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A Survey on AI-Driven Crop Disease Prediction and Management for Sustainable Agriculture

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Abstract: Agriculture is a vital sector that faces substantial challenges due to crop diseases, affecting both productivity and the livelihood of farmers. Traditional methods for identifying and managing crop diseases are often labor-intensive, time-consuming, and lack the precision required for effective mitigation. This survey paper presents an overview of recent advancements in AI-driven crop disease prediction and management systems, focusing on their transformative potential in modern agriculture. The study explores the integration of deep learning models, such as MobileNetV2, for image-based disease detection and highlights the role of environmental data—temperature, humidity, and weather conditions—in improving predictive accuracy. Key features such as real-time alerts, multilingual support, and treatment recommendations tailored for specific crops (e.g., cotton, sugarcane, soybean) are discussed, alongside potential deployment challenges and data requirements. Additionally, we review existing solutions, architectural frameworks, and methodologies to provide insights into the system's development and the scalability needed for diverse agricultural contexts. The paper concludes by addressing future directions, including the implementation of a subscription model for agronomist support, an integrated e-marketplace, and economic considerations for system sustainability. This survey underscores the importance of AI in enhancing crop resilience and supporting farmers with accurate, timely, and accessible disease management tools.
Keywords: Crop Disease Prediction, AI in Agriculture, Deep Learning, MobileNetV2, Image-based Disease Detection, Environmental Data Integration, Precision Agriculture, Agronomist Subscription Model

I. INTRODUCTION

The rising global population and changing climatic conditions have heightened the challenges faced by farmers, including the identification and management of plant diseases. These diseases can significantly reduce crop yield and quality, posing economic losses and threatening food security. Traditional methods for disease diagnosis rely on manual inspection, which is time-consuming and subjective. Technological advancements in agriculture, however, offer innovative solutions to these challenges.

Machine learning, particularly image recognition, has been effective in early detection of plant diseases, thus minimizing damage. Computer-aided diagnosis systems have been developed to assist farmers, with deep learning algorithms like convolutional neural networks (CNNs) showing promise in disease identification. Despite their potential, the reliability of these systems is questioned due to the black-box nature of deep learning models [1].

The global population increase is placing pressure on traditional farming methods, which are becoming inadequate for meeting food security and employment needs in developing countries. Governments are offering financial support and enhancing strategies to improve food production and reduce waste. However, challenges like climate change, plant diseases, and overuse of pesticides threaten crop yields and health. Smart farming using AI, IoT, and machine learning techniques is being explored to detect crop diseases more efficiently. Innovations like convolutional neural networks (CNNs) and transfer learning are prominent in identifying plant diseases, despite issues like data scarcity. The survey highlights the need for improved AI deployment in agriculture and acknowledges ongoing research efforts to develop automated, effective disease detection methods [2]. Agriculture and forestry are crucial for food security and economic development, especially in rural areas. The emergence of Smart Agriculture is essential to address the challenge of providing food security to a rapidly growing population amidst decreasing resources. Traditional agricultural methods are becoming ineffective, and advanced technologies like sensors, drones, and communication systems are being implemented to enhance productivity by monitoring crop stress levels and optimizing resource use. Smart agriculture employs data analysis and technology to manage farming practices efficiently, thus improving yields and supporting sustainable growth. This transition to technology-driven agriculture is described as the fourth revolution in the sector. It involves innovations like nutrient monitoring and stress tracking to assist in better crop management. Implementing these advanced systems is seen as critical to tackling issues of hunger and poverty more effectively than other methods [3].

II. LITERATURE REVIEW

Plant disease detection plays a crucial role in agriculture productivity with significant impact on the economy [8]. Timely identification and management of plant diseases helps in preventing crop losses, ensuring a stable food supply and supporting the livelihoods of farmers [9]. This section presents an overview of recent ML model-based approaches for plant disease detection.

Ferentinos et al. [10] presented the development of CNN models with variants (AlexNet, AlexNetOWTBn, GoogleNet, Overfeat, VGG) for plant disease detection and diagnosis using images of simple leaves from healthy and diseased plants. The models were trained on an extensive database of 87,848 images, encompassing 25 plant species in 58 unique [plant, disease] combinations. The best-performing model achieved an impressive 99.53% success rate in accurately identifying the [plant, disease] combination or healthy plants.

Mehedi et al. [11] developed a transfer learning approach with three pre-trained models (EfficientNetV2L, MobileNetV2, ResNet152V2). The study detected 38 leaf diseases across 14 different plants. The dataset was taken from Kaggle [12]. EfficientNetV2L demonstrated the highest accuracy at 99.63%. The integration of XAI through LIME enhances model interpretability.

Mohanty et al. [13] utilized a public dataset [14] containing 54,306 images of diseased and healthy plant leaves, deep CNNs (AlexNet and GoogLeNet) were trained to identify 14 crop species and 26 diseases with an impressive accuracy of 99.35% on a held-out test set.

Jasim et al. [14] explored the application of DL models in the early detection and classification of plant diseases, highlighting the potential for increased accuracy compared to traditional ML approaches. The Plant Village [14] dataset was used with 20,636 images as three plants, namely, tomato, pepper, and potato crops were chosen because of the most famous types of plants. The CNN classifier achieved 98.029% accuracy, with the potential for further improvement with a larger training dataset.

Ramesh et al. [15] employed Random Forest for clas-sifying healthy and diseased leaves based on leaf images. The proposed methodology involved dataset creation, fea-ture extraction using Histogram of an Oriented Gradient (HOG), classifier training, and classification. In testing with 160 papaya leaf images, the Random Forest classifier achieved approximately 70% accuracy.

III. METHODOLOGY

A. *Existing Systems*

The integration of Artificial Intelligence (AI) in agriculture has opened new avenues for managing crop diseases more effectively. Several existing systems leverage machine learning (ML) and image recognition techniques for early-stage plant disease detection. These systems collect and analyze data from various sources, including images of crops, environmental conditions, and agronomical factors, to predict and manage diseases. AI-powered systems, such as the PlantVillage app and PlantNet, provide farmers with real-time, accessible disease diagnosis by simply uploading photos of their crops. These platforms use convolutional neural networks (CNNs) and other deep learning techniques to classify and predict diseases based on visual data. This empowers farmers with timely information, allowing them to take preventive measures, reducing the risk of crop loss.

For example, the use of MobileNetV2 in mobile applications has enhanced disease detection in cotton and soybean crops by providing accurate predictions based on image inputs. AI-driven systems can offer scalable solutions that make disease management more efficient, particularly in resource-limited settings where human expertise may be scarce. Such systems are critical for early detection, which minimizes the impact of diseases on crop yield and quality, directly contributing to enhanced food security.

B. *Challenges in Existing Systems*

Data Accessibility and Integration: While these systems provide useful predictions, many are limited by data accessibility issues. In regions with poor internet connectivity, real-time data updates and disease predictions become less effective. Integration across different platforms and varying data sources (such as weather, soil, and pest data) remains a challenge, often resulting in inconsistencies in disease prediction and treatment recommendations. User Interface and Experience: Many existing systems are designed with expert users in mind, which can make them difficult for farmers with minimal technical knowledge to operate. This results in underutilization of the technology, limiting its impact. Accuracy and Generalization: Current disease prediction models may perform well for certain crops but may struggle with accuracy when applied to diverse crop varieties or different environmental conditions. Models need to be generalized to accommodate varying local agricultural practices and climates. Sustainability Concerns: While AI models help in disease prediction, the recommended treatment practices often prioritize short-term solutions over sustainable, eco-friendly methods. The lack of integration of sustainability practices limits the overall benefit of these technologies for long-term agriculture health.

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C. Proposed System

The proposed system for AI-driven crop disease prediction and management integrates multiple key modules that work together to offer real-time, accurate, and sustainable solutions to farmers. This system focuses on utilizing deep learning and AI techniques to identify crop diseases, provide treatment suggestions, and promote sustainable farming practices. Data Collection Modules: The system uses data from multiple sources, including: Image Data Collection Module: A key feature of the system is the image recognition capability. Farmers can capture images of crops through the mobile app, which are then analyzed using deep learning models like MobileNetV2 for disease identification. Environmental Data Module: The system collects data related to environmental factors such as weather (temperature, humidity), soil conditions, and pest information to improve the accuracy of disease predictions. Agronomist Insights Module: This module provides access to expert recommendations on disease management and prevention strategies, promoting sustainable farming practices. Data Processing Unit: Once the data is collected, it is processed and analyzed using AI algorithms. The system applies Convolutional Neural Networks (CNNs) to classify and predict the presence of crop diseases. In addition, machine learning models analyze environmental data to provide accurate predictions of disease spread based on local conditions. The processing unit ensures that the predictions are timely and relevant to the specific crop and geographical location.

D. User Interface (UI)

The processed data is presented to users through an intuitive and easy-to-use mobile interface. The app provides:
Real-time Disease Predictions: Based on the uploaded crop images, users receive immediate disease diagnoses, along with severity levels and suggestions for treatment. Weather and Environmental Alerts: Users are notified of adverse weather conditions that might exacerbate disease spread. Treatment Recommendations: The system offers a range of treatment options, including both chemical and organic solutions, depending on the severity of the disease and user preferences. The goal is to promote sustainable practices by prioritizing eco-friendly treatments where possible. Sustainability and Decision Support Module: In addition to disease management, the system includes a Sustainable Farming Recommendations Engine, which offers advice on best practices for environmentally friendly farming. It takes into account factors such as crop rotation, integrated pest management, and water conservation techniques. The system encourages users to adopt long-term, sustainable agricultural practices, contributing to overall environmental health. Feedback and Community Engagement: To foster a community-driven approach, the system allows farmers to share their experiences and feedback. This helps in improving the model's accuracy over time and encourages collaboration between farmers, agronomists, and researchers. Users can also access a repository of tips, videos, and articles on crop disease management, enhancing their knowledge and skills in sustainable farming practices: System Integration and Scalability: The architecture is designed to be scalable and adaptable to different agricultural regions. It ensures that disease predictions are accurate, even in areas with limited data availability, by incorporating locally relevant information into the models. Additionally, the system is capable of continuous learning through machine learning algorithms that improve prediction accuracy over time based on new data collected from different users.

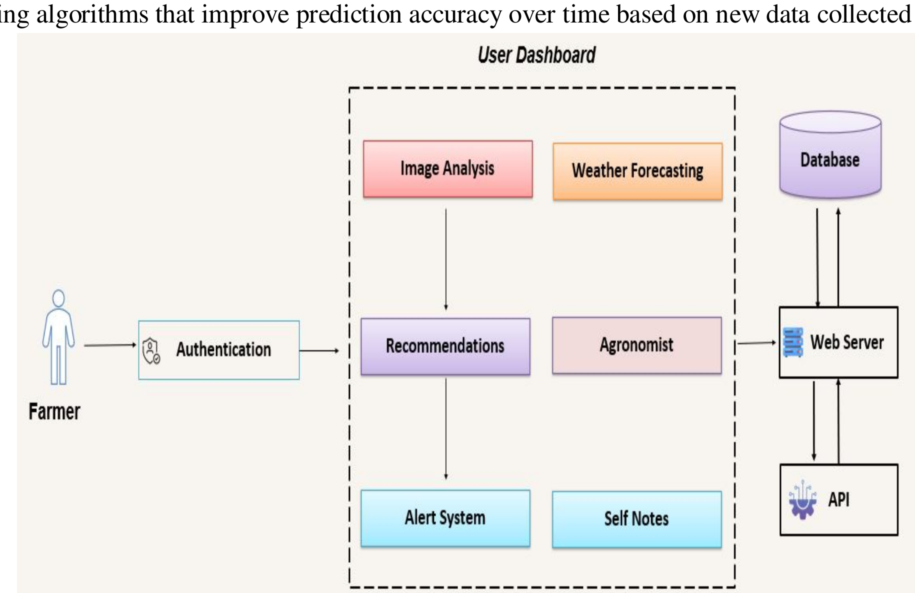


Figure 1 System Architecture

IV. MOTIVATION

The proposed AI-driven crop disease prediction and management system seeks to revolutionize agricultural practices in India by providing farmers with real-time, data-driven insights into crop health. With agriculture being a cornerstone of the Indian economy, the sector faces significant challenges, including unpredictable weather, crop diseases, and environmental changes, all of which threaten food security and economic stability. By leveraging AI and machine learning models, this system will offer early detection of crop diseases, personalized treatment recommendations, and sustainable farming practices. The integration of real-time weather and environmental data will empower farmers to make informed decisions, reduce crop losses, and enhance productivity.

Ultimately, this initiative aims to support sustainable agriculture, improve food security, and contribute to the overall economic well-being of rural India.

V. FUTURE SCOPE

The development of an AI-driven crop disease prediction and management system has immense potential for future advancements in agricultural sustainability. By integrating machine learning and deep learning models, the system could evolve to predict not only crop diseases but also pest infestations and environmental stressors, offering a more comprehensive health diagnosis for crops. This could be further enhanced by incorporating drone technology for aerial image analysis, allowing for real-time monitoring of vast agricultural fields. Expanding the system’s scope, it could cover a wider variety of crops, including fruits and vegetables, enabling global application and creating a universal platform for crop disease management. The system could integrate with precision agriculture tools, such as soil sensors and weather stations, to provide more accurate, location-based insights. Furthermore, the inclusion of blockchain technology could improve the transparency and traceability of the agricultural supply chain, ensuring that farmers, suppliers, and consumers are assured of sustainably produced goods. The app could also collaborate with agricultural extension services, offering farmers expert consultations and crop management strategies based on the latest data. Additionally, integrating the system with e-commerce platforms could help farmers access agricultural products and services, such as pesticides, fertilizers, and equipment, directly from the app. Supporting multiple languages and an intuitive interface would improve accessibility for farmers across regions with varying literacy levels. The system could also integrate with government databases to support policy-making and aid in the distribution of subsidies and support to farmers in need. By incorporating predictive analytics, the app could assist in forecasting crop yields, providing valuable insights to farmers for better market planning and resource allocation. Finally, the development of an offline mode would make the system accessible in rural areas with limited internet connectivity, ensuring that farmers can rely on the app even in remote regions.

VI. CONCLUSION

This survey emphasizes the transformative potential of AI-driven crop disease prediction and management systems in revolutionizing agricultural practices in India. By providing farmers with real-time, data-driven insights into crop health, weather conditions, and disease prevention, the system aims to enhance productivity, reduce crop losses, and promote sustainable farming practices. The integration of machine learning for early disease detection and future advancements, such as drone-based monitoring and blockchain for supply chain transparency, further strengthens the system’s impact. Ultimately, this approach not only supports farmers in making informed decisions but also contributes to the long-term sustainability of agriculture, food security, and rural economic growth.

REFERENCES

[1] N. Nigar, H. Muhammad Faisal, M. Umer, O. Oki and J. Manappattukunnel Lukose, "Improving Plant Disease Classification With Deep-Learning-Based Prediction Model Using Explainable Artificial Intelligence," in IEEE Access, vol. 12, pp. 100005-100014, 2024, doi: 10.1109/ACCESS.2024.3428553.

[2] M. Louta, K. Banti and I. Karampelia, "Emerging Technologies for Sustainable Agriculture: The Power of Humans and the Way Ahead," in IEEE Access, vol. 12, pp. 98492-98529, 2024, doi: 10.1109/ACCESS.2024.3428401.

[3] T. Mahmud et al., "An Approach for Crop Prediction in Agriculture: Integrating Genetic Algorithms and Machine Learning," in IEEE Access, doi: 10.1109/ACCESS.2024.3478739.

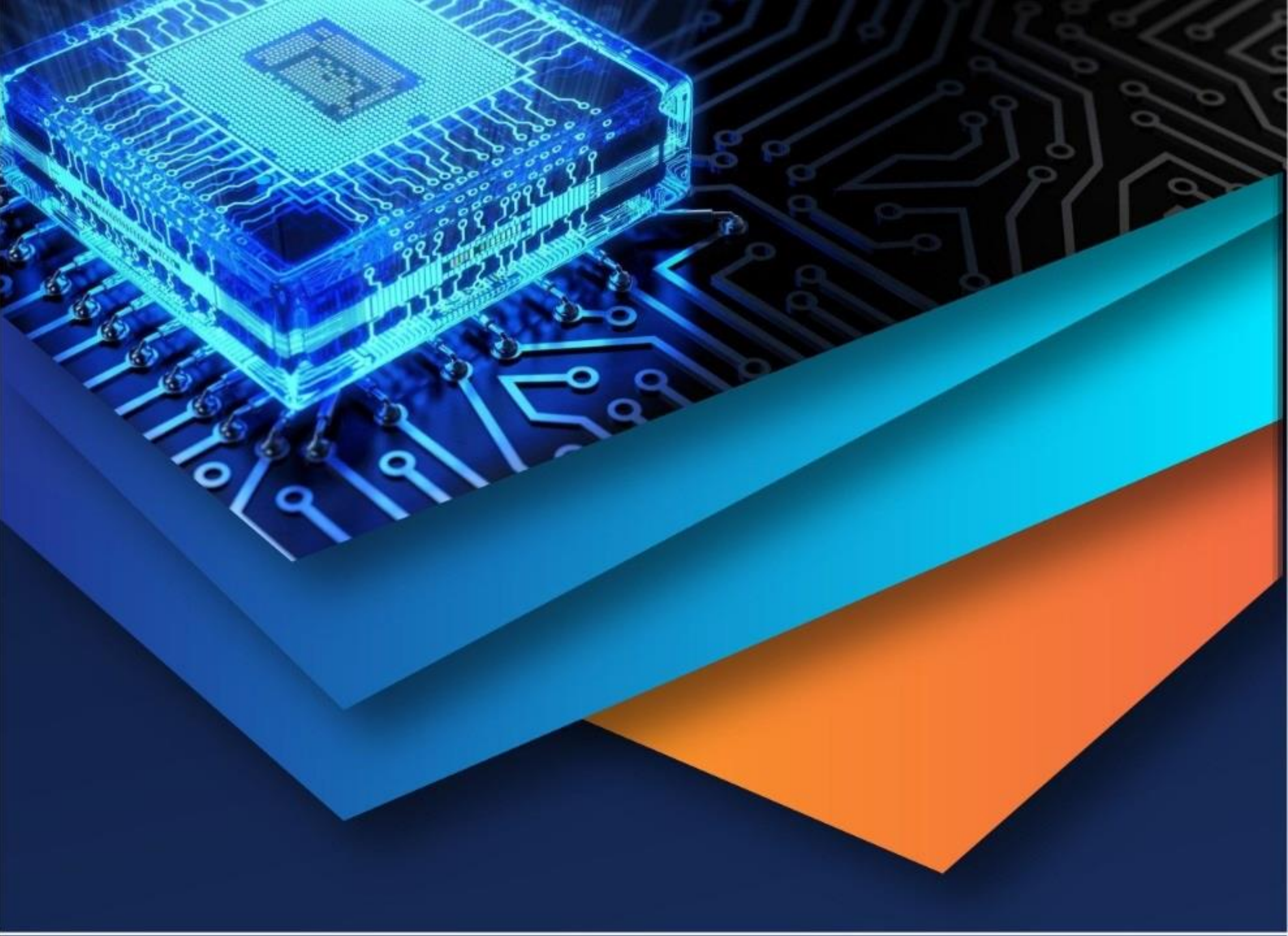
[4] A. A. AlZubi and K. Galyna, "Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture," in IEEE Access, vol. 11, pp. 78686-78692, 2023, doi: 10.1109/ACCESS.2023.3298215.

[5] R. Rani, J. Sahoo, S. Bellamkonda, S. Kumar and S. K. Pippal, "Role of Artificial Intelligence in Agriculture: An Analysis and Advancements With Focus on Plant Diseases," in IEEE Access, vol. 11, pp. 137999-138019, 2023, doi: 10.1109/ACCESS.2023.3339375.

[6] E. Elbasi et al., "Artificial Intelligence Technology in the Agricultural Sector: A Systematic Literature Review," in IEEE Access, vol. 11, pp. 171-202, 2023, doi: 10.1109/ACCESS.2022.3232485.

[7] S. I. Hassan, M. M. Alam, U. Illahi, M. A. Al Ghamdi, S. H. Almotiri and M. M. Su’ud, "A Systematic Review on Monitoring and Advanced Control Strategies in Smart Agriculture," in IEEE Access, vol. 9, pp. 32517-32548, 2021, doi: 10.1109/ACCESS.2021.3057865.

[8] V. K. Vishnoi, K. Kumar, and B. Kumar, ''Plant disease detection using computational intelligence and image processing,'' J. Plant Diseases Protection, vol. 128, pp. 19–53, Aug. 2021.
[9] S. Kinger and V. Kulkarni, ''Explainable ai for deep learning based disease detection,'' in Proc. 13th Int. Conf. Contemp. Comput. (IC), 2021, pp. 209–216.
[10] K. P. Ferentinos, ''Deep learning models for plant disease detection and diagnosis,'' Comput. Electron. Agricult., vol. 145, pp. 311–318, Feb. 2018.
[11] M. H. K. Mehedi, A. K. M. S. Hosain, S. Ahmed, S. T. Promita, R. K. Muna, M. Hasan, and M. T. Reza, ''Plant leaf disease detection using transfer learning and explainable AI,'' in Proc. IEEE 13th Annu. Inf. Technol., Electron. Mobile Commun. Conf. (IEMCON), Oct. 2022, pp. 0166–0170.
[12] S. Bhattarai. New Plant Diseases Dataset. [Online]. Available: https://www.kaggle.com/datasets/vipoooool/new-plant-diseases-dataset
[13] S. P. Mohanty, D. P. Hughes, and M. Salathé, ''Using deep learning for image-based plant disease detection,'' Frontiers Plant Sci., vol. 7, p. 1419, Sep. 2016.
[14] S. Mohanty. PlantVillage Dataset. [Online]. Available: https://github.com/salathegroup/plantvillage_deeplearning_paper_dataset
[15] S. Ramesh, R. Hebbar, M. Niveditha, R. Pooja, N. Shashank, and P. V. Vinod, ''Plant disease detection using machine learning,'' in Proc.Int. Conf. Design Innov. 3Cs Compute Communicate Control (ICDI3C), Apr. 2018, pp. 41–45.



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