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Applications of Machine Learning in Agriculture

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INTRODUCTION

India is an agricultural country. This basically means that agriculture is an important part of our livelihood. In India, agriculture is our primary economic activity and about two-thirds of our population is engaged in the same. It is the art and science of farming, which includes cultivating soil, growing crops, and raising livestock. It is a key part of the economy, providing food and raw materials for industries. It's also a major source of income for many people, especially in rural areas.

The Sustainable Development Goals (SDGs) are the blueprint to transform our world, for people, planet and prosperity, now and in the future. Agriculture is considered the common thread that connects the Sustainable development goals because it's linked to many challenges, including: Hunger and malnutrition, Poverty, Water and energy use, Climate change, and Unsustainable production and consumption. Sustainable agriculture can help address these challenges by: Empowering small farmers, Promoting gender equality, Ending rural poverty, Ensuring healthy lifestyles, and Tackling climate change.

Present issues such as water scarcity, unregulated costs owing to supply and demand, and unpredictable weather compel farmers to adopt smart farming practices. Specifically, the low productivity of crops resulting from uncertain climate changes, inadequate irrigation infrastructure, decline in soil fertility, and reliance on traditional farming methods must be resolved. Machine learning represents one such method applied to forecast crop yield in agriculture. A range of machine learning methods like prediction, classification, regression, and clustering are employed to estimate crop yield.

Machine learning has the potential to revolutionize the agriculture industry by providing farmers with valuable insights, enabling more efficient resource management, and ultimately increasing productivity and profitability while minimizing the environmental impact. Machine learning can be applied to farming in various ways to optimize processes, increase efficiency, and improve outcomes.

Crop Monitoring and Management:

The cultivation of most crops depends upon the regional weather conditions. So, the analysis of the agro-climatic conditions of a zone contributes significantly to deciding the right crop for the right land in the right season to obtain a better yield. Crop management comprises a large layer of pre-harvesting activities that are responsible for future yields. However, this is one of the most challenging stages in the agricultural lifecycle. An increased frequency of drought, higher temperatures, unpredictable wetting, and drying cycles can influence crop resistance. Therefore, machine learning has been widely used to amplify this stage and facilitate this process to a great extent for better results. Crop variety selection is a type of machine learning used in agricultural applications and techniques. Crops should have the right gene sequence to become disease and weather resistant. ML-based deep learning can simplify crop breeding. Algorithms simply collect field data on plant behavior and use these data to develop a probabilistic model.

Predictive Analysis for yield optimization

Crop yield prediction is one of the challenging problems in precision agriculture, and many models have been proposed and validated so far. This problem requires the use of several datasets since crop yield depends on many different factors such as rainfall, climate, weather, soil, use of fertilizer, and seed variety and actual crop information. An accurate crop yield prediction model can help farmers to decide on what to grow and when to grow. There are different approaches to crop yield prediction. Based on these inputs, ML algorithms like neural networks and multiple linear regressions produce forecasts.

Agriculture Water Management

The global agricultural sector is the largest consumer of freshwater resources, accounting for approximately 70% of the world's total freshwater usage. As the global population is projected to approach nearly 10 billion by 2050, the demand for agricultural products is expected to rise dramatically. This surge in demand presents significant challenges for sustainable food production, particularly in balancing the need for increased agricultural output with the limited availability of water resources. The IoT based farm water management system can be provided which can control irrigation intelligently.

This system may be used to collect data by connecting several sensors such as soil moisture, temperature, and PIR motion sensors, among others. By monitoring water levels, farmers may detect possible water loss locations and take action to prevent them.

Crop Disease Prediction and Information System

Machine learning methods can be used for the prediction of diseases in crops. Image processing tools can also be used for the same. ML approaches are increasingly being used to automatically detect patterns or anomalies indicating the presence of crop disease Deep learning networks, including convolution neural networks (CNNs), recurrent neural networks (RNNs) and auto encoders, can identify these disease patterns in images.

Pest Detection and Management:

Insect pest management is one of the most important ways to enhance crop productivity and quality in agriculture. To detect insect pest's timely and accurate manner, this is critical to agricultural production. Pest detection can be performed using deep learning methods.

Crop health heavily depends on spraying to prevent the infestation of pests and diseases. Machine learning projects in agriculture address this area as well. Precision or targeted spraying is the technology that takes the best from intelligent software and computer vision in the agriculture sector. Thus, the technology obtains the target information such as the size and shape of the plant, and then applies herbicides as needed.

Livestock management

Animal welfare and livestock production are also among salient machine learning in agriculture

applications and techniques. The technology can be applied to a number of different areas. These include animal welfare assessment, predictive modeling of animal production, as well as estimating the environmental impact from livestock operations.

Thus, farmers can get a better idea of livestock well-being by monitoring vitals, daily activity levels, and food intake. This technology relies on a chip with a sensor that is connected to an RFID reader, and users' mobile phones or computers. This way, the software can detect and monitor most health aspects from eating to fertility.

Related Work

Machine learning (ML) has emerged as a transformative technology in the agriculture sector, offering numerous applications to enhance productivity, sustainability, and decision-making processes. ML-enabled Internet of Things (IoT) solutions are being utilized for smart agriculture, allowing farmers to leverage predictive analytics for improved harvesting decisions (Kuppusamy et al., 2023). These systems can monitor crucial data such as humidity, air temperature, and soil quality through remote sensors, enabling more effective irrigation planning and yield forecasting. The applications of ML in agriculture span across various domains, including crop, water, soil, and animal management (Araújo et al., 2023). Specific use cases include crop yield prediction, disease detection, and crop phenotyping (Pathan et al., 2020). ML techniques such as prediction, classification, regression, and clustering are employed to forecast crop yields, with algorithms like artificial neural networks, support vector machines, and decision trees being commonly used (Palanivel & Surianarayanan, 2019). In the oil palm industry, ML has been applied for regression analysis to predict fruit yield, harvest time, and oil yield, as well as for classification of trees, fruit, disease levels, and land (Khan et al., 2021). Interestingly, while ML has shown great potential in agriculture, it is still underutilized for predictive analysis in some areas, such as the oil palm industry (Khan et al., 2021). However, the integration of ML with other technologies like computer vision, IoT, and unmanned aerial vehicles (UAVs) is driving the evolution of precision agriculture and smart farming (Alaoui et al., 2024). These advancements are not only improving crop productivity but also optimizing resource use, reducing chemical usage, and enhancing soil fertility (Pathan et al., 2020). The automation of all-terrain vehicles (ATVs) through ML and AI vision has also shown promising results, with potential improvements in crop yield (15-20%), overall investment reduction (25-30%), and farming efficiency (20-25%) (Padhiary et al., 2024). In conclusion, machine learning is revolutionizing the agriculture sector by providing intelligent solutions for various challenges faced by farmers. From crop yield prediction and disease detection to precision farming and automated vehicles, ML is paving the way for more efficient, sustainable, and technologically advanced agricultural practices. As research in this field continues to evolve, we can expect further innovations that will address global challenges such as food security and environmental sustainability in agriculture.

CONCLUSION

In conclusion machine learning is transforming the agriculture sector by offering innovative solutions for challenges such as crop yield prediction, disease detection and resource management foster sustainable practices and addressing food security, especially as research and interdisciplinary collaboration continue to evolve in developing regions.

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