A Comprehensive Review of Deep Learning Applications in Soybean Disease Detection

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Abstract – **Soybean (Glycine max) is very important on a global scale because it gives both people and animals needed protein and oil. Still, its production is halted by the presence of numerous diseases that are brought about by fungi, bacteria, viruses and nematodes. Detection of diseases at the right time and with accuracy saves crops from being damaged and ensures enough food supplies. Checking things manually in the usual way is time-consuming, adds inconsistency and requires experts, so it becomes harder to use on a large scale. Over the past few years, deep learning (DL) has proved to be very effective in automating the process of detecting diseases. This work provides a broad review of new studies using deep learning for identifying soybean diseases. We examine multiple DL models, for example, Convolutional Neural Networks, hybrid models made of CNNs and GNNs, Vision Transformers and the latest YOLOv8-DML object detection tool. Many things separate these models in terms of discovering important features for signs, immediate diagnosis and applying their skills in various complex environments. The role of tools such as Grad-CAM is highlighted, since they bring more clarity to the model and build user trust. Various research papers are reviewed in a systematic way and their methods, results and problems are explained in detail. Besides, it is shown in the table that the accuracy, datasets, how easy to interpret they are and their ability to be used in real situations are not the same for all models. Even though many positive things have been achieved, several challenges still exist. It is still very difficult to convert research findings into actual applications because of the shortage of different data, variations in the environment, dependence on specific hardware and poor understanding of the math used. Therefore, the paper also discusses areas of research that remain unsolved and suggests creating light, understandable and adaptable AI systems that support different types of information and fit with IoT systems. The main goal of this review is to serve as a basic reference for people working in agriculture, data science and crop health analysis. The article makes progress for precision agriculture by uniting research and pointing out areas where great advances can be made.**

Keywords – **Artificial Intelligence, Convolutional Neural Networks, Deep Learning, Explainable AI, Soybean, Vision Transformers, YOLO.**