

**Title:** PollenNet: A novel architecture for high precision pollen grain classification through deep learning and explainable AI

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**Abstract:** Pollen grains play a critical role in environmental, agricultural, and allergy research despite their tiny dimensions. The accurate classification of pollen grains remains a significant challenge, mainly attributable to their intricate structures and the extensive diversity of species. Traditional methods often lack accuracy and effectiveness, prompting the need for advanced solutions. This study introduces a novel deep learning framework, PollenNet, designed to tackle the intricate challenge of pollen grain image classification. The efficiency of PollenNet is thoroughly evaluated through stratified 5-fold cross-validation, comparing it with cutting-edge methods to demonstrate its superior performance. A comprehensive data preparation phase is conducted, including removing duplicates and low-quality images, applying Non-local Means Denoising for noise reduction, and Gamma correction to adjust image brightness. Furthermore, Explainable AI (XAI) is utilized to enhance the interpretability of the model, while Receiver Operating Characteristic (ROC) curve analysis serves as a quantitative method for evaluating the model's capabilities. PollenNet demonstrates superior performance when compared to existing models, with an accuracy of 98.45 %, precision of 98.20 %, specificity of 98.40 %, recall of 98.30 %, and f1-score of 98.25 %. The model also maintains low Mean Squared Error (0.03) and Mean Absolute Error (0.02) rates. The ROC curve analysis, the low False Positive Rate (0.016), and the False Negative Rate (0.017) highlight the reliability and dependability of the model. This study significantly improves the efficacy of classifying pollen grains, indicating an important advancement in the application of deep learning for ecological research.

**Keywords:** Pollen grain classification, Image processing, Deep learning, PollenNet model, Explainable AI

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