Current Trends in the Application of Artificial Intelligence Methods in Aviation

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ABSTRACT

The authors have analyzed the documents of the International Civil Aviation Organization (ICAO) on the use of new technologies to minimize risks and improve safety in the aviation system. ICAO has identified new approaches to improve efficiency in aviation – the use of Artificial Intelligence (AI) models to organize Collaborative Decision-Making (CDM) by all aviation professionals based on general flight information. The effectiveness of Air Navigation System (ANS) operators' decisions depends on the rational use of intelligent automation at all stages of an aircraft flight in the form of Expert Systems or Intelligent Decision Support Systems (IDSS) with Hybrid Intelligence. To use CDM in IDSS in an emergency, a multilayer recurrent Artificial Neural Network with biases is designed. An illustrative example of the CDM models used by ANS operators (pilot, controller, engineer) and AI in the emergency "engine failure in flight" is presented. To improve the efficiency of aviation systems, it is proposed to introduce AI methods for collaborative training of aviation specialists.

INTRODUCTION

Aviation plays a pivotal role in the global transportation network. To maintain the safe and efficient operation of aviation companies, it is essential to maximize the utilization of the expanded capabilities provided by new technological advancements. Today, a primary strategic goal is the application of

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Artificial Intelligence (AI) in aviation to find effective solutions and support decision-making (DM) in complex and dynamic environments (Annebicque, 2012; International Air Transport Association, 2018; Airbus, 2023a; Boeing, 2023a; Airservices Australia, 2023; Abdillah et al., 2024). AI is defined as a system capable of performing human-like intellectual activities related to the perception and processing of knowledge, which is critical in aviation, especially for DM during emergencies (Kashyap, 2019a).

Aviation systems represent highly complex environments in which human performance is influenced by numerous interconnected elements, including technical, political, physical, social, economic, and cultural factors. For this reason, aviation infrastructures such as the Air Navigation System (ANS) are typically classified as Socio-Technical Systems (STSs). These systems possess two key characteristics: the intensive use of advanced technologies and the presence of high-risk operational activities, where failures in safety mechanisms may lead to severe or catastrophic consequences (Kharchenko, Shmelova, & Sikirda, 2012; Kharchenko, Shmelova, & Sikirda, 2016; Shmelova, & Sikirda, 2021). The level of safety and operational effectiveness in such systems largely depends on the quality of decisions made by human operators. These decisions are shaped by factors including professional training, competence, practical experience, and the availability and capability of modern information processing technologies (International Civil Aviation Organization, 2004; ICAO, 2013a; ICAO, 2016; ICAO, 2023).

At present, Artificial Intelligence (AI) technologies are increasingly incorporated into decision-making models within Air Navigation Sociotechnical Systems (ANSTS) through the application of Expert Systems (ES) and Intelligent Decision Support Systems (IDSS). These intelligent tools are intended to support aviation personnel – such as pilots, air traffic controllers, engineers, flight dispatchers, and operators of Unmanned Aerial Vehicles (UAVs) – particularly in emergencies. In such conditions, strict time constraints and elevated operational risks significantly increase the cognitive workload on human operators, making automated analytical support especially valuable (Kashyap, 2019a; Kharchenko, Shmelova, & Sikirda, 2012; Kharchenko, Shmelova, & Sikirda, 2016).

BACKGROUND

To support the safe and efficient functioning of aviation organizations, the International Civil Aviation Organization (ICAO) has issued guidance describing modern approaches for strengthening preventive safety management. These approaches rely on the rapid development of information technologies, with particular emphasis on the implementation of Artificial Intelligence (AI) within the aviation sector (ICAO, 2018). The idea of applying AI in aviation emerged from the objective of creating computer-based systems capable of demonstrating intelligent behavior comparable to human reasoning. Researchers sought to design artificial systems able to perform certain operational tasks more effectively than human operators, whose capabilities are typically referred to as Natural Intelligence (NI). Over time, the spectrum of AI technologies has expanded considerably and has been successfully implemented in many scientific and industrial domains (Kashyap, 2019a; Izonin, 2022; Salem, 2020). In aviation, the integration of these technologies contributes to improving the operational performance of airlines and supporting services by enabling more effective use of advanced technological capabilities. The International Air Transport Association (IATA) also emphasizes the benefits of modern AI technologies, including Machine Learning (ML), Natural Language Processing (NLP), Expert Systems (ES), computer vision, speech technologies, automated planning, and robotics (IATA, 2018). Addressing contemporary challenges in aviation therefore requires the development of intelligent tools such as Expert Systems and Intelligent Decision Support Systems