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Localised Rain Prediction Model in Feedforward-Feedback Control Structure for Smart Irrigation Management

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Integrating artificial intelligence with agricultural practices promises transformative advancements in sustainable farming. One such innovation is an AI-driven system for highly localised rain prediction, designed to work within a feedforward-feedback control structure to enable precise, responsive irrigation management. This research presents a model that uses Convolutional Neural Networks (CNNs) to interpret real-time cloud images and predict rainfall for specific areas, allowing for a smarter, more adaptable irrigation system that activates based on short-term rain forecasts. Traditional irrigation systems typically depend on broad weather forecasts or soil moisture sensors, often falling short when dealing with localised and unpredictable rain patterns. This can lead to over- or under-irrigation, impacting crop health and wasting resources. By contrast, the proposed CNN model, trained on cloud formation data correlated with actual rainfall events, provides localised rain predictions that can be directly integrated into a feedforward-feedback control system. In the feedforward path, rain predictions from the CNN model proactively adjust irrigation schedules by anticipating rainfall, reducing water output if rain is expected. This approach minimizes water waste by addressing the likelihood of natural rainfall in advance. Simultaneously, in

the feedback loop, real-time soil moisture data and environmental conditions are continuously monitored to refine water delivery further, ensuring that the crop's actual water needs are met. If rainfall is not expected, feedback controls adjust the irrigation output accordingly, maintaining optimal soil moisture levels for crop growth. This AI-based, dual-path control approach significantly enhances water-use efficiency, reducing waste and operational costs. It primarily benefits water-scarce regions and aligns with broader sustainability goals, enabling proactive and adaptive resource management. Extensive field tests will evaluate the model's accuracy and the control system's efficacy, paving the way for widespread adoption of a smarter, data-driven irrigation solution.



Heavy Rain	83.33	10.67	6
Light to Medium Rain	6.468	86.07	7.463
No Rain	5.705	14.09	80.2
Heavy Rain	Light to Medium Rain	No Rain	

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