ICEAIST-24
International Conference on Exploring AI, IOT, Science & Technology-24
ESP Journal of Engineering Technology Advancements / ISSN: 2583-2646

Original Article

Enhancing Agricultural Productivity: A Deep Learning Approach for Precision Crop Recommendation in India

K.Mohan[1], S.Pandeeswari[2], B.Mahesh[3]
[1,2,3]*Dept. of ECE, Solamalai College of Engineering, Tamil Nadu, India.*

Abstract: *Data mining is the practice of examining and deriving purposeful information from the data. Data mining finds its application in various fields like finance, retail, medicine, agriculture etc. Data mining in agriculture is used for analysing the various biotic and biotic factors. Agriculture in India plays a predominant role in economy and employment. The common problem existing among the Indian farmers are they don't choose the right level of watering based on their soil requirements. Due to this they face a serious setback in productivity. This problem of the farmers has been addressed through precision agriculture. Precision agriculture is a modern farming technique that uses research data of soil characteristics, soil types, crop yield data collection and suggests the farmers the right crop based on their site-specific parameters. This reduces the wrong choice on a crop and increase in productivity. In this work, this problem is solved by proposing a watering system through an deep learning model with long short term memory to control the water level of farm.*

Keywords: *Agricultural Productivity ,Deep Learning, Precision Agriculture, Crop Recommendation, India Agriculture, Machine Learning, Crop Yield Prediction, Data-Driven Agriculture, Precision Farming, Agricultural Data Analytics, I In Agriculture, Smart Farming, Crop Selection Optimization, Farm Management Systems, Soil Health Monitoring, Climate Impact On Crops, Remote Sensing, Geospatial Analysis.*

I. INTRODUCTION

A. Precision Agriculture:

Precision agriculture (PA) is a farming management strategy based on observing, measuring and responding to temporal and spatial variability to improve agricultural production sustainability.[2] It is used in both crop and livestock production. Precision agriculture often employs technologies to automate agricultural operations, improving their diagnosis, decision-making or performing.[3][4] First conceptual work on PA and practical applications go back in the late 1980s.[5] The goal of precision agriculture research is to define a decision support system (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.

Among these many approaches is a phytogeomorphological approach which ties multi-year crop growth stability/characteristics to topological terrain attributes. The interest in the phytogeomorphological approach stems from the fact that the geomorphology component typically dictates the hydrology of the farm field. The practice of precision agriculture has been enabled by the advent of GPS and GNSS. The farmer's and/or researcher's ability to locate their precise position in a field allows for the creation of maps of the spatial variability of as many variables as can be measured (e.g. crop yield, terrain features/topography, organic matter content, moisture levels, nitrogen levels, pH, EC, Mg, K, and others).[10] Similar data is collected by sensor arrays mounted on GPS-equipped combine harvesters. These arrays consist of real-time sensors that measure everything from chlorophyll levels to plant water status, along with multispectral imagery.[11] This data is used in conjunction with satellite imagery by variable rate technology (VRT) including seeders, sprayers, etc. to optimally distribute resources.

However, recent technological advances have enabled the use of real-time sensors directly in soil, which can wirelessly transmit data without the need of human presence.[12][13]Precision agriculture has also been enabled by unmanned aerial vehicles that are relatively inexpensive and can be operated by novice pilots. These agricultural drones can be equipped with multispectral or RGB cameras to capture many images of a field that can be stitched together using photogrammetric methods to create orthophotos.

These multispectral images contain multiple values per pixel in addition to the traditional red, green blue values such as near infrared and red-edge spectrum values used to process and analyze vegetative indexes such as NDVI maps.[14] These drones are capable of capturing imagery and providing additional geographical references such as elevation, which allows software to perform map algebra functions to build precise topography maps. These topographic maps can be used to correlate crop health with topography, the results of which can be used to optimize crop inputs such as water, fertilizer or chemicals such as herbicides and growth regulators through variable rate applications.

II. LITERATURE REVIEW

Srilikhitha; et al automates the irrigation process thereby reducing the manual intervention and the water losses. It is more helpful in the places where water scarcity is seen more. It consists of 2 sensors which takes the values of temperature of surroundings and moisture level of soil. Output of these sensors are given to ADC and then to microcontroller's; R. Suresh Kumar ;provides a solution for these problems by helping farmer monitor and control various activities through his mobile via GSM and DTMF technology in which data is transmitted from various sensors placed in the agricultural field to the controller and the status of the agricultural parameters are notified to the farmer using which he can take decisions accordingly. The main advantage of this system is that it is semi-automated i.e. the decision is made by the farmer instead of fully automated decision that results in precision agriculture.

Deepali Kothari er al a method which utilizes the potential of low power, high speed microcontrollers by using widely accepted open source Android platform. The proposed model enables us to control the field devices over a wireless link which is GSM based and can read signals from sensors connected in the field and can send the sensed electrical parameters of the motor or pump to an Android device.M. O. Sharma et al propose android based agricultural support system, that is, automatic irrigation system which adjusts the quantity of water based on sensor data. Monitoring and control of water irrigation and level detector with liquid fertilizer is being proposed in dissertation work with different control schemes and monitoring methods implemented using the micro-controller 89S52 and PIC 18F4550.

A. Ruby Roselin et al proposed project is to making agriculture smart using IoT technologies. The important feature of this project includes the prevention of crops from spoilage during rain and efficiently recycling the rain water for irrigation. Secondly, it includes intruder alarm/buzzer which is used to detect any human/animal intruder into the farm. Finally, the operation will be performed by interfacing Wi-Fi module, GSM module and sensors with Arduino. Ateeq Ur Rehman et al proposed design also has the feature of GSM which makes this system wireless. The electricity required by components is provided through solar panels hence this liberates us from interrupted power supply due to load shedding. The water content is constantly judged and whenever moisture level of soil gets low, the system sends a signal to motors asking them to turn on.

G Kavianand; V M Nivas presents a fully automated drip irrigation system which is controlled and monitored by using ARM9 processor. PH content and the nitrogen content of the soil are frequently monitored. For the purpose of monitoring and controlling, GSM module is implemented al describes the automated system to make effective utilization of water resources for agriculture and crop growth monitoring using GSM. The effective utilization of drip irrigation process is improved by using the signals obtained from soil moisture sensor. The output signals of the sensors are coordinated by the microcontroller and transmitted to the user with the help of GSM Modem. Irrigation is the process of artificially supplying water to land where crops are cultivated.

Ashok Jhunjhunwala et al presents a new approach to building an Agricultural Advisory System aimed at bridging the information gaps that exist between farmers and extension workers and agricultural scientists in a country like India. It demonstrates the power of two-way mobile phones today, which when combined with innovative methods could provide services to farmers that could not even be envisaged till yesterday.

A. Proposed System:

In this work, this problem is solved by proposing a recommendation system through machine learning model to recommend a crop for the site specific parameters with high accuracy and efficiency. Different sensors that measure the environmental parameters according to the plant requirement are used for controlling the environment. Then, a cloud server creates for remotely accessing the system when it connects using IoT. Suitable crop is also being advised to the farmers according to the parameters. A platform to buy and sell products online will help the farmers grow in an increasingly digital world. A discussion forum has also been added so that farmers can have their questions answered by the agricultural experts. This paper aims to ease the life of the farmers.3

- There is a database which consists of all the different sensor values which we have taken into account.
- The module is trained repetitively to attain the maximum accuracy.

- If a new data is given to the module its features get compared with the features that are already trained in the database.

It Then Provides The Appropriate Crop For Higher Yield:

This project is intended to aid in the detection and classification of paddy leaf diseases by CNN classification technique. First the diseased region is found using segmentation by Genetic K-means clustering, then both color and texture features are extracted. Finally classification technique of sum is used to detect the type of leaf disease.

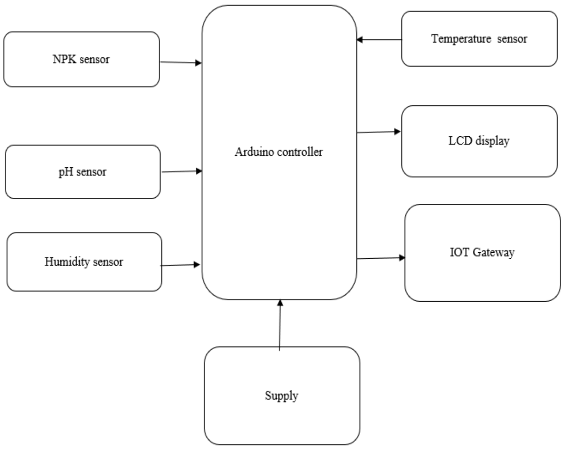

Figure 1: Proposed System

B. Image Acquisition:

The images of the paddy leaf are captured through the camera. This image is in RGB (Red, Green and Blue) form. Colour transformation structure for the RGB leaf image is created, and then, a device-independent color space transformation for the colour transformation structure is applied.

C. Image Pre-processing:

To remove noise in image or other object removal, different pre-processing techniques is considered. Image clipping i.e. cropping of the leaf image to get the interested image region. Image smoothing is done using the smoothing filter. Image enhancement is carried out for increasing the contrast. The RGB images into the grey images using colour conversion using equation (1).f(x)=0.2989*R + 0.5870*G + 0.114.*B - - - - - - - - - - - - - (1)Then the histogram equalization which distributes the intensities of the images is applied on the image to enhance the plant disease images. The cumulative distribution function is used to distribute intensity values [2].

D. Image Segmentation:

Segmentation means partitioning of image into various parts of same features or having some similarity. The segmentation can be done using CNN. In Deep Learning, Convolutional Neural Networks are a class of Deep Neural Networks that are mostly used in visual imagery. They are a special architecture of the Artificial Neural Networks (ANN) which was proposed in 1998 by Yann LeCunn. The Convolutional Neural Networks consist of two parts.

III. HARDWARE INTERFACE

A. Arduino Micro Controller:

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the and C++ programming languages.

B. Soil NPK sensor (JXBS-3001 soil NPK sensor):

Soil NPK sensor is produced by a JXCTIOT. The **low cost, quick responsive, high precision & portable** NPK sensor consists 3 probes made with austenitic 316 steel which works for longtime without corrosion by withstanding from rust, salt-alkali and electrolytic behaviours. The protection casing is filled with high quality epoxy resin which protects against the moisture from entering the main body of the sensor for a healthy long run of the sensor. The chipset which is used inside the sensor can create high sensitivity measurements with stable signal at low power consumption. The sensor is rated IP68 for water and dust proof.

C. MAX485 TTL to RS485 converter module overview:

The MAX485 TTL to RS485 converter module helps to convert the TTL signals to RS485 signal by adopting half-duplex communication. This module works at 5Volts power supply with 300 µA power consumption and gives long range communications upto 4000 feet (1.2kms) even in the electrically noisy environments. This module lets you to communicate between multiple devices 32 devices at a data speed of 2.5Mbps in the same data line through master and slave configuration (linear/multidrop) which makes it useful in the industrial applications. As the distance increases the data speed decreases proportionally.With the help of this MAX485 module we can communicate between RS485 differential signal from NPK sensor and Microcontrollers such as Arduino.

D. MAX485 TTL to RS485 Converter module pinout diagram:

MAX485 module has 8 pins 4 pins on each side. Check the below image of pinout diagram showing all the pins with their names.

- Receiver output (RO): which outputs the signal, should be connected to RX.
- Receiver Enable (RE): This is active LOW by default and to enable the receiver drive HIGH through digital pin of microcontroller.
- Driver Enable (DE): This is active HIGH by default and normally jump red to RE pin.
- Driver Input (DI): Should be connected to TX of microcontroller as it takes data as input.
- Right pins:
- VCC: Should be connected to 5v power supply
- B: inverted line for Data 'B'. Also connects to the screw pin as shown in image.
- A: Non-inverted line for Data A. Also connects to the screw pin as shown in image.
- GND: Ground.

Humidity Sensor:

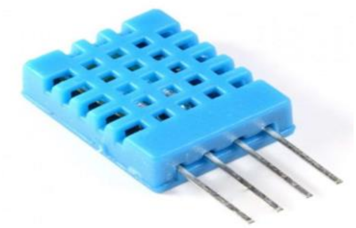

Figure 2: Temperature Sensor

This DHT11 Temperature and Humidity Sensor include an aligned advanced flag output with the temperature and mugginess sensor ability. It is incorporated with an elite 8-bit microcontroller. Its innovation guarantees the high dependability and magnificent long haul steadiness. This sensor incorporates a resistive component and a sensor for wet NTC temperature estimating gadgets. It has great quality, quick reaction, hostile to impedance capacity and high performance.

IV. RESULT & DISCUSSION

Data set has been collected from open source Kaggle website with different attributes. Below figure 5.1 shows the data set cases.

N	P	K	temperatu	humidity	ph	rainfall	label
90	42	43	20.87974	82.00274	6.502985	202.9355	rice
85	58	41	21.77046	80.31964	7.038096	226.6555	rice
60	55	44	23.00446	82.32076	7.840207	263.9642	rice
74	35	40	26.4911	80.15836	6.980401	242.864	rice
78	42	42	20.13017	81.60487	7.628473	262.7173	rice
69	37	42	23.05805	83.37012	7.073454	251.055	rice
69	55	38	22.70884	82.63941	5.700806	271.3249	rice
94	53	40	20.27774	82.89409	5.718627	241.9742	rice
89	54	38	24.51588	83.53522	6.685346	230.4462	rice
68	58	38	23.22397	83.03323	6.336254	221.2092	rice
91	53	40	26.52724	81.41754	5.386168	264.6149	rice
90	46	42	23.97898	81.45062	7.502834	250.0832	rice
78	58	44	26.8008	80.88685	5.108682	284.4365	rice
93	56	36	24.01498	82.05687	6.984354	185.2773	rice
94	50	37	25.66585	80.66385	6.94802	209.587	rice
60	48	39	24.28209	80.30026	7.042299	231.0863	rice
85	38	41	21.58712	82.78837	6.249051	276.6552	rice
91	35	39	23.79392	80.41818	6.97086	206.2612	rice

Figure 3: Input Data Formation

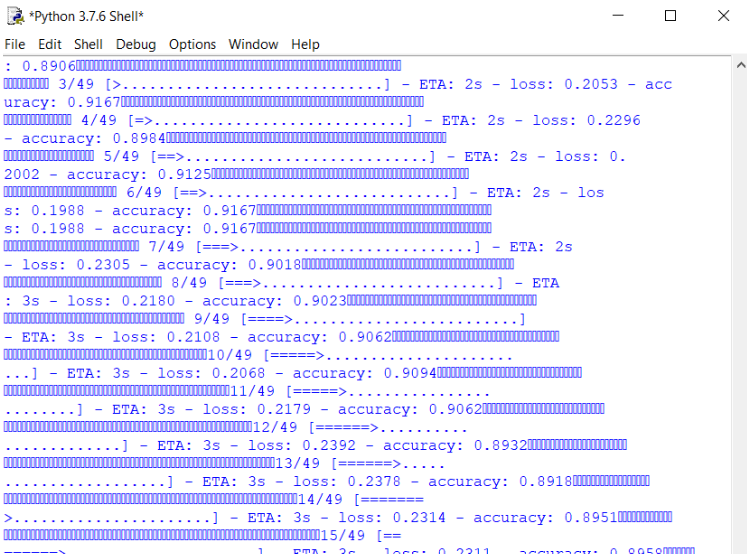

Figure 4: LSTM Training Result

The above figure shows training loss for LSTM model for the corresponding data set. The loss function of the model achieved a minimum error value for varying iterations.

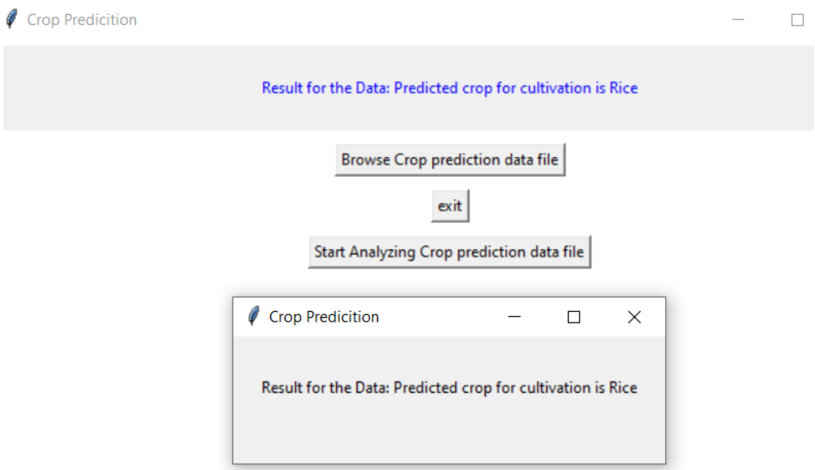

Figure 5: LSTM Model Predicted Result

The above figure 5.6 shows the predicted output. For prediction, the individual processing LSTM model adopts only for linear data. This work uses LSTM for feature extraction.

```
1/1 [==============================] - ETA: 0s - loss: 0.0331 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 16ms/step - loss: 0.0331 - accuracy: 0.0952
Epoch 496/500
1/1 [==============================] - ETA: 0s - loss: 0.0420 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 16ms/step - loss: 0.0420 - accuracy: 0.0952
Epoch 497/500
1/1 [==============================] - ETA: 0s - loss: 0.0351 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 16ms/step - loss: 0.0351 - accuracy: 0.0952
Epoch 498/500
1/1 [==============================] - ETA: 0s - loss: 0.0386 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 0s/step - loss: 0.0386 - accuracy: 0.0952
Epoch 499/500
1/1 [==============================] - ETA: 0s - loss: 0.0348 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 16ms/step - loss: 0.0348 - accuracy: 0.0952
Epoch 500/500
1/1 [==============================] - ETA: 0s - loss: 0.0267 - accuracy: 0.0952▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯1/1 [
==============================] - 0s 16ms/step - loss: 0.0267 - accuracy: 0.0952
```

Figure 6: LSTM Training Result

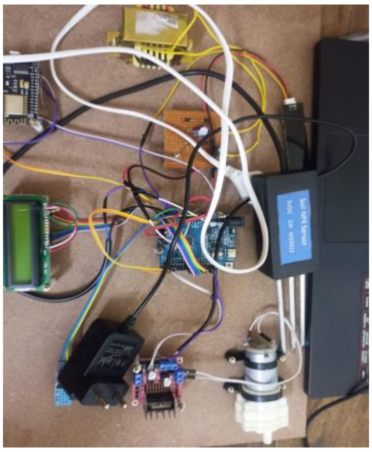

Figure 7: Hardware Implementation

V. RESULTS

Figure 8: Thing Speak View Of Results

In this figure 5.7, the loss and accuracy can be determined by LSTM training result. The proposed LSTM models shows loss values of 0.0348 with the accuracy of 98.35 for validation data set. Accuracy is defined as the percentage of correct predictions for the test data. It can be calculated by dividing the number of correct predictions by the number of total predictions. From the below figure 5.11 it's clear that our proposed model has the high accuracy while comparing other machine learning algorithm.

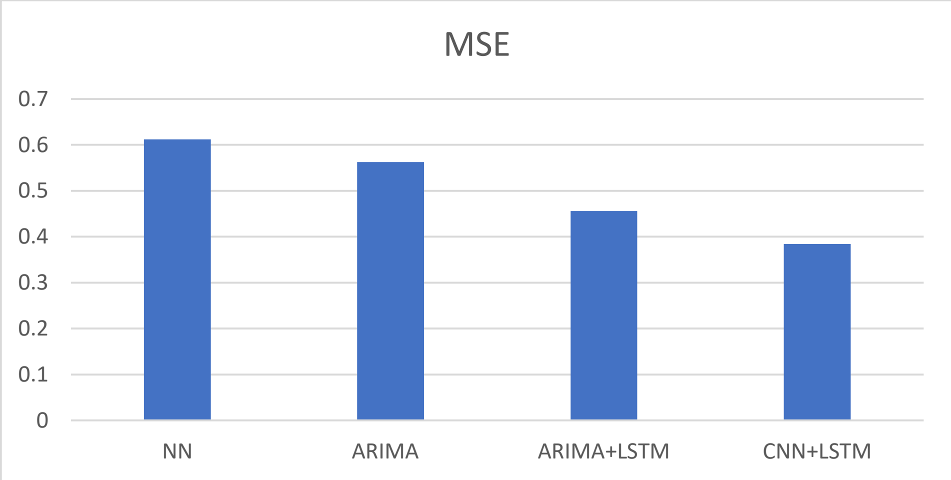

Figure 9: Performance Analysis – Accuracy

Table 1: Comparison of Results

Models	F1-Score	Accuracy	Precision	Specificity
RF	89.46	84.43	87.76	78.18
DT	92.92	89.76	92.13	85.39
SVM	90.38	86.32	89.06	79.87
ANN	94.76	94.84	97.61	92.47

The table 5.1, compare the performance of other machine learning algorithm. The comparison of result is LSTM having high accuracy.

V. CONCLUSION

The application of agriculture networking technology is need of the modern agricultural development, but also an important symbol of the future level of agricultural development; it will be the future direction of agricultural development. After building the agricultural crop recommendation system hardware and analyzing and researching the network hierarchy features, functionality and the corresponding software architecture of precision agriculture, actually applying the intelligence to the highly effective and safe agricultural production has a significant impact on ensuring the efficient use of resources as well as ensuring the efficiency and stability of the agricultural production.

VI. REFERENCES

[1] Siuli Roy, Somprakash Bandyopadhyay, "A Test-bed on Real-time Monitoring of Agricultural Parameters using Wireless Sensor Networks for Precision Agriculture"
[2] C. Arun, K. Lakshmi Sudha "Agricultural Management using Wireless Sensor Networks – A Survey" 2012 2nd International Conference on Environment Science and Biotechnology IPCBEE vol.48 (2012) © (2012)IACSIT Press, Singapore
[3] Anurag D, Siuli Roy and Somprakash Bandyopadhyay, "Agro-Sense: Precision
[4] Agriculture using Sensor-based Wireless Mesh Networks", ITU-T "Innovation in NGN", Kaleidoscope Conference, Geneva 12-13 May 2008.
[5] Yiming Zhou, Xianglong Yang, Liren Wang, Yibin Ying, A wireless design of low-cost irrigation system using ZigBee technology, 2009 International Conference on Networks Security, Wireless Communications and Trusted Computing, 978-0-7695-3610-1/09 , IEEE.
[6] Ning Wang, Naiqian Zhang, Maohua Wang, "Wireless sensors in agriculture and food industry—Recent development and future perspective", published in Computers and Electronics in Agriculture 50 (2006) 1–14.
[7] Izzatdin Abdul Aziz, Mohd Hilmi Hasan, Mohd Jimmy Ismail, MazlinaMehat, Nazleeni Samiha Haron, "Remote Monitoring in Agricultural Greenhouse Using Wireless Sensor and Short Message Service (SMS)", 2008.
[8] Jeonghwan Hwang, Changsun Shin, and Hyun Yoe "Study on an Agricultural Environment Monitoring Server System using Wireless Sensor Networks",2010.
[9] Zhang xihai, Zhang changli Fang junlong. Smart Sensor Nodes for Wireless Soil Temperature Monitoring Systems in Precision Agriculture 2009. 237-241
[10] Bogena H R, Huisman J A, OberdÊrster C, et al. Evaluation of a low cost soil water content sensor for wireless network applications [J].Journal of Hydrology, 2007, 32-42

[11] Weizheng, S., Yachun W., Zhanliang C., and Hongda W.," Grading Method of Leaf Spot Disease Based on Image Processing" International Conference on Computer Science and Software Engineering - Volume 06 ,PP. 491-494,December 2008.

[12] S. S. Sannakki, V. S. Rajpurohit, V. B. Nargund,and P. Kulkarni, "Diagnosis and Classification of Grape Leaf Diseases using Neural Networks", IEEE 4th ICCCNT, 2013.

[13] P. Chaudhary, A. K. Chaudhari, Dr. A. N. Cheeran and S.Godara, "Color Transform Based Approach for Disease Spot" International Journal of Computer Science and Telecommunications Volume 3, Issue 6, pp.65-70,June 2012

[14] H. Al-Hiary, S. Bani-Ahmad, M. Reyalat, M. Braik and Z. ALRahamneh, "Fast and Accurate Detection and Classification of Plant Diseases", IJCA, Vol-17,No.-1,pp. 31-38, March 2011.

[15] P. Babu, M. S. and Srinivasa Rao, "Leaves recognition using backpropagation neural network - advice for pest and disease control on crops". Technical report, Department of Computer Science & Systems Engineering, Andhra University, India, www.indiakisan.net on May 2010.

[16] Suman T. and Dhruvakumar T., "Classification of paddy leaf diseases using shape and color features", IJEEE, Volume 07, Issue 01, PP.239- 250, Jan- June 2015.

[17] Julian, Anitha , Mary, Gerardine Immaculate , Selvi, S. , Rele, Mayur & Vaithianathan, Muthukumaran (2024) Blockchain based solutions for privacy-preserving authentication and authorization in networks, *Journal of Discrete Mathematical Sciences and Cryptography,* 27:2-B, 797–808, DOI: 10.47974/JDMSC-1956

[18] Muthukumaran Vaithianathan"Digital Signal Processing for Noise Suppression in Voice Signals", IJCSPUB - INTERNATIONAL JOURNAL OF CURRENT SCIENCE (www.IJCSPUB.org), ISSN: 2250-1770, Vol.14, Issue 2, page no.72-80, April-2024, Available: https://rjpn.org/IJCSPUB/papers/IJCSP24B1010.pdf

[19] Muthukumaran Vaithianathan, "Real-Time Object Detection and Recognition in FPGA-Based Autonomous Driving Systems," *International Journal of Computer Trends and Technology*, vol. 72, no. 4, pp. 145-152, 2024. Crossref, https://doi.org/10.14445/22312803/IJCTT-V72I4P119

[20] Muthukumaran Vaithianathan, Mahesh Patil, Shunyee Frank Ng, Shiv Udkar, 2023. "*Comparative Study of FPGA and GPU for High-Performance Computing and AI*" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 1, Issue 1: 37-46. [PDF]

[21] Muthukumaran Vaithianathan, Mahesh Patil, Shunyee Frank Ng, Shiv Udkar, 2024. "*Low-Power FPGA Design Techniques for Next-Generation Mobile Devices*" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 2: 82-93. [PDF]

[22] Dhamotharan Seenivasan, Muthukumaran Vaithianathan, 2023. "*Real-Time Adaptation: Change Data Capture in Modern Computer Architecture*" ESP International Journal of Advancements in Computational Technology (ESP-IJACT) Volume 1, Issue 2: 49-61. [PDF]

[23] Muthukumaran Vaithianathan, Mahesh Patil, Shunyee Frank Ng, Shiv Udkar, 2024. "*Integrating AI and Machine Learning with UVM in Semiconductor Design*" ESP International Journal of Advancements in Computational Technology (ESP-IJACT) Volume 2, Issue 3: 37-51. [PDF]

[24] Chanthati, Sasibhushan Rao. (2021*). A segmented approach to encouragement of entrepreneurship using data science.* World Journal of Advanced Engineering Technology and Sciences. https://doi.org/10.30574/wjaets.2024.12.2.0330, [link]

[25] Patel, N. (2024, March). SECURE ACCESS SERVICE EDGE(SASE): "EVALUATING THE IMPACT OF CONVEREGED NETWORK SECURITYARCHITECTURES IN CLOUD COMPUTING." Journal of Emerging Technologies and Innovative Research. https://www.jetir.org/papers/JETIR2403481.pdf

[26] Vishwanath Gojanur , Aparna Bhat, "Wireless Personal Health Monitoring System", IJETCAS:International Journal of Emerging Technologies in Computational and Applied Sciences,eISSN: 2279-0055,pISSN: 2279-0047, 2014. [Link]

[27] Mistry, H., Shukla, K., & Patel, N. (2024). Transforming Incident Responses, Automating Security Measures, and Revolutionizing Defence Strategies throughAI-Powered Cybersecurity. Journal of Emerging Technologies and Innovative Research, 11(3), 25. https://www.jetir.org/

[28] Aparna Bhat, "Comparison of Clustering Algorithms and Clustering Protocols in Heterogeneous Wireless Sensor Networks: A Survey," 2014 INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR)-ISSN : 2349-4689 Volume 04- NO.1, 2014. [Link]

[29] Shashikant Tank Kumar Mahendrabhai Shukla, Nimeshkumar Patel, Veeral Patel, 2024." AI BASED CYBER SECURITY DATA ANALYTIC DEVICE", 414425-001, [Link]

[30] Aparna Bhat, Rajeshwari Hegde, "Comprehensive Study of Renewable Energy Resources and Present Scenario in India," 2015 IEEE International Conference on Engineering and Technology (ICETECH), Coimbatore, TN, India, 2015. [Link]

[31] Sarangkumar Radadia Kumar Mahendrabhai Shukla ,Nimeshkumar Patel ,Hirenkumar Mistry,Keyur Dodiya 2024." CYBER SECURITY DETECTING AND ALERTING DEVICE", 412409-001, [Link]

[32] Aparna K Bhat, Rajeshwari Hegde, 2014. "Comprehensive Analysis Of Acoustic Echo Cancellation Algorithms On DSP Processor", International Journal of Advance Computational Engineering and Networking (IJACEN), volume 2, Issue 9, pp.6-11. [Link]

[33] Nimeshkumar Patel, 2022." QUANTUM CRYPTOGRAPHY IN HEALTHCARE INFORMATION SYSTEMS: ENHANCING SECURITY IN MEDICAL DATA STORAGE AND COMMUNICATION", Journal of Emerging Technologies and Innovative Research, volume 9, issue 8, pp.g193-g202. [Link]

[34] Bhat, A., & Gojanur, V. (2015). Evolution Of 4g: A Study. International Journal of Innovative Research in ComputerScience & Engineering (IJIRCSE). Booth, K. (2020, December 4). How 5G is breaking new ground in the construction industry. BDC Magazine.https://bdcmagazine.com/2020/12/how-5g-is-breaking-new-ground-in-the-constructionindustry/. [Link]

[35] Nimeshkumar Patel, 2021." SUSTAINABLE SMART CITIES: LEVERAGING IOT AND DATA ANALYTICS FOR ENERGY EFFICIENCY AND URBAN DEVELOPMENT", Journal of Emerging Technologies and Innovative Research, volume 8, Issue 3, pp.313-319. [Link]

[36] Bhat, A., Gojanur, V., & Hegde, R. (2014). 5G evolution and need: A study. In International conference on electrical, electronics, signals, communication and optimization (EESCO)—2015.[Link]

[37] A. Bhat, V. Gojanur, and R. Hegde. 2015. 4G protocol and architecture for BYOD over Cloud Computing. In Communications and Signal Processing (ICCSP), 2015 International Conference on. 0308-0313. Google Scholar. [Link]

[38] Gokul Ramadoss , 2022." Care and Disease Management: Why Managed Care Organizations (MCOs) Need to have an Inclusive Approach to Patient Care", Progress in Medical Science, VOL 6, NO. 3, PAGE 1 – 5, [Link]

[39] Gokul Ramadoss , 2022." EHR & EMR - A Wholesome View on its Impact in EDI Transaction", Progress in Medical Science, VOL 6, NO. 5, PAGE 1 – 4, [Link]

[40] Radhika Kanubaddhi, "Real-Time Recommendation Engine: A Hybrid Approach Using Oracle RTD, Polynomial Regression, and Naive Bayes," SSRG International Journal of Computer Science and Engineering , vol. 8, no. 3, pp. 11-16, 2021. Crossref, https://doi.org/10.14445/23488387/IJCSE-V8I3P103

[41] Radhika Kanubaddhi, 2022. "Designing an Enterprise-Grade, Cloud-Native Chatbot Solution for the Hospitality Industry Using Azure QnA Maker and Azure LUIS", ESP Journal of Engineering & Technology Advancements, 2(1): 56-62. https://espjeta.org/jeta-v2i1p108

[42] Anusha Medavaka, 2024. "*AWS AI from Financial Services Transforming Risk Management and Investment Strategies*" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 3: 116-129.

[43] Muthukumaran Vaithianathan, Mahesh Patil, Shunyee Frank Ng, Shiv Udkar, 2024. "*Verification of Low-Power Semiconductor Designs Using UVM*", *ESP Journal of Engineering & Technology Advancements* 4(3): 28-44.

[44] Lakshmana Kumar Yenduri, 2024. "*Low Latency High Throughput Data Serving Layer for Generative AI Applications using the REST-based APIs*" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 3: 61-76.

[45] Anusha Medavaka, 2023. "*Building Intelligent Systems on AWS: From Data Lakes to AI-Powered Insights*", *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 1, Issue 3: 68-80.