ID: 501

Advancing Banana Cultivation Through Multispectral Imaging and Precision Agriculture: A Scalable Algorithm for Crop Optimization

Danilo Yánez-Cajo[1], Luis Godoy-Montiel[1], Ángel Cedeño-Moreira[1], Ronald Villamar-Torres[1], Fernando Cabezas-Guerrero[1], Gregorio Vázconez-Montufar[1], María Romero-Roman[1] and Marco Heredia-Pinos[1]

[1]Agricultural and Livestock Engineering, Faculty of Animal and Biology Sciences, Quevedo State Technical University, Quevedo, Ecuador.

Abstract

Precision agriculture has emerged as a transformative approach to modern crop management, integrating advanced technologies to optimize productivity, resource efficiency, and sustainability. This research presents a novel multispectral image classification algorithm specifically designed for banana cultivation (*Musa* AAA), combining aerospace technology, spectral analysis, and machine learning to address critical challenges in tropical agriculture. The study was conducted in a commercial banana plantation, where high-resolution visible and near-infrared spectral data were acquired using state-of-the-art optical sensors mounted on unmanned aerial vehicles (UAV). The methodology employed the Normalized Difference Vegetation Index (NDVI) as a primary tool for crop zoning and health assessment. Through sophisticated image processing techniques implemented in Python, we generated precise vegetation and soil fragmentation masks at the administrative plot level, enabling spatial resolution in crop monitoring. The algorithm successfully identified subtle variations in plant health and nutritional status across different sectors of the plantation, allowing for the creation of detailed sub-plots with distinct agronomic requirements. Comprehensive statistical analysis of spectral data provided actionable insights into plot-specific needs, facilitating data-driven recommendations for fertilizer application, irrigation scheduling, and pest management. This work represents a significant advancement in precision agriculture for banana cultivation, offering a scalable solution that can be adapted to diverse growing conditions in Ecuador and the around the world. The integration of aerospace technology with advanced analytics not only improves production efficiency but also contributes to sustainable farming practices by minimizing unnecessary resource inputs. With further development, this approach could be extended to other tropical crops, potentially revolutionizing agricultural practices in developing nations. The study underscores the critical role of spectral technology in addressing global food security challenges while promoting environmental stewardship.

Key Words: *Multispectral imaging, Precision agriculture, NDVI, Banana crop optimization*