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IOT and sensor fusion in next generation flight monitoring and pre crash alerting system

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Abstract

The rapid evolution of aviation technologies has accelerated the development of intelligent flight monitoring systems capable of improving safety, reliability, and operational efficiency. The integration of Internet of Things (IoT) frameworks with advanced sensor fusion techniques provides a transformative approach for real-time aircraft health assessment, anomaly detection, and pre-crash risk prediction. This chapter explores the role of connected aircraft architectures, multi-modal sensing technologies, artificial intelligence-driven analytics, edge–cloud computing, and digital twin frameworks in establishing next-generation aviation safety ecosystems. Advanced sensor fusion methodologies enable the integration of heterogeneous data sources, including navigation systems, engine monitoring units, structural health sensors, environmental sensors, and optical sensing platforms, to achieve accurate situational awareness under complex flight conditions. Artificial intelligence-based predictive analytics and decision-support mechanisms further enhance the capability of aviation systems to identify potential failures, optimize maintenance strategies, and generate timely safety alerts. The chapter discusses emerging challenges related to cybersecurity, data interoperability, computational complexity, and regulatory compliance while highlighting future research directions toward autonomous, resilient, and intelligent aircraft monitoring systems.

Keywords: Internet of Things (IoT); Sensor Fusion; Flight Monitoring Systems; Artificial Intelligence; Predictive Analytics; Pre-Crash Alerting Systems.

Introduction

The aviation industry has continuously evolved through significant technological advancements aimed at improving flight safety, operational reliability, and passenger security [1]. The increasing complexity of modern aircraft systems, combined with the rapid growth of global air transportation, has created a strong demand for intelligent monitoring mechanisms capable of evaluating aircraft performance in real time [2]. Conventional flight monitoring systems primarily focused on recording operational parameters through onboard instruments and flight data recorders for post-event analysis. Although these technologies contributed significantly to aviation accident investigation and safety improvement, their capabilities remained limited in predicting potential failures before critical situations developed. The emergence of digital transformation in aerospace engineering has shifted the focus from reactive safety management toward proactive and predictive approaches [3]. Modern aircraft now incorporate advanced sensing technologies, high-speed communication networks, and intelligent computational frameworks that enable continuous observation of aircraft health and environmental conditions. These developments have established the foundation for next-generation flight monitoring systems capable of collecting, processing, and interpreting large-scale operational data [4]. The integration of Internet of Things (IoT) technologies and intelligent data analysis methods has become a key research direction for developing connected aircraft platforms that support real-time monitoring, early fault detection, predictive maintenance, and enhanced decision-making capabilities throughout the entire flight lifecycle [5].

The increasing adoption of Internet of Things (IoT) technologies has transformed conventional aircraft into highly connected intelligent systems capable of seamless communication among onboard components, ground stations, maintenance centers, and cloud-based analytical platforms [6]. IoT-enabled aviation frameworks consist of interconnected sensors, communication networks, edge computing devices, and data processing infrastructures that continuously exchange operational information during flight operations [7]. Aircraft engines, structural components, navigation systems, fuel management units, environmental control systems, and avionics equipment generate extensive streams of data that provide valuable insights into aircraft performance and system health. Effective management of these heterogeneous data sources requires advanced communication architectures capable of supporting reliable, secure, and low-latency information exchange under demanding aviation environments [8]. IoT integration facilitates real-time aircraft monitoring by enabling remote diagnostics, automated maintenance planning, fleet-level performance evaluation, and rapid identification of abnormal operational conditions. The combination of onboard intelligence and cloud-based analytics further enhances the capability of aviation systems to process large volumes of sensor information and generate meaningful operational insights [9]. This transition toward connected aircraft represents a major advancement in aviation technology, enabling continuous awareness of aircraft conditions and supporting the development of safer, more efficient, and highly responsive flight operations [10].