Advanced Drone-Based Monitoring of Agricultural, Forestry, and Aquatic Ecosystems: Technical Framework

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Abstract. The rapid advancement of drone technology has significantly transformed environmental monitoring by enhancing capabilities for observing and managing agricultural, forestry, and aquatic ecosystems. This paper presents a comprehensive technical framework for implementing advanced drone-based systems into ecosystem monitoring, focusing on the integration of high-resolution sensors, data processing, and AI analytics. The proposed framework incorporates modern technologies, including DJI or FPV drones equipped with metric cameras, which facilitate aerial photogrammetry. These drones can be further enhanced with multispectral and LiDAR sensors, allowing real-time data collection and analysis [1].

Furthermore, the Proxmox Virtual Environment is used as the core of the system's architecture [2], hence increasing effective virtualization and deployment. Core data processing technologies include Python scripts, QGIS and Pix4D, which are employed for advanced image analysis [3]. The system also integrates Elasticsearch for database management [4], ensuring the efficient acquisition, storage and retrieval of large volumes of environmental data. Additionally, Kibana is utilized to provide interactive data visualization through customizable dashboards, offering stakeholders the ability to make informed, evidence-based decisions.

Designed with a service-oriented architecture (SOA), the system's modularity allows it to easily integrate new tools and methodologies concerning photogrammetry and image processing [5]. The framework will be validated in real-world environments, demonstrating its efficacy in overcoming the challenges of ecosystem management, especially in remote or inaccessible areas. This approach offers a comprehensive and adaptive technical framework for sustainable ecosystem management, contributing to improved decision-making processes and the long-term health of the environmental system.

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