A Simulation Platform for Airport Runway Collision Warning System

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Abstract. The increasing passenger throughput makes the large-scale aviation hub being unable to bear the burden gradually. Flight delays caused by cannot fly through the ATC tower in time are becoming more and more common, which makes airlines have to face the problem of passenger loss. Meanwhile, runway intrusion incidents caused by the high load operation of the airport also occur frequently. Once there is a collision, airlines will suffer huge economic losses. In order to avoid runway intrusion, improve air transport efficiency and reduce airline losses, runway collision avoidance system emerges as the times require. Based on the real airport map geographic coordinate data, this paper draws the airport dynamic map in the onboard moving map for the pilot, defines several kinds of runway intrusion scenarios, and introduces 3D real-time visual display into the platform in order to build a complete set of simulation verification platform for airport runway collision avoidance system. The research results of this paper can be used to verify the optimization algorithm of runway collision avoidance system and the test of airport dynamic map in the future, which is of great significance to improve the traffic condition of large airports in the future.

1. Introduction

With the rapid development of China's national economy in recent years, people's living standards have been greatly improved. Economic development has brought a high-speed pace of life, making the aircraft into the fastest and most efficient means of transportation, get more and more people's choice. The surge in the number of flying passengers has led to a sharp increase in the daily throughput of large aviation hubs, which has made the originally orderly airport gradually overburdened. The probability of runway intrusion is greatly increased. A serious runway intrusion event may directly lead to two or more aircraft collisions, resulting in aircraft crashes and human death. Take the runway intrusion event at Shanghai Hongqiao International Airport in 2016 as an example, an Airbus A330 aircraft encountered another Airbus A320 aircraft invading the runway during take-off and taxiing, which nearly caused the tragedy of two aircraft collision and human death. Aircraft collision will make Airlines suffer huge economic losses, which any stakeholders in air transport activities do not want to face[1].

Some of the airborne equipment suppliers see such business opportunities and have developed some solutions to help flight crew and airport tower controllers carry out collision avoidance control. However, there are challenges for large-scale aircraft to take off and land at busy times, and because China has not issued relevant airworthiness laws and regulations, the collision avoidance algorithms in
various solutions are different, and the airport maps are also various, which brings some difficulties to verify the effectiveness of the solutions. The purpose of this paper is to establish a complete simulation platform to solve the verification problem of runway collision warning system solution.

2. Available technology in the industry

2.1. Automatic Dependence Surveillance Broadcast(ADS-B)
ADS-B is an Air Traffic Management(ATM) surveillance system that could be considered as a replacement for the traditional radar-based aircraft surveillance system. In an ADS-B system, there is an invisible wireless net in the air which available for aircraft to exchange their position, traffic and other information with the ground station. Based on the data fusion function in ADS-B, controllers are able to get timely alerting information about potential risks. Instead of using large and expensive ground based radar to get aircraft position, ADS-B uses GPS to find the position of each aircraft and report to the ground station automatically. Figure 1 illustrates the working principle of an ADS-B system[2].

![Figure 1. ADS-B operation mechanism](image)

2.2. Direct alerting to the cockpit for runway incursions
Runway incursions avoidance has been considered as one of the highest prior issues by FAA. A series of ground technologies-based systems have been developed and installed in many world-famous airports. Since the existing systems are not able to fully solve the runway incursion problem because of unacceptable delay often happens in alerting the flight crew. The performance of the radar-based system might be impacted by poor weather conditions. Several research programs reveal that with the help of flight deck enhancements, runway safety could be improved. Accordingly, a solution called Direct Alert to the Cockpit(DAC) system is introduced to cope with all the shortages mentioned above[3].

Figure 2 illustrates an onion structure and shows the location of a direct alerting system in the hierarchy of runway safety mechanisms. The first protection mechanism is the airport procedures such as FAA regulations and air traffic controller instructions[4]. Then many potential conflicts will be caught by radar-based systems when the airport procedures fail to keep airport surface safety. In adverse weather conditions, the performance of these systems will be reduced. The next layer which contents a direct alerting system will be taken into effect to keep aircraft away from conflicts. The
direct alerting system can be cockpit-based or ground-based[5]. At the last layer in the core of the “onion”, the pilot’s “see and avoid” behaviour working on avoiding runway accidents.

3. Airport runway collision warning system simulation platform

Airport runway collision warning system simulation platform.

3.1. Simulation architecture

Airport runway collision warning system simulation platform architecture is shown in figure 2.

3.2. Research content of the simulation platform

3.2.1. Airport map generator. The on-board moving map(OAMM) is built based on a real airport geographical map pick up from a commercial airport map database. In order to import the airport map into the simulation platform, the airport map generator is developed to provide a map convention function. The airport map could be rotated in the OAMM depends on the real-time heading angle of the main aircraft.

3.2.2. Pilot user interface. The pilot user interface in this airport runway collision warning system simulation platform is an optional mode for an on-board moving map(OAMM) in the cockpit primary flight display(PFD) which can be activated during the ground movement. It provides the airport moving map, the main aircraft and other aircraft’s real-time position. Since other aircraft access the safety area of the main aircraft, the system will trigger the warning alert according to the predefined logic[6]. Figure 4 shows the OAMM user interface for the pilot.
3.2.3. Aircraft movement simulator. An aircraft movement simulator is established in this simulation platform and it can be applied to simulate not only the main aircraft movement but also the intruder’s movement on the OAMM. The movement parameters include ground speed, heading angle and the real-time axis values. The aircraft movement is implemented by continuously updating the x and y value in the axis.

3.2.4. Runway incursion scenarios definition. Three kinds of runway incursion scenarios are predefined in this simulation platform, which are single intruder scenario, multiple intruders scenario and runway occupation scenario. Different scenario links to different warning information which would be displayed on the OAMM.

3.2.5. 3D visual display. The 3D visual display is implemented by embedding a flight simulator program as a real-time display output for aircraft movement in the airport. The flat earth axis values are converted to geometric latitude, longitude and altitude so that the simulation platform user is enabled to aware of the runway incursion process at the pilot view. Figure 5 reveals the 3D visual display for the airport runway collision warning system simulation platform.

Figure 4. The OAMM for pilot

Figure 5. 3D visual display
4. Conclusion
The rapid development of economy leads to the surge of airport operation load, which makes airport runway collision becomes an urgent issue for nowadays’ air transport participants.

This paper describes the architecture of the simulation platform, the main functions and possible application scenarios in future research work. Based on this airport runway collision warning system simulation platform, researchers can easily verify the algorithm of runway collision avoidance, collect pilot’s feedback and improve the system functionality. This research for promotion on the simulation and verification technology of airport ground collision avoidance system. And it will provide significant meaning in improving future air traffic situation.

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