** International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, T.N., India. 6 - 8 May 2015

[10] Somesh Katta, M. S. Prasad Babu "An Approach to Classify Flue-Cured Tobacco Leaves using Deep Convolutional Neural Networks" 2017 IEEE

[11] Jay Gholap, Anurag Ingole, Jayesh Gohil, Shailesh Gargade, Vahida Attar "Soil data analysis using classification techniques and soil attributes prediction",2012

[12] R.Sindhuja and B.Krithiga " Soil Nutrient Identification Using Arduino" Asian Journal of Applied Science and Technology (AJAST) Volume 1, Issue 4, Pages 40-42, May 2017

[13] Raheela Shahzadi, Javed Ferzund, Muhammad Tausif, Muhammad Asif Suryani " Internet of Things based Expert System for Smart Agriculture" (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 7, No. 9, 2016

[14] Hemantkumar Wani, Nilima Ashtankar "An Appropriate Model Predicting Pest/Diseases of Crops Using Machine Learning Algorithms" 2017 International Conference on Advanced Computing and Communication Systems (ICACCS -2017), Jan. 06 – 07, 2017

[15] Singh, V., & Misra, A. K. (2017). Detection of plant leaf diseases using image segmentation and soft computing techniques. Information Processing in Agriculture, 4(1), 41–49. doi:10.1016/j.inpa.2016.10.0

[16]S. Sannakki, V.S. Rajpurohit, F. Sumira, H.Venkatesh "A Neural Network approach for Disease Forecasting in Grapes using Weather Parameters",4th ICCCNT, 2013

[17] Hannah Shayler, Murray McBride, Ellen Harrison "Guide to Soil Testing and Interpreting Results" Cornell Waste Management Institute,2009

ISSN: 2005-4262IJGDC

[18] https://link.springer.com/article/10.1007/BF01082974

[19] **Habibi Aghdam**, Hamed, **Jahani Heravi**, Elnaz,"Guide to Convolutional Neural Networks A Practical Application to Traffic-Sign Detection and Classification" Springer International Publishing 2017

[20] Skaria, S., Al-Hourani, A., Lech, M., & Evans, R. J. (2019). *Hand- Gesture Recognition Using Two-Antenna Doppler Radar with Deep Convolutional Neural Networks. IEEE Sensors Journal, 1–1.* doi:10.1109/jsen.2019.2892073

[21] Beulah, R., & Punithavalli, M. (2016). *Prediction of sugarcane diseases using data mining techniques. 2016 IEEE International Conference on Advances in Computer Applications (ICACA).* Doi:10.1109

[22]Archana S. Mathur, Surajit Das and Subhalakshmi Sircar ,Status of Agriculture in India: Trends and Prospects,Economic and Political Weekly *Vol. 41, No. 52 (Dec. 30, 2006 - Jan. 5, 2007). pp. 5327-5336*

[23]Jeetendra Prakash Aryal, Teahadur Sapkota, Dil Bahadur Rahut, M.L.Jat, Agricultural sustainability under emerging climatic variability: the role of climate-smart agriculture and relevant policies in India,International Journal of Innovation and Sustainable Development,Vol 14,issue 12,2020

[24]Warjan Mundi, SKGosal and Jupinder Kaur,Effect of pesticides on growth kinetics and plant growth promoting activities of biofertilizer, The Pharma Innovation Journal2020; 9(7): 442-446

[25]Elbert Jonathan Brata, Akbar Adhi Utama,INVENTORY COST EFFICIENCY IN 2019 BY APPLYING PERISHABLE INVENTORY POLICY AND DEMAND FORECAST IN AGRICULTURE WHOLESALER: STUDY CASE PT BIMANDIRI AGRO SEDAYA,International Journal of Economics, Business and Management ResearchVol. 4, No. 09;2020

[26]Jia Lu, Guarangcheng Shao,Yang Gao,Kun Zhang,Qun Wei,Jifan Cheng,Effects of water deficit combined with soil texture, soil bulk density and tomato variety on tomato fruit quality: A meta-analysis,Agricultural Water Management Volume 243, 1 January 2021, 106427

ISSN: 2005-4262IJGDC