


Chapter 2

Autonomous Energy– Efficient Drone System for Intelligent Aircraft Inspection Using Hybrid Hydrogen Power and Multimodal AI Vision

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ABSTRACT

This research proposes a self-sufficient, energy-efficient drone system for smart aviation inspection, integrating hybrid hydrogen-electric propulsion to achieve longer range with reduced carbon emissions. Equipped with a multimodal AI vision system combining infrared thermography, high-resolution RGB imagery, and 3D LiDAR sensing, the drone ensures robust defect detection under varying conditions. Onboard deep learning fusion, SLAM, and GPS-denied localization techniques enable seamless autonomous navigation in both indoor hangars and outdoor airfields. By combining sustainable propulsion with advanced AI-driven inspection capabilities, the system significantly improves inspection accuracy, reduces downtime, and enhances overall sustainability in aviation maintenance.

INTRODUCTION

The aviation industry is now growing tremendously as a result of reduced number of working hours and further enhanced superiority of the planes in terms of technology. This is what is happening as many things are coinciding. Consequently, the maintenance processes have been put under greater scrutiny and have to become more accurate, cost-effective, and efficient without losing their safety or adherence to the regulations (Hammadi, 2024). Consequently, the level of stress that is generated out of this has greatly escalated. Although simulating planes by hand and subjecting them to fixed apparatus is a sure method of testing and investigating them, it has numerous drawbacks. Airplanes can be inspected in both visual and manual ways (Pekias et al., 2023). The weather, light, and accessibility may be restricting factors that may severely limit the number of times and effort required to carry out these activities. These limitations have boosted the shift towards inspection systems that use autonomous drones. Such systems can be more accurate, can apply in a wider range of situations, and could be much less manpower-intensive.

The present state of drone systems is beneficial for numerous types of businesses. Renewable energy asset management and infrastructure monitoring are responsibilities of several of these companies (Omara et al., 2024). When compared to other industries, the aviation industry's inspection procedure is riddled with issues. A significant limitation that has been discovered is the flying endurance. A large number of unmanned air vehicles only use batteries which are of lithium-ion technology. With these batteries, the drone can only remain in the air for a short duration. Consequently, the operation becomes less efficient, and every mission can only cover a lesser distance before a battery is recharged or replaced (Karbasishargh et al., 2024).

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