International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

An Intelligent Crop Recommendation System using Deep Learning

Dr. Kanaga Suba Raja S.[1], Durai Arumugam S. S. L. [2], Dr. R. Praveenkumar[3], Dr. V. Balaji[4]

Submitted: 28/05/2023 **Revised**: 07/07/2023 **Accepted**: 25/07/2023

Abstract: A promising study area has been in the work of prediction of crop production based on certain factors like soil, characteristics of crop, water, etc. Agriculture elements like as weather, rain, the fertilizer used, pesticides, and the type of soil are some of the primary contributors to increased crop production. The presence of certain nutrients like Phosphorus, Nitrogen, Magnesium, Sulfur including some others are investigated in this research using a hybrid approach of Neural network and Image Processing to investigate soil supplements. The purpose of this research is to examine the approaches employed in extracting the water bodies utilizing the mode of satellite remote sensing. The goal of the proposed work is to collect the data of temperature and humidity and utilize algorithm of clustering with the method of k-Nearest Neighbor to find out the patterns which are all hidden in them with a help of huge amount of dataset. By this way the retrieved data is converted into data which can be used in the climate prediction and categorization.

Keywords: *Crop yield, Neural Network, Image processing, Remote sensing, K-Nearest Neighbor method.*

1. Introduction

India is one of the world's oldest countries that still practices agriculture. However, due to globalization, agricultural practices have substantially changed in recent years. One of the major areas of focus is agriculture. They contribute significantly to society since they generate a huge amount of the food. In many countries, this is still the case. With an increasing population, many people are experiencing food shortages. Agriculture in today's world frequently employs sophisticated technologies. Farmers may increase profit, efficiency, safety, and environmental friendliness by using these improved agricultural technologies. For image processing, MATLAB is used as IDE. For training the model the algorithm of Hybrid Neural Network is employed and also to improve the program's accuracy in calculating the soil's nutrient and pH levels. Machine learning is the branch of AI that doesn't require any explicit programming.

The strategies are derived from the learning process in Deep Recurrent Q-Network learning agricultural systems. These procedures necessitate extensive training in order to do a certain task. The developed system makes assumptions for testing the information retrieved when the training phase is completed. We can observe how artificial and deep neural networks are being used. Deep learning is a model that predicts from a variety of data groupings. With the best set of iterations, a deep Q-Learning algorithm, which is based on DRL, is employed to improve efficiency of the forecasting of the agricultural yield. The proposed work will help to enhance smart agriculture, which will result in increased food production. Thus, the model of Deep Recurrent Q-Network (DRQN) [1] and the Deep Q-learning algorithm for crop yield forecasting.

2. Related Works

Artificial Intelligence's potential evolution has unquestionably limitless possible outcomes. Deep learning has exploded in popularity, accompanied by massive data advances, in order to provide new opportunities. As a result, better measures are needed to conceptualize, determine, and evaluate data-intensive tactics in agricultural contexts. Crop production prediction comes under the pattern recognition model where the Artificial Intelligence is demonstrated to find out the significant efficiency in the applications of the agricultural field. The ANN was proposed by Abrougui et al. to estimate potato crop yields based on soil parameters and the tillage system. The ANN system displayed a lot of promise in terms of yield estimation. ANN was used by Haghverdi et al. to denies the prediction of phenology of crop indices in the cotton lint. Around 61200 models connecting to each single indices of crop for estimating. The results were generated using the ANN technique.

Byakatonda et al. presented a climatic indices-based ANN-based yield projection for the crop of maize as well as the precipitation duration to make farming easier, ANN models are used to forecast yield in planning. The ANNs were used in the approaches discussed before utilized for feature extraction in the processing. Via means of time-domain and

[1]*Professor, CSE Department, SRM Institute of Science and Technology , Tiruchirapalli, Tamil Nadu. Mail ID: skanagasubaraja@gmail.com*
[2]*Assistant Professor, Dept. of Information Technology, Easwari Engineering College, Ramapuram, Chennai, Tamil Nadu. Mail ID: duraiarumugam36@gmail.com*
[3]*Assistant Professor, Dept. of Electronics and Communications Engineering, Easwari Engineering College, Ramapuram, Chennai,Tamil Nadu. Mail ID: rpjcspraveen@gmail.com*
[4]*Associate Professor, Easwari Engineering College, Ramapuram, Chennai, Tamil Nadu. Mail ID: balaji.iniyan@gmail.com*

frequency-domain processing. As a result, manual feature extraction has a disadvantage. For predicting, a lot of people rely on past knowledge of the data-yield, as well as the ANN's shallow learning system the yield prediction's complicated non-linear correlations system. Such issues are becoming less of a problem with the advantages of deep learning technique. To a certain extent, it's been managed. Yang et al. developed a deep CNN model to forecast estimation of the crop of rice yield at the ripening stage. From a high spatial resolution RGB image, the CNN itself learn the important properties related to yield of the crop . Crop mapping approach used deep learning for the determination of the crop production in each area. On the basis of the picture of the leaf which was affected by the disease acquired by the method of image processing, Ramesh et al. suggested the optimized deep neural network methodology to recognize and for classifying the crop-yield

Babak et al. used the DSSAT model which uses the rainfall and irrigation as the input to create a crop growth forecast model for the crop of maize in the production prediction. Using deep learning, a best autonomous estimation system of crop yield heading date for the rice has been developed.

Desai et al. presented a CNN network based on the RGB series of photographs of the particular crops. For mango fruit production estimation, Koirala et al. presented a method in deep learning utilizing the CNN model which was two staged . The ANN procedure is found to be the effective method of prediction in the literature, but approaches of deep learning is used to distinguish the crop feature extraction by using the DNN architecture in deep learning approaches in which the hierarchical representation is found. DNN architecture, on the other hand, necessitates a large quantity of prior expertise and information, limiting its generalizability. As a result, a smart architecture based on Deep Reinforcement learning (DRL) is incorporated in investigating the prediction of the crop yield. DRL permits the creation of a meta-learning factor that is able to generalize to a new environment . DRL finds use in a variety of fields, including agriculture, energy management , health care areas and game theory as a generic means. The optimization to the problems is achieved through the method of trial and error. The Deep Q-Network-DRL algorithm and the approach incorporated for the approached system are briefly discussed in the next section.

3. Proposed System

The proposed system makes use of Deep Learning which enables the way for testing the soil with the help of Image processing. It is done by making use of the measurements and the observations of the soil parameters. The proposed system helps is lowering the soil degradation rate of probability and helps to maintain and manage the health of the crop. Parameters including the moisture, temperature and humidity are used in the system. These data are sensed by the technique stored in the local system and they are analysed using the deep learning algorithms such as DBN. These results help by giving suggestions to retain the growth and to find out the most suitable crop for the field. In addition to that, we use water footprint to check the availability of water using historical data (Met data tool).

Deepq-Network Algorithm Background

Deep-reinforcement learning is progressed alongside massive data increase and improved measure persistence tocreate new possibilities for determining, evaluating, and acknowledgingAgriculture frameworks with significant data methods.

Some of the most important aspects to consider are:

- Patterns or the basic structures can be deduced in the limited sample space.
- We're going through the objectives with the representation of the constant events.
- The framework's performance should be sufficient for accommodating the consistent dynamic actions.
- The resultant section goes through the learning of reinforcement, Q-learning, and then it goes through the deep Q-Network algorithm in great detail.

DEEP Q-NETWORK

Deep Q-networks is one of the advanced reinforcement learning agent that employs DNN which helps in mapping the connections between states and actions, similar to how a neural network maps the connections between neurons. In Q-Learning, there is a Q-Table. Convolutional Neural Networks, for example, are DNNs, CNN, RNN, SNN.

The role of a DQN agent is similar to that of a Q-Learning agent in that it makes contact with the environment by means of a series of observations or actions. The network gets the input as a state and generates Q-Values for each and every action in the space of action. The neural network's main motivation is to learn and get trained with the parameters.

The network which was trained is used to forecast the consequent optimal action in the environment throughout the prediction phase. In essence, Q-Learning is found to be achieving the state-action value function with a specific goal-policy, which then chooses the best action. It only operates in a limited action and the state space. However, storing millions of entries in programme memory may be required for a large set of action space. As a result, the memory volume is innated, resulting in the dimensionality curse or representation of a Q-Function which will be unstable.

The correlations present in the continuous set of observations cause the instability in Q-Learning. Minimal changes in Q-value can cause a major shift in the agent's policy, as well as the relation between the Q-Value target and. Deep Q-Network overcomes these flaws by employing two types of strategies namely

- Experience replay
- Iterative updating.

The updates in the iterates helps in reducing the co-relation between the target and the Q-values by adjusting the Q-values towards the target values over time. While data randomization uses smoothing instead of the changes in the data distribution and the experience replay to find the solution for the correlation problem.

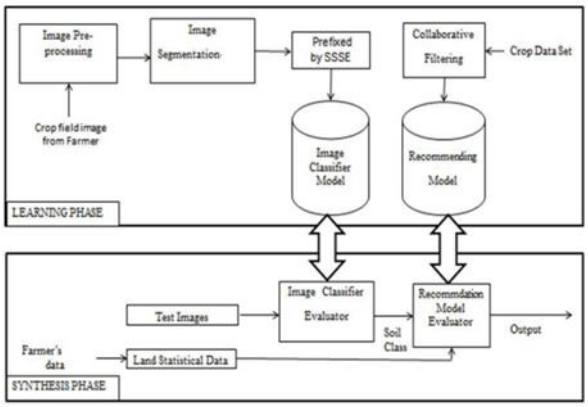


Fig. 1 Architecture Diagram

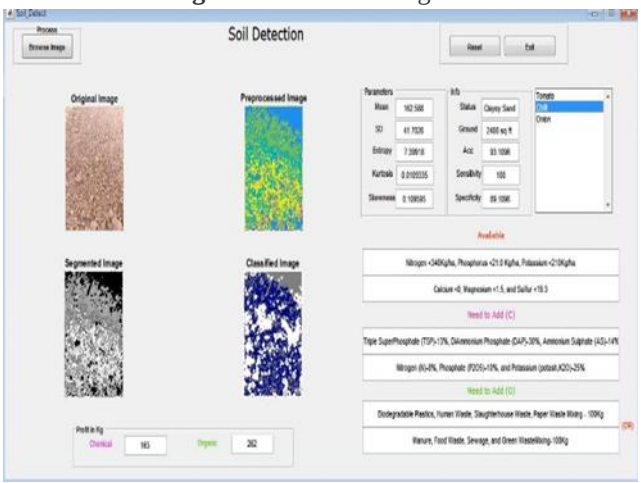


Fig. 2 Expected output for soil detection

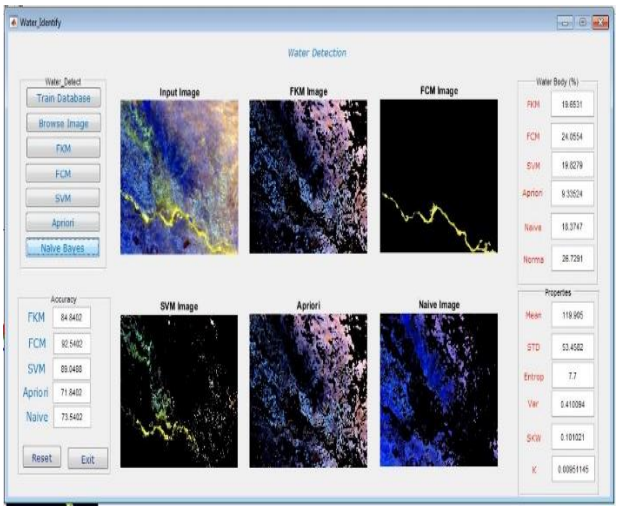


Fig. 3 Expected Output for Water Detection

4. Implementation and Results

MATLAB serves as the IDE for the process of image processing. This process comprises of five individual categories that include image input, preprocessing, image segmentation, classification, and the output. The Hybrid Neural Network is incorporated as the training model in the main motive to increase the system's accuracy in the way of providing the highly positively predicted values or levels of the nutrients and the soil's pH..

1. Data Collection

Soil nutrient Dataset required for this work was collected from Department of Agriculture at some of the districts like Ariyalur, Salem, Trichy in Tamil Nadu. The dataset collected contains information like attributes, the values of soil samples that corresponds to the respective district from which the soil was taken. There are around 12 attributes in the dataset and the total instance of 1676 soil samples are used for the proposed system. The attribute description of the dataset collected was depicted in the table provided below as Table 1.

2. Data Pre-Processing

In this step described about removing unwanted data from the dataset which helps to extract required result data from the dataset.

3. Data Conversion

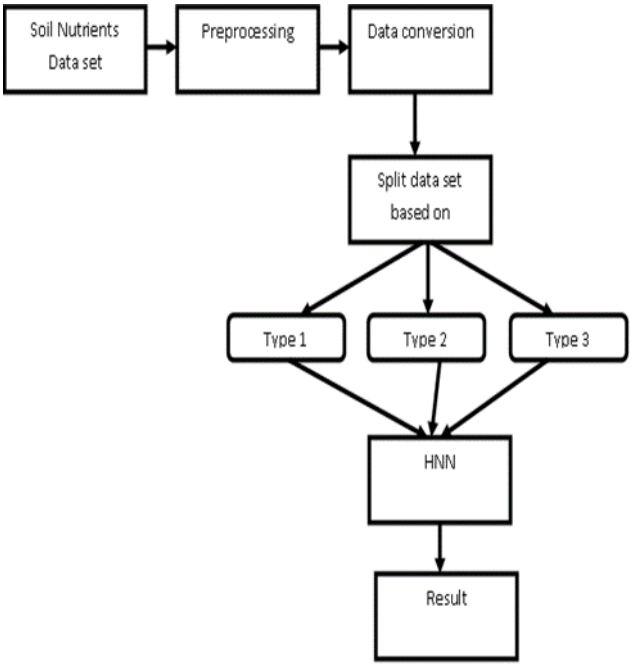
If data mining uses MATLAB tool, the data must be in MAT format. All the data sheets converted into .MAT file "MATLAB file format". This MAT file has sections those are Header and Data Information.

4. Classification

This technique of data mining is based on machine learning using concepts of algorithms. In this soil nutrient datasets are classified using deep learning and CNN classification algorithms.

5. Prediction

The classification algorithm is noted for the accuracy and the performance analysis and it provides suggestion to farmer to choose the best crop for the soil.

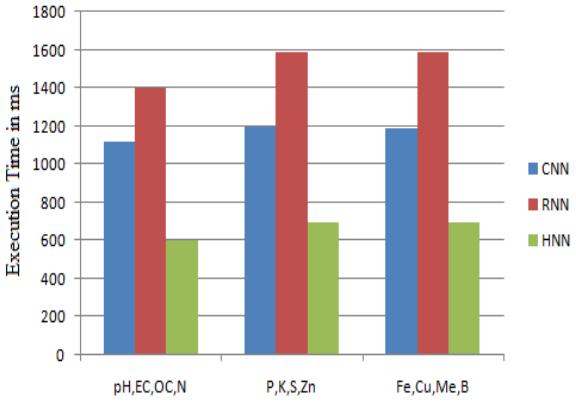


PROPOSED WORK PROPOSED WORK FLOW

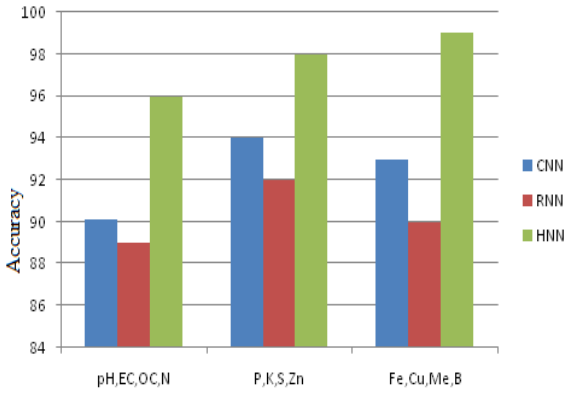
The dataset collected are pre-processed and the unwanted data was removed. After the step of pre-processing the complete set of data was divided into LOW, MEDIUM and the HIGH depending on the level of nutrients present.

Then the algorithms like CNN, RNN and the Hybrid Classification. Then based on these algorithms the nutrients in the soils are classified in the following levels Very High, High, Medium, Low and Very Low.

The Table:2 depicts the comparative analysis of classifiers. The following figures shows the time of execution of the various classification algorithms by grouping the three types of nutrients and also the accuracy in the rate of those algorithms with the help of the set of three different nutrients.



ACCURACY FOR CLASSIFIERS



EXECUTIONTIME OF CLASSIFIERS

District	pH	EC	OC	N	P	K	S	Zn	Fe	Cu	Mn	B
Ariyalur	8.30	0.26	0.54	43.2	17.6	789	10.5	2.45	2.45	3.56	3.67	3.4
Ariyalur	5.10	0.17	0.40	60.60	16.25	60	17.50	0.53	5.23	0.17	3.38	1.0
Coimbatore	6.50	0.38	0.18	231.0	18.0	400	8.10	0.80	5.10	2.20	2.60	0.30
Coimbatore	7.80	0.18	0.18	173.0	13.6	284	17.24	1.0	5.30	1.40	2.60	0.41
Karur	7.90	0.6	0.35	80.00	2.70	189	8.10	0.84	1.40	0.02	1.08	1.10
Karur	8.10	1.50	0.15	45.00	2.70	233	0.11	0.10	2.60	0.03	1.70	1.10
Salem	7.90	0.10	0.28	162	7.50	315	29.2	0.23	10.5	0.72	7.23	2.30
Salem	7.80	0.10	0.11	189	10	378	33.20	0.32	13.5	0.74	0.32	1.0
Thanjavur	6.90	0.15	0.75	205	75	250	25	1.30	6.80	1.80	2.0	1.0
Thanjavur	7.70	0.17	0.69	189	75	300	20.60	1.60	7.40	0.90	2.0	1.0
Trichy	7.0	1.10	0.25	179	53.0	195.0	12.20	1.06	5.72	0.96	3.48	0.10
Trichy	6.80	0.40	0.19	147	25.0	185.0	12.60	0.95	6.27	0.91	5.76	0.10

Table 1 SAMPLE NUTRIENT DATA-SET

District	pH	EC	OC	N	P	K	S	Zn	Fe	Cu	Mn	B
Ariyalur	H	L	M	L	M	H	M	H	L	H	M	H
Ariyalur	L	L	L	L	M	L	H	L	M	L	M	M
Coimbatore	L	L	L	L	M	H	L	L	M	H	M	L
Coimbatore	H	L	L	L	M	H	H	L	M	M	M	L
Karur	H	L	L	L	L	M	L	L	L	L	L	H
Karur	H	M	L	L	L	M	L	L	L	L	L	H
Salem	H	L	L	L	L	H	H	L	H	L	H	H
Salem	H	L	L	L	L	H	H	L	H	L	L	M
Thanjavur	M	L	H	L	H	M	H	L	M	H	M	M
Thanjavur	H	L	M	L	H	H	H	M	M	L	M	M
Trichy	M	M	L	L	H	M	M	L	M	L	M	L
Trichy	M	L	L	L	H	M	M	L	M	L	H	L

Table 2 COMPARATIVE ANALYSIS OF CLASSIFIERS BASED ON NUTRIENTS

5. Conclusion

The need of maintaining the health of the soil resource base as a critical component of long-term development is increasingly recognized. Agriculturists will be able to improve crop productivity by using data mining techniques in the field. The soil nutrients are mostly responsible for yield production. The study of the nutrients presence in the soil helps is determining the types of crop, which can be used in the specific soil in order to get the good yield. The healthiest soils generate the healthiest and most plentiful food. We conclude that the Data Mining and Remote Sensing area provides

many algorithms and prognosis strategies for classification of soil attributes databased on the literature. Thus, the collected data of temperature and humidity helped in the process of prediction and categorization system of climate using the algorithms like K-Nearest Neighbor, which helps in uncovering the hidden patterns. In order to extract water features from satellite photos, a variety of satellites are used. A few of the findings are talked over. And as the result an attempt was proposed by considering the existing issues as well as the futuristic possibilities of extraction from water body approaches to a conclusion.

References

[1] Elavarasan, D., & Vincent, P. D. (2020). Crop yield prediction using deep reinforcement learning model for sustainable agrarian applications. IEEE access, 8, 86886-86901.

[2] Bhuyar, V. (2014). Comparative analysis of classification techniques on soil data to predict fertility rate for Aurangabad District. Int. J. Emerg. Trends Technol. Comput. Sci, 3(2), 200-203.

[3] Baskar, S. S., Arockiam, L., & Charles, S. (2013). Applying data mining techniques on soil fertility prediction. International Journal of Computer Applications Tecnology and Research, 2(6), 660-662.

[4] Gholap, J. (2012). Performance tuning of J48 Algorithm for prediction of soil fertility. arXiv preprint arXiv:1208.3943.

[5] Gholap, J., Ingole, A., Gohil, J., Gargade, S., & Attar, V. (2012). Soil data analysis using classification techniques and soil attribute prediction. arXiv preprint arXiv:1206.1557.

[6] Suman, B. B. N., &Naib, B. (2013). Soil classification and fertilizer recommendation using WEKA. IJCSMS International Journal of Computer Science & Management Studies, 13(05).

[7] Hemageetha, N., &Nasira, G. M. (2016). Analysis of soil condition based on pH value using classification techniques. IOSR J ComputEng (IOSR-JCE), 18(6), 50-54.

[8] Bhargavi, P., &Jyothi, S. (2011). Soil classification using data mining techniques: a comparative study. *International Journal of Engineering Trends and Technology*, *2*(1), 55-59.

[9] Rajeswari, V., &Arunesh, K. (2016). Analysing soil data using data mining classification techniques. Indian journal of science and Technology, 9(19), 1-4.

[10] Noble, I., Bolin, B., Ravindranath, N., Verardo, D., &Dokken, D. (2000). Land use, land use change, and forestry. Environmental Conservation, 28(3), 284-293.

[11] Henderson, F. M. (1995). Environmental factors and the detection of open surface water areas with X-band radar imagery. International Journal of Remote Sensing, 16(13), 2423-2437.(13),pp.2423–2437,September1995.

[12] Nath, R. K., & Deb, S. K. (2010). Water-body area extraction from high resolution satellite images-an introduction, review, and comparison. International Journal of Image Processing (IJIP), 3(6), 265-384.

[13] Prakash, A., & Gupta, R. P. (1998). Land-use mapping and change detection in a coal mining area-a case study in the Jharia coalfield, India. International journal of remote sensing, 19(3), 391-410.

[14] Zhang, Q., Wang, C., & Shinohara, F. (2007, November). Automatic extraction of water body based on EOS/MODIS remotely sensed imagery. In MIPPR 2007: Automatic Target Recognition and Image Analysis; and Multispectral Image Acquisition (Vol. 6786, pp. 1068-1074). SPIE..

[15] Nath, R. K., & Deb, S. K. (2010). Water-body area extraction from high resolution satellite images-an introduction, review, and comparison. International Journal of Image Processing (IJIP), 3(6), 265-384.

[16] Li, S., Peng, S., Chen, W., & Lu, X. (2013). INCOME: Practical land monitoring in precision agriculture with sensor networks. Computer Communications, 36(4), 459-467.

[17] Jones, A. D., Ngure, F. M., Pelto, G., & Young, S. L. (2013). What are we assessing when we measure food security? A compendium and review of current metrics. Advances in nutrition, 4(5), 481-505.

[18] Ogutu, G. E., Franssen, W. H., Supit, I., Omondi, P., &Hutjes, R. W. (2018). Probabilistic maize yield prediction over East Africa using dynamic ensemble seasonal climate forecasts. Agricultural and forest meteorology, 250, 243-261.

[19] Holzman, M. E., Carmona, F., Rivas, R., &Niclòs, R. (2018). Early assessment of crop yield from remotely sensed water stress and solar radiation data. ISPRS journal of photogrammetry and remote sensing, 145, 297-308.

[20] Singh, A., Ganapathysubramanian, B., Singh, A. K., & Sarkar, S. (2016). Machine learning for high-throughput stress phenotyping in plants. Trends in plant science, 21(2), 110-124.

[21] Balaji, V., Raja, S., & Suba, K. (2022). Recommendation Learning System Model for Children with Autism. *Intelligent Automation And Soft Computing*, *31*(2), 1301-1315.

[22] Kiruthika, U., Raja, S. K. S., Balaji, V., & Raman, C. J. (2020, December). E-agriculture for direct marketing of food crops using chatbots. In *2020 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)* (pp. 1-4). IEEE.

[23] Raja, S. K. S., Balaji, V., &Vivekanandan, M. (2015). Autonomous mobile navigation robot for agricultural purpose. *International Journal of Applied Engineering Research*, *10*(10), 27333-27341.

[24] Srikanth, V. Natarajan, B. Jegajothi, S. S. L. Durai Arumugam and D. Nageswari, "Fruit fly Optimization with Deep Learning Based Reactive Power Optimization Model for Distributed Systems," 2022 International Conference on Electronics and Renewable Systems (ICEARS), 2022, pp. 319-324, doi: 10.1109/ICEARS53579.2022.9751908.

[25] S.Kanaga Suba Raja, R. Rishi, E. Sundaresan and V. Srijit, "Demand based crop recommender system for farmers," 2017 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), 2017, pp. 194-199, doi: 10.1109/TIAR.2017.8273714.

[26] M.Vivekanandan ,S. Kanaga Suba Raja, (2022) ' Virtex-II Pro FPGA Based Smart Agricultural System', Wireless Personal Communications, ISSN 0929-6212. Volume 125 Issue 1, pp 119–141.https://doi.org/10.1007/s11277-022-09544-x.

[27] S. K. Suba Raja, D. A. S S L, R. P. Kumar and J. Selvakumar, "Recognition of Facial Stress System using Machine Learning with an Intelligent Alert System," 2023 7th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2023, pp. 1-4, doi: 10.1109/ICCMC56507.2023.10083566.

[28] Ekaterina Katya, S.R. Rahman. (2020). Void Node Detection and Packet Re-routing in Underwater Wireless Sensor Network. International Journal of New Practices in Management and Engineering, 9(04), 01 - 10. Retrieved from http://ijnpme.org/index.php/IJNPME/article/view/93

[29] Sindhwani, N., Anand, R., Vashisth, R., Chauhan, S., Talukdar, V., & Dhabliya, D. (2022). Thingspeak-based environmental monitoring system using IoT. Paper presented at the PDGC 2022 - 2022 7th International Conference on Parallel, Distributed and Grid Computing, 675-680. doi:10.1109/PDGC56933.2022.10053167 Retrieved from www.scopus.com