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YOLO P-House: An AI based Polyhouse

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Abstract **– As technology is evolving exponentially every day, there has been very drastic changes in the art of farming and agricultural activities. To develop off season crops and to increase crop production, a smart concept of polyhouse is already being used by many farmers worldwide. The proposed research is an attempt to reduce the efforts, maintenance and workload of a farmer in a polyhouse environment using AI based frameworks. This paper will provide a framework to automate mostly all the processes used in a polyhouse. An AI based model will be created for an automated system which will automatically monitor and control all the environmental factors of the polyhouse. The tasks which will be automated are temperature, soil, humidity, pH and the main goal will be the detection of unhealthy and diseased plants using image processing and artificial intelligence. The main aim of this research will be a model to detect accurate diseases in plants inside a polyhouse. The prediction of diseases in crops inside the polyhouse will be carried out using the concepts of Artificial Intelligence.**

Keywords **– YOLO, CNN, ANN, DHT11, Yield, Smart Agriculture.**

I. INTRODUCTION

As technology is evolving exponentially every day, there has been very drastic changes in the art of farming and agricultural activities. The traditional methods used for crop production in agriculture were thought to be sufficient in earlier times. But in recent times, as the population is increasing exponentially, the demand for agricultural yield is also increasing day by day. To increase off-season yield, the most popular technology developed in the agricultural field is a Polyhouse. A polyhouse is basically a specialized structure that creates a controlled climate condition inside itself for the growth of non-seasonal crops at any point of time. A polyhouse has evolved the traditional methods of farming used in earlier days. This led to the development of new opportunities in the agricultural domain. Polyhouse helps to get better and sufficient yield while utilizing very fewer resources. A polyhouse generally uses polythene sheets to cover its structure and separate its internal environment from that of the outside [1]. The polyhouses have become very popular in the areas where climatic conditions are not optimal for any type of yield production [2]. There are several challenges faced by the farmers to work and maintain such polyhouses. This paper will elaborate AI based model which will automate most of the processes inside a polyhouse. Scenarios such as monitoring and controlling various climatic parameters will help in minimizing the cost of maintaining a polyhouse environment using AI based technologies. This research will develop a model to automate the polyhouse system which will efficiently monitor and control the environmental factors inside the polyhouse by monitoring the temperature, soil moisture, humidity, pH and also predict unhealthy plants using image processing and artificial intelligence. The main aim of this research is to detect the accurate disease in a plant inside a polyhouse so that the necessary actions/remedy can be taken by the farmer. The proposed model consists of a database server to store the real-time data that navigates through a predefined map of polyhouse. The research carried out in the field of polyhouse, IOT and AI will ensure development of an intelligent model which will automate the tasks inside a polyhouse [3]. Artificial intelligence is made up of powerful complex concepts such as genetic algorithm, particle swarm optimization, simulation, ANNs and some hybrid models [4]. Artificial Intelligence is generally based on the concept of mapping non-linear behavior within input and output tasks [5]. AI can solve very

difficult tasks that require high end human intelligence such as detection, recognition, decision-making and all such related tasks including performing like human brain [6]. Artificial Intelligence allows both the detection and recognition of any kind of properties using various algorithms which has proven to be a crucial aspect in the development of research based on the precise detection and prediction of things, which will be utilized in the controlling and automation of the polyhouse [7].

A novel approach is proposed for the disease detection problem in a polyhouse in which the latest YOLOv7 will be used. The earlier models mostly used CNNs for feature extraction during image processing [8] [9]. But the accuracy while using CNNs is very less and time consuming [10]. Hence, our approach will be a novel YOLOv7 which will detect the diseases in crops inside a polyhouse in real time scenario. YOLO is a popular algorithm which is used for real time object detection using neural networks [11]. This algorithm is also used in autonomous vehicles because of its accuracy and speed [12] [13]. YOLO uses CNN to detect objects based on images as well as a real time video [14] [15].

II. Problem Statement

Farmers cannot afford to make any type of mistakes in a polyhouse system, because losing control of a single crop is very much costly in a polyhouse. The sudden drastic change in climatic factors is a serious threat and has terrible effects on agricultural crop yield. Although polyhouse is already a popular invention for off-season crop yield production and with increased demand of off-season crop yield and with the advancements in technology, it has become a mandate to apply efficient automation in a polyhouse system. Therefore, an automated AI based smart polyhouse which will mainly rely on complex AI algorithm such as YOLO and CNN, it will be the most efficient proposed model to boost the off-season crop yield production. The diseases in crops inside the polyhouse nit only creates a loss to one crop but also sometimes spreads the disease to its neighboring crops. Hence, the crop disease prediction is a crucial problem which can make huge losses in the crop yield.

III. Proposed Methodology

The present research and the developments going on in the field of smart polyhouse system mainly focuses on monitoring, alerting, automation and data analysis of the crops based in a polyhouse. The system design architecture for automatic monitoring of the polyhouse is divided into four parts i.e., temperature, humidity, soil moisture and pH. The proposed model will control the temperature inside the polyhouse using DHT11 which is a popular temperature and humidity sensor module. The model will also provide automatic switching of water for the purpose of efficient irrigation. The proposed design will also consist of an alarm module which will send alerts to the farmer in any ambient cases when the polyhouse will require the immediate attention of the farmer. Finally, the main focus of the proposed model would be the implementation of disease detection in plants using YOLOv7 and CNN techniques.

A. *Overview of YOLOv7*

The official YOLO had older versions like YOLO, YOLOv2, YOLOv3, YOLOv4, YOLOv5 and YOLOv6. Each new version had some improvements based on efficiency and accuracy with the previous ones. In terms of accuracy and speed, the most popular YOLO algorithm, YOLOv7, performs better than many object detection models. If compared to other neural networks, the YOLOv7 can be trained significantly more faster on even minor datasets and a cheaper hardware will perform the task for YOLOv7 easily. The object identification

objective may be formulated as a single regression problem to directly convert picture pixels into bounding box coordinates and class probabilities. A single neural network for the boxes predicts several bounding boxes and class probabilities at once. While training on entire pictures, YOLO instantly improves the ability of detection. The YOLO trained model has a variety of benefits over traditional object identification techniques. The YOLOv7 model is more accurate and faster than other models as it outperforms all neural networks in both speed and accuracy.

B. *Overview of CNN*

CNN (Convolutional neural networks), also referred to as ConvNet, is an artificial neural network commonly used for image analysis. CNNs have been most commonly used for image analysis, but they can also be applied to other data evaluation and categorization problems. CNN can be characterised as an artificial neural network with a specialised ability to identify and interpret patterns. CNN is most useful for image analysis as a result of this pattern identification approach. CNN is referred to as convolutional layers due to its concealed convolutional layers. CNN receives an image as input, and each layer produces the number of activation mechanisms that are transmitted to the subsequent layer. In general, the first layer recognises and removes edges that run horizontally or diagonally. This output is then sent to the subsequent layer, which discovers far more complicated image features, such as corners and boundaries. CNN is capable of distinguishing complicated objects, such as features and objects, and is, therefore, the most prevalent technique for categorization.

C. *Proposed Model*

For monitoring the health of plants inside a polyhouse, high resolution cameras will be used to capture images and videos in real time which will then send these images for feature extraction using YOLOv7 and our trained model will automatically detect the unhealthy plants and will also automatically prescribe the fertilizers and pesticides required for curing the plants inside the polyhouse [16] [17]. The dataset which will be used for the training of the model will consist of sensor data such as temperature, humidity, sunlight, soil moisture etc. Also, the dataset of different diseased plants including their cure will be included in our dataset for training our model. Block diagram of the proposed model is given in Figure 1. The first block consists of our input data which will be generated using sensors for temperature, humidity, soil moisture etc. High resolution cameras will be used to capture real time images of the crops in the polyhouse. This real time dataset then will be pre-processed using machine learning techniques. Pre-processing includes image resampling, image augmentation, random oversampling and under sampling [18] [19]. After pre-processing our model will be trained using YOLOv7 and CNN algorithm [20]. After training the model the accuracy will be tested based on polyhouse parameters.

D. *Model Training for Disease Detection*

The DHT11 sensor which is an affordable low-cost digital temperature and humidity sensor will send the inputs to the Raspberry Pi or Arduino. The Raspberry Pi and Arduino are the most popular efficient development boards in the fields of IOT. The fast-processing speed of DHT11 sensors and the fast computation power of complex algorithms like YOLO and CNN will easily perform advanced task of disease identification using image processing. The Wireless LAN and Bluetooth capabilities as well as a display port and a dedicated camera port makes it easier for our model to collect real time clean dataset which will be used for processing [21]. The crop disease detection model will be trained using CNN which is the most accurate and efficient

technique till date used for image processing. The model will also provide the cure for plant diseases by training our model using past datasets of diseased plants.

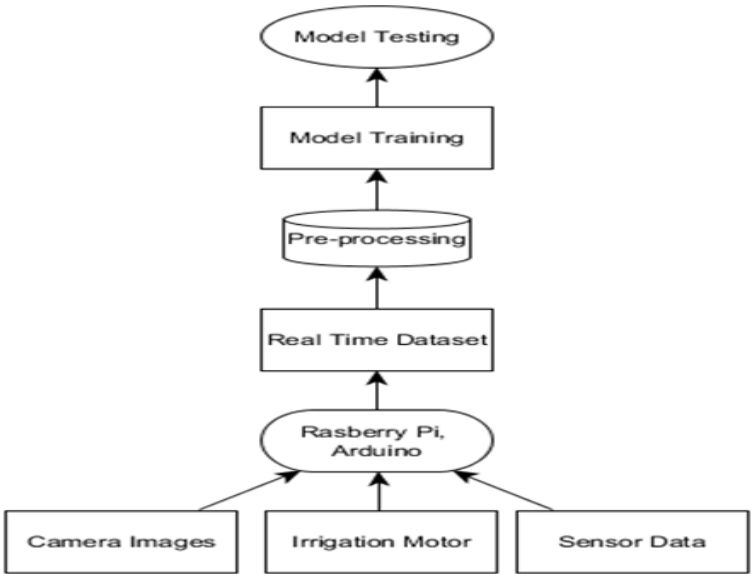

Fig. 1. Block Diagram for Proposed Model.

D. *Model Training for Disease Detection*

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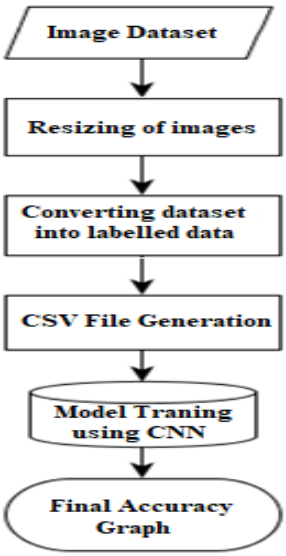

Fig. 2. Model Training for Disease Detection.

Figure 2 shows the steps that are included in training the model for crop disease detection. The dataset of high-resolution images will be developed and stored in our database. Then, the dataset will be labelled as per the requirements of YOLOv7 and CNN.

After the labelling of our dataset, a csv file will be created for our dataset. This csv file will be used for model training using CNN techniques. The CNN will classify the dataset into feature vectors and also into the class scores of the identified patterns, and then at last the bounding-boxes outside only those plants which are affected by any diseases are returned as final output.

IV. CONCLUSION

Neural networks are deployed in several applications across various fields for the purpose of implementing deep learning and AI based solutions to complex problems. However, in case of a polyhouse where the requirement was quite complex for the real-time plant disease detection, the traditional CNN won't give the best results as per the demand. Hence, a novel AI based model is proposed which will integrate the real time plant detection using YOLOv7 algorithm and the cure for the same will be trained using CNN based on available dataset. This integration will provide the highest accuracy and efficiency as compared to traditional algorithms such as R-CNN, SVM etc. This research work is very useful for future of automation in agricultural sector specially in a polyhouse. The future work in this research includes an android application which will help the farmers to monitor the entire polyhouse through their smartphones. With this research model, the farmers will be able to identify the diseases in their crops inside a polyhouse quickly with one touch through their smartphones. The proposed research model of AI based smart polyhouse is a unique framework for monitoring, alerting, automation and prediction of diseases in crops.

REFERENCES

[1] Singh, I., & Ram, B. (2021). When should government subsidise production activity: The case of polyhouse cultivation in India. Academia Letters. https://doi.org/10.20935/al551.
[2] Singla, R., & Rampal, V. K. (2021). Constraints faced by farmers in adoption of Polyhouse Technology. Indian Journal of Extension Education, 57(3), 22–27. https://doi.org/10.5958/2454-552x.2021.00126.2
[3] Zahraee, S. M., Khalaji Assadi, M., & Saidur, R. (2016). Application of artificial intelligence methods for hybrid energy system optimization. Renewable and Sustainable Energy Reviews, 66, 617–630. https://doi.org/10.1016/j.rser.2016.08.028
[4] Jha, K., Doshi, A., Patel, P., & Shah, M. (2019). A comprehensive review on automation in agriculture using artificial intelligence. Artificial Intelligence in Agriculture, 2, 1–12. https://doi.org/10.1016/j.aiia.2019.05.004
[5] Ye, Z., Yang, J., Zhong, N., Tu, X., Jia, J., & Wang, J. (2020). Tackling environmental challenges in pollution controls using Artificial Intelligence: A Review. Science of the total environment, 699, 134279. https://doi.org/10.1016/j.scitotenv.2019.134279
[6] Wu, J., Lin, X., Guo, Y., Liu, J., Fang, L., Jiao, S., & Dai, Q. (2022). Analog Optical Computing for Artificial Intelligence. Engineering, 10, 133–145. https://doi.org/10.1016/j.eng.2021.06.021
[7] Ge, M. (2022). Recognition and Detection Methods of artificial intelligence in computer network faults under the background of big data. In R. A Saeed (Ed.), Wireless Communications and Mobile Computing (Vol. 2022, pp. 1–13). Hindawi Limited. https://doi.org/10.1155/2022/5332876
[8] Obafemi, O., Stephen, A., Ajayi, O., & Nkosinathi, M. (2019). A survey of artificial neural network-based prediction models for thermal properties of biomass. Procedia Manufacturing, 33, 184–191. https://doi.org/10.1016/j.promfg.2019.04.103
[9] Gruson, D. (2021). Big Data, Artificial Intelligence and Laboratory Medicine: Time for Integration. Advances in Laboratory Medicine/ Avances En Medicina De Laboratorio, 2(1), 1–3. https://doi.org/10.1515/almed-2021-0003
[10] Alhnaity, B., Pearson, S., Leontidis, G., & Kollias, S. (2020). Using deep learning to predict plant growth and yield in Greenhouse Environments. Acta Horticulturae, (1296), 425–432. https://doi.org/10.17660/actahortic.2020.1296.55.
[11] Diwan, T., Anirudh, G., & Tembhurne, J. V. (2022). Object detection using YOLO: challenges, architectural successors, datasets and applications. In Multimedia Tools and Applications (Vol. 82, Issue 6, pp. 9243–9275). Springer Science and Business Media LLC. https://doi.org/10.1007/s11042-022-13644-y.
[12] Sarda, A., Dixit, S., & Bhan, A. (2021). Object detection for autonomous driving using YOLO [You Only Look Once] algorithm. In 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV). 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV). IEEE. https://doi.org/10.1109/icicv50876.2021.9388577
[13] Bratulescu, R.-A., Vatasoiu, R.-I., Sucic, G., Mitroi, S.-A., Vochin, M.-C., & Sachian, M.-A. (2022). Object Detection in Autonomous Vehicles. In 2022 25th International Symposium on Wireless Personal Multimedia Communications (WPMC). 2022 25th International Symposium on Wireless Personal Multimedia Communications (WPMC). IEEE. https://doi.org/10.1109/wpmc55625.2022.10014804
[14] Du, J. (2018). Understanding of Object Detection Based on CNN Family and YOLO. In Journal of Physics: Conference Series (Vol. 1004, p. 012029). IOP Publishing. https://doi.org/10.1088/1742-6596/1004/1/012029.

[15] Ahmad, T., Ma, Y., Yahya, M., Ahmad, B., Nazir, S., & Haq, A. ul. (2020). Object Detection through Modified YOLO Neural Network. In Scientific Programming (Vol. 2020, pp. 1–10). Hindawi Limited. https://doi.org/10.1155/2020/8403262
[16] Rodić, L.D., Županovic, T., Perković, T., Šolić, P., & Rodrigues, J. J. P. C. (2021). Machine learning and soil humidity sensing: Signal strength approach. In ACM Transactions on Internet Technology (Vol. 22, Issue 2, pp. 1–21). Association for Computing Machinery (ACM). https://doi.org/10.1145/3418207
[17] Bhadani, P., & Vashisht, V. (2019). Soil moisture, temperature and humidity measurement using Arduino. 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence). https://doi.org/10.1109/confluence.2019.8776973
[18] Nanni, L., Paci, M., Brahnam, S., & Lumini, A. (2021). Comparison of Different Image Data Augmentation Approaches. In Journal of Imaging (Vol. 7, Issue 12, p. 254). MDPI AG. https://doi.org/10.3390/jimaging7120254
[19] Wongvorachan, T., He, S., & Bulut, O. (2023). A comparison of under sampling, Oversampling, and SMOTE Methods for Dealing with Imbalanced Classification in Educational Data Mining. In Information (Vol. 14, Issue 1, p. 54). MDPI AG. https://doi.org/10.3390/info14010054
[20] Kido, S., Hirano, Y., & Hashimoto, N. (2018). Detection and classification of lung abnormalities by use of convolutional neural network (CNN) and regions with CNN features (R-CNN). 2018 International Workshop on Advanced Image Technology (IWAIT). https://doi.org/10.1109/iwait.2018.8369798.
[21] Cicolani, J. (2021). Raspberry Pi and Arduino. Beginning Robotics with Raspberry Pi and Arduino, 119–177. https://doi.org/10.1007/978-1-4842-6891-9_5.

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