

智慧氣象防災技術的落實與應用

Implementation and Application of Smart Meteorological Technology for Disaster Reduction

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摘 要

本研究旨在探討多元人工智慧 (AI) 與機器學習技術於氣象防災的落實應用。在極端天氣監測方面，本研究導入機器學習演算法於機場能見度預測，有效降低傳統推估模式的誤差，展現減緩航運衝擊之實務潛力；同時，利用卷積自編碼器 (CNN-AE) 進行天氣類型分類，實現複雜大氣特徵的自動化識別。針對水資源最具關鍵的降雨預報，本研究應用多尺度殘差網路 (MSRN) 進行空間降尺度，將粗網格資料精緻化；並結合自編碼器 (AE) 建構智慧季節曆，提煉長週期展期氣候的時序指引。此外，本研究亦深入探討新一代 AI 氣象模式的引進與災防落地。包含透過擴散模型 (Diffusion Model) 實現「大氣環流至降雨量」的高動態生成；同時，介紹使用 NVIDIA StormCast 模組進行臺灣公里尺度對流 AI 模式的訓練成果，以及運用 CorrDiff 擴散模型將區域天氣解析度大幅提升至 2 公里。上述技術不僅顯著縮短數值運算時間，更大幅提升了資料科學技術在災防預警上的實用性，為第一線防災應變提供更即時、可靠的決策情資。

關鍵字：AI、機器學習、智慧防災、StormCast、季節曆、天氣類型

Abstract

This study explores the application of diverse artificial intelligence (AI) and machine learning technologies in meteorological disaster reduction. To enhance extreme weather monitoring, a machine learning framework is introduced for airport visibility prediction, minimizing estimation errors in traditional models and mitigating aviation disruptions. Concurrently, a Convolutional Autoencoder (CNN-AE) is utilized for weather typing to automate the identification of complex atmospheric features. Addressing precipitation forecasting for water resource management, a Multi-Scale Residual Network (MSRN) is applied for spatial downscaling to refine coarse-grid data, while an Autoencoder (AE) is integrated to construct a smart seasonal calendar, offering robust temporal guidance for extended-range climate predictions.

Furthermore, this research delves into the deployment of AI weather models for localized disaster management. This includes leveraging a Diffusion Model to achieve high-dynamic generation from atmospheric circulation to precipitation. Meanwhile, we present the training outcomes of a Taiwan-specific, kilometer-scale convective AI model utilizing the NVIDIA StormCast framework, alongside the CorrDiff diffusion model to enhance regional weather resolution to a 2-kilometer scale. These technologies markedly accelerate computational efficiency over traditional numerical weather prediction and elevate the practicality of data science in early warning systems, ultimately providing more timely, reliable actionable intelligence for front-line emergency responses.

Key words : AI, Machine Learning, Smart disaster reduction, StormCast, Seasonal calendar, Weather type