

# 建構應用影像辨識技術為基礎之 智慧化茶園灌溉體系

## Construction of an Intelligent Irrigation System for Tea Plantations Using Image Recognition Technology

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### 摘要

作物灌溉為影響農作物產量與品質的關鍵要素之一，然而無論是灌溉不足或過度灌溉，皆可能導致產量下降、品質劣化，甚至對水資源造成額外負擔。傳統灌溉策略多倚賴農民經驗判斷，雖近年隨著感測設備普及與自動化控制技術之發展，智慧灌溉系統已逐漸應用於農業生產，並展現一定的精準灌溉成效。然而，多數現有系統仍主要依賴氣候環境資訊及預設作物參數進行灌溉決策，難以因應不同地區、季節與環境條件下作物生長狀態的變化，進而產生需水量預判誤差的問題。

本研究針對上述問題，建構一套整合影像辨識與雲端運算技術的智慧化茶園灌溉體系。系統核心包括：1) 可現場拍攝並自動上傳至雲端之植物監測裝置(Plantation Monitoring System, PMS)，2) 自動化白平衡校正模組，3) 針對茶樹場域開發之茶芽影像辨識與生長階段分類演算法，以及 4) 結合辨識結果建立之茶樹生長趨勢動態模型。該系統可每日自動蒐集與分析茶芽採摘面影像，即時評估茶芽生長狀態，並提供依據以動態調整灌溉參數。

本體系已完成初步場域部署與功能驗證，成功實現茶樹生長即時監控、遠端資料傳輸與自動辨識處理流程。未來將進一步結合土壤含水感測與氣候參數，導入灌溉轉換係數模型，建立針對豐產型、節水型與高品質型等不同目標之灌溉策略模組，達成可擴充且具彈性調控能力之智慧化灌溉決策支持系統，推進精準農業技術的實地應用。

關鍵詞：智慧灌溉、茶園灌溉、茶芽影像辨識

### Abstract

Crop irrigation is one of the key factors influencing both yield and quality in agricultural production. However, insufficient or excessive irrigation can lead to reduced yields, deterioration in crop quality, and even place additional strain on water resources. Traditional irrigation strategies largely rely on farmers' experience and intuition. In recent years, the widespread availability of sensing devices and the advancement of automated control technologies have promoted the adoption of smart irrigation systems in agricultural production, demonstrating a certain level of precision irrigation performance. Nevertheless, most existing

systems still rely primarily on environmental and climatic data, as well as pre-set crop parameters, to make irrigation decisions. This limits their ability to adapt dynamically to changes in crop growth status across different regions, seasons, or environmental conditions, often resulting in inaccurate estimations of crop water requirements.

To address these issues, this study developed an intelligent tea plantation irrigation system that integrates image recognition and cloud computing technologies. The core components of the system include: (1) a Plantation Monitoring System (PMS) capable of capturing field images and uploading them automatically to the cloud; (2) an automated white balance correction module; (3) an image recognition and growth-stage classification algorithm specifically designed for tea buds in tea plantations; and (4) a dynamic tea plant growth trend model constructed based on the recognition outputs. The system enables the daily automated collection and analysis of images from tea harvesting surfaces, allowing for real-time assessment of bud growth status and providing a basis for dynamic adjustment of irrigation parameters.

The system has completed preliminary field deployment and functional validation, successfully realizing real-time monitoring of tea plant growth, remote data transmission, and automated image analysis. In future work, the system will be further enhanced by integrating soil moisture sensors and climatic parameters, incorporating an irrigation coefficient transformation model, and developing irrigation strategy modules tailored to different production goals, such as high yield, water conservation, and premium quality. This will lead to a practical, scalable, and flexible decision support system for smart irrigation, advancing the on-site application of precision agriculture technologies.

**Keywords:** Smart Irrigation, Tea Plantation Irrigation, Tea Bud Image Recognition