Chapter 7

Applications of Artificial Intelligence in Flight Management Systems

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ABSTRACT

Flight management system (FMS) is one of the key elements of the modern airplane. It is a computer-based system that helps a pilot with different routine operations. FMS includes numerous algorithms of Artificial Intelligence to support navigation, guidance, and control of aircraft. FMS hosts algorithms of airplane positioning by data from navigational aids and data fusion from multiple sensors. The internal memory of FMS includes global air navigation databases such as runways, airports data, air navigation charts, navigational aids, SIDs, STARs, approaches, and routes for automatic support of airplane operation.

BACKGROUND

Operation of each system of a modern airplane is connected with usage of numerous digital computation equipment. An airplane body can be referred to the complicated dynamic system. Numerous different systems are used to control an airplane state in three-dimensional space. Airframe orientation is provided by the flight control system. Operation of flight control surfaces is supported by hydraulic and pneumatic systems. Engine control system uses measurements of various pressure, temperature and flow sensors to provide required thrust value within safe engine operation. Fuel system provides the required fuel supply for normal engine operation and supports constant fuel flow between fuel tanks in order to guarantee airplane mass balancing. The electrical system provides generation and power distribution between all avionics equipment of an airplane. Each of these systems uses some elements of artificial intelligence

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at different levels of control and data processing (Villarroel & Rodrigues, 2016). For example, at a low level of data processing, adaptive filters are used to reduce random noise. Search for outliers, filling the gaps, interpolation, and extrapolation of data is another place for artificial intelligence application (Solomentsev et al., 2018; Nanduri & Sherry, 2016). All functions of automatic control can be referred to artificial intelligence. In general, system control is based on a well-defined math model of process and set of parameters, interrogation with each can change a system state.

Airplane navigation is another important task for safe aviation. Navigation equipment supports safe take-off, flight by predefined trajectory and landing of the airplane within predefined time-frame. Airplane navigation within defined airspace takes significant attention from pilots. Airplane trajectory in most cases is predefined by specific documents and air navigation charts that need from pilots to spend a lot of time for airplane guidance and control. Flight management system (FMS) helps pilots with navigation and airplane guidance. FMS performs all technical routine operations with different airplane systems that are used during flight, and allows the pilot to spend more time on the flight control, rather than tuning and setting up avionics systems. FMS is a computer-based system that includes numerous important information for safe air navigation of the airplane and uses different sensor data to optimize flight trajectory in order to achieve better performance. Also FMS utilize algorithms of trajectory extrapolation and smoothing (Duanzhang et al., 2016). FMS is digital computation equipment that in basic configuration does not include any sensors. FMS uses specific software to run multiple algorithms of data processing and picture generation. And, of course, FMS utilizes multiple artificial intelligence operations at different levels. Introduction of FMS in aviation helped to reduce the number of persons in the cockpit that is needed for airplane control and guidance. Algorithms of FMS have utilized all duties of navigating officer (also called “air navigator” or “flight navigator”) and makes possible to reduce the number of crew members to two persons only (captain and first officer). All heavy historical airplanes that are not equipped with FMS might required a flight engineer, radio operator or navigation officer to assist pilots for normal airplane operation (had to be a member of flight crew in commercial aviation on older aircraft, particularly used before 1990s, for example: MD-80, B-314, An-22, An-124, An-225). Therefore, FMS could be referred to only one system that fully replayed person responsibility on board of an airplane. In this case, FMS reduces the number of human functions with a help of deep automatization and leads to minimize human factor influence in aviation safety that is the main cause of the big amount of incidents that took place (Rizun & Shmelova, 2016; Wiegmann & Shappell, 2017).

Multiple advantages of FMS make it widespread in aviation. Nowadays each modern airplane is equipped with one of the FMS models and the future of avionics will not be imagined without FMS.

FMS supports multiple functions for big data analysis, data fusion, decision making support, automatic control, and navigation. Algorithms of FMS includes multiple application of artificial intelligence at different levels of data processing. The motivation and contribution of this chapter is to demonstrate application of artificial intelligence at different functions of FMS.

**PLACE OF FMS IN AVIONICS**

There are multiple commercially available architectures of FMS in civil aviation. In general, FMS includes FMS computer and Multifunction Control and Display Unit (MCDU) (Figure 1). FMS computer that utilizes all computational facilities is located at avionics compartment. Control and access to FMS
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