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Review IJTET

Optimizing Aircraft Navigation Control: An Extensive Review

Ancy A.S.[1], Mohammed Faisal I.[2,*]

Abstract

In the earlier world, the number of airplane uses and transportation through airlines were limited but now the people are upgraded, and they choose the easiest way for transportation then naturally the air traffic is also increased. Optimizing aircraft navigation control has become an important field of research because of the quick advances in aviation technology and the growing desire for economical air travel. A detailed overview of contemporary aircraft navigation optimization techniques, technologies, and strategies is given in this study. It includes conventional techniques, the incorporation of contemporary technology like artificial intelligence and machine learning, and it talks about the difficulties and potential paths forward in this area. We need to reduce the plane crashes and other airplane disaster my maintaining by controlling and better communication. Navigation control helps to control the paths of airplane and can be optimized in several ways through several techniques. In this study, we give a brief review about the airplane control block and path control like something, which is helpful for navigation control. New methods are also mentioned, and some experimental results are noted. The complex problem of optimizing airoplane navigation control calls for the fusion of conventional techniques with cutting-edge technologies and creative thinking. Even though there has been a lot of progress, more research and development are still needed to solve new issues and maintain the sustainability, efficiency, and safety of air travel. Robust cybersecurity measures, a comprehensive approach to air traffic management, and the seamless integration of cutting-edge technologies are key components of the future of aircraft navigation control.

Keywords: Advanced air mobility, control, GNC, guidance, navigation, PIL

INTRODUCTION

Nowadays, the use of airplanes is more common than earlier, so when the crowd increases then there is a proportional increase in the airlines also then the control of plane path also needs to be controlled to avoid unwanted crashes. There should be a replan needed to change the airpath, Advance air mobility is envisioned without proper replan there should be more risk factors. The HJ reachability method is proposed for small, commanded headings. Absence of further information the controller will attempt a normal rejoin and collision may occur. Safety is the main issue faced during the navigation control time. Autopilot blocks for fixed wing aircraft and the implementation process done by PIL test platform and MATLAB and used in this era. There are some regulations in some nonlinear filters are used. Visual based navigation systems are also actively traditional path planning which can be solved using the method Q-Learned algorithm, this technique is optimized and increases efficiency and stability. Hybrid Fuzzy model is used for reducing complexity in air traffic.

***Author for Correspondence**
Mohammed Faisal I.
E-mail: mohammedfaisali786@gmail.com

[1]Scholar, Department of Electrical & Electronics Engineering, Thangal Kunju Musaliar College of Engineering, Kerala, India
[2]Assistant Professor, Department of Electrical & Electronics Engineering, Thangal Kunju Musaliar College of Engineering, Kerala, India

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LAGRANGIAN AND PIL TEST

Guidance means determination of desired path; navigation means determination of orientation and velocity state and control means control over the aircraft. Reachability can analyze either forward or backward time direction. Backward reachability formulation is more likely to numerical stability problems. Lagrangian methods are used to compute forward reachable set problems. Safety analysis based on discrete vector field and navigation plans for autonomous fixed wing aircraft are explained. Airplane in a feedback motion is shown in Figure 1. Controller will produce control commands for the error between the vehicles angle, vehicle direction and vehicle location. But the main drawback is that these have computational and space complexity [1–4]. It provides an overview of the methodologies for GNC in UAVs. Geometric stimulation is given by Monte Carlo simulation. This method provides advantages in safety, corner case detection. Challenges related to this are complexity, resource requirements and practical implementations as discussed in Table 1.

The design of autopilot blocks, control, guidance and navigation. Control block design is based on classical control theory, Piper 4 aircraft model and adhering to the MILF-8785C design requirements standard. The PIL test platform provides simulated aircraft model on a PC. The communication between these elements allows for testing the Autopilot system's functionality for predefined missions. The design of control blocks allows modifications that give way to future scope. The responses of the aircraft, including aerodynamic velocity, altitude, and yaw angle during the missions, were monitored and analyzed and results can be plotted in MATLAB for better studies [5, 6]. The result present in this paper gives the successful development and testing of autopilot system it is reliable, accurate, high precision and efficient.

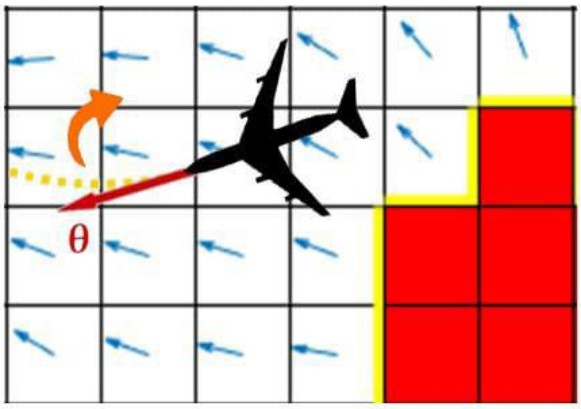

Figure 1. Airplane in feedback motion.

This explains the visual based docking of two vertical compound aircraft. Focus on the 6 degree of freedom docking mechanism mounted on the chaser aircraft. Monocular camera on the chaser aircraft to capture visual of landing gear, attitude and position. A 6-DOF docking mechanism on the chaser aircraft is designed to interact with the target aircraft's landing gear tires. The architecture of visual based navigation system is shown in Figure 2. Three-point problem (p3p) solving method is approached. Explain about the numerical and experiment demonstrate the practical application. Introduction of path and attitude planning gives the concept of collision avoidance during the docking process which helps to enhance the safety and efficiency of the operation [7, 8]. Challenges need to face are the complexity of the chaser platform.

CTO and Q-LEARNING

This aim is to optimize Calculation Time Over (CTO) operations by estimating compliance rates and mean expected delays. Data collected during trial and shadow operations to estimate the compliance rate of assigned CTOs and crucial for successful CTO deployment. As a result, this paper

aims to improve the CTO efficiency and highlight the importance of high compliance rates in reducing air traffic disturbances. Need optimal configurations to maximize mean expected delay. 22% increase in compliance rate and a slight increase in expected delay per flight. Future research can simulate air traffic with CTO operations more realistically [9, 10].

Q-Learning algorithm is used for dynamic aircraft path planning, and it enhances stability, efficiency, and helps avoid conflicts in the path planning it focuses on the safety and efficiency. Methods used are optimized Q-Learned algorithm. Simulation model and its result give the algorithm performance validation. Airport traffics rules with dynamic path planning method improve this method problems. Optimized path planning helps to reduce the workload of air traffic controllers.

FUZZY MODEL

Hybrid models are used to detect and resolve the problems in air traffic routes. Use fuzzy model and generate algorithm for the navigation problems. Hybrid model with fuzzy logic is the first method introduced and the next is global and dynamic analysis are used for the optimum flight level change actions. In this paper mostly discuss about the workload of air traffic controllers and complexity in managing air traffic and controlling errors and it focus on to improve the control system for air traffic management. This model improves safety, decision making and optimizes airspace models.

EN ROUTE ARRIVAL MANAGEMENT (AMAN)

In this introduce about new technique on En Route Arrival Management (AMAN) system which is used to reduce the arrival sequence and taxi time. As a result, runway assignment and speed control rule are strict in air traffic management it will help to reduce the delay also. The method used is Decision tree analysis visualize the distinct strategies of traffic control and agent based simulation is used to evaluate the system effectiveness. Literature states that major airports are implemented with scientific system design for En Route Arrival Management (AMAN). This system helps to improve air traffic control efficiency, delay time and taxi arrival time.

In this section, we mainly focus on the ALOS guidance law for the vehicle path following and explain about the adaptive control and guidance for both the marine and land vehicles. Discuss the concept of coordinate system and tracking error dynamics they use kinematic equation to explain the problem. Methods used are ALOS guidance law with robustness properties and another is switching mechanism along with a piecewise linear path for the selection of waypoints. Drift force is needed to compensate due to wind, waves, and ocean current. This system aims to minimize cross tracking error. The robust navigation algorithm used for unmanned ground vehicles integrates the strapdown inertial navigation system and visual odometer for precision control. The idea proposed is RHCKF filter to enhance localization accuracy for our challenging environment. Integrated navigation system with strapdown internal navigation and visual odometer is the first method another method is robust nonlinear filter based on Kalman filter and the third one used is SINS and VO system integration used for the improving navigation vehicles accuracy. Here, the SD-ABN architecture integrates SDN into ABN, for traffic scheduling. Literature states that Man use the discrete data link systems like Link-11 and Link-16. SDN enhances UAV network control and management system. Existing systems also focus on civilian SDN network architecture design. The problem with this is only limited data on the traffic scheduling for airborne networks. Methods used are segment routing (SR) applied with modifications for the SD-ABN system another one is MRP-TS algorithm designed for traffic scheduling in SD-ABN and the third one used is Bandwidth preemption algorithm considering traffic decomposition (TD-BP). MRP-TS algorithm enhances transmission reliability and bandwidth utilization. SD-ABN helps to improve battlefield communication with the help of segment routing technology.

OBSTACLES AND PROSPECTS FOR THE FUTURE

Online Safety

As our reliance on digital technologies grows, cybersecurity is becoming a major worry. In order to preserve aviation safety and integrity, cyber threats must be neutralized and navigation systems must be protected.

Unmanned Aerial Vehicle (UAV) Integration

Because of their various operating characteristics and requirements, UAV integration into the airspace poses navigation control issues. Future airspace management depends on the development of systems that can smoothly integrate human and unmanned aircraft.

Taking the Environment Into Account

Reducing the environmental impact of aviation through navigation control optimization is a continuous problem. This involves using cutting-edge navigation and flight planning strategies to reduce pollutants, noise pollution, and fuel consumption.

Human Elements

The workload and decision-making of the pilot are two important human elements in navigation control. Navigation systems can be made safer and more efficient overall by improving human–machine interfaces and offering decision support capabilities.

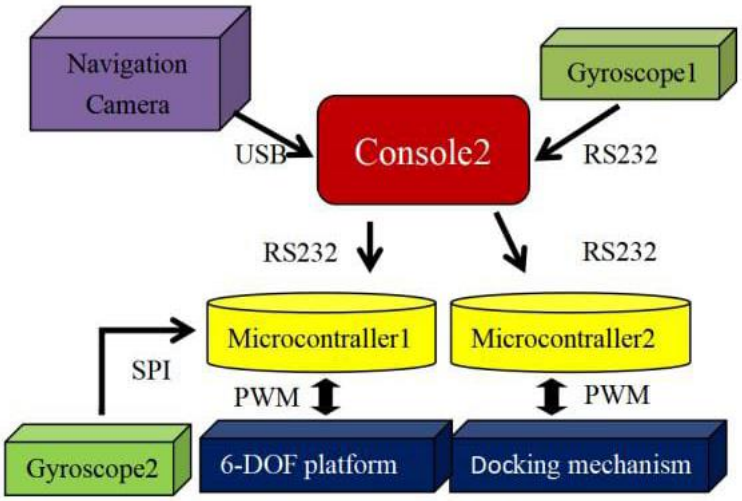

Figure 2. Architecture of visual based navigation system.

Table 1. Advantage and disadvantage.

Methods	Advantage	Disadvantage
Lagrangian methods	Enhanced safety	complexity
	Geometric analysis	Resource intensive
PIL test	Successful mission result	Lack of visual aids
	Efficient	Limited discussion
CTO	Enhance military communication	High cost
Docking mechanism	Enhance operational efficiency	Sensitivity
	Compliance rate improvement	Operational challenges
Q-Learning algorithm	Optimized Q-Learning algorithm improve efficiency	Changing environment
	Enhance bandwidth utilization	Iteration stability
Fuzzy model	Analyze complexity	Impossible to find feasible scenarios
En Route Arrival Management (AMAN)	Help to reduce delay time by 21%	Environmental impact
	Arrival taxi time decreased by 6.9%	Lack of data
ALOS guidance law	Follow a specific law	Global stability issues
	Better tracking capabilities	Environmental impact
Kalman filter	System accuracy and adaptive methods used and accurate with environmental challenges	Inadequate system
UAV network control	Enhance transmission reliability.	Limited research

CONCLUSIONS

From this study, we can clearly understand that many existing systems have very efficiency and precision problems and each of them is facing environmental challenges. New methods like HJ reachability, PIL test, Kalman, fuzzy model and many more nonlinear methods are introduced to enhance the system efficiency, precision, accuracy, safety and try to reduce the complexity, delay time, taxi arrival time delay and environmental challenges. From all of these methods nonlinear methods are much accurate and now a days also they are undergoing research and provide better outperformance.

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