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A Helicopter Path Planning Method Based on AIXM Dataset

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ABSTRACT

ICAO has emphasized that aeronautical information agencies should provide digitized aeronautical data and information, and realize that aeronautical data exchanging internationally in AIM. The AIXM structured aeronautical information dataset will be the main source of aeronautical basic data in the aeronautical information exchange network. In this article, the authors first analyze the spatio-temporal attributes of AIXM dataset and design the query method of AIXM structured obstacle data based on the research of AIXM coding specification. Secondly, the helicopter path planning is taken as the research scenario. Using the AIXM obstacle dataset and route dataset, combining the helicopter performance constraints to construct the envelope frame for collision judgment, and a new path planning method with improving the classical A* algorithm based on the AIXM dataset is proposed. The proposed method is validated and visualized. The validation results show that the proposed method reduces the frequency of helicopter turning, and ensures the safe distance between the flight path and the obstacles.

KEYWORDS

A* Algorithm, Air Transportation, AIXM Dataset, Helicopter Path Planning, Spatio-temporal Data

INTRODUCTION

In 2008, ICAO put forward the requirement to transform from Aeronautical Information Services (AIS) to Aeronautical Information Management (AIM). To regulate data management and release data under the AIM system, the Aeronautical Information Exchange Model (AIXM) specification was adopted as the underlying data structure for all kinds of aeronautical information (ICAO 2014, 2018). The aeronautical data in the AIXM structure will become the primary data to support general aviation operations in the future. As AIXM is essentially a spatiotemporal dataset, research on AIXM should

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also study the related spatiotemporal data model research and spatiotemporal data retrieval research in addition to the research on the AIXM specification, which can provide a deeper understanding of AIXM from basic geographic information knowledge. Scholars have proposed solutions for the field based on research on spatiotemporal data models and data retrieval.

For big data information in the logistics and transportation industry, Wen and Yan (2018) established a data mining method based on a spatiotemporal data model, using real-time transmission of vehicle location information and image data to generate the optimal route of the corresponding scene information, which at the same time can be used for path planning. Zhang et al. (2016) proposed a spatiotemporal data prediction model based on deep learning and built a real-time people flow prediction system called UrbanFlow. Huỳnh et al. (2017) proposed a parallel R-tree construction scheme based on the Hadoop framework to improve the retrieval of big data. Azqueta-Alzúaz et al. (2017) proposed a scheme to load big data in parallel to improve the data loading efficiency of HBase. Laksmiwati et al. (2015) proposed a general architecture for spatiotemporal unpredictable data processing systems in disaster management information systems. Zhang et al. (2020) proposed a 3DPS-based spatiotemporal data model service sharing scheme with a research objective of spatiotemporal data model sharing. They applied it to two scenarios of ground settlement monitoring and railroad emergency rescue simulation in integrated disaster mitigation. Liu et al. (2021) researched and designed a set of spatiotemporal data model construction methods for natural resources based on hybrid modeling. This solved the need for integrated expression of natural resources in time, space, semantics, management, and services. To meet the needs of spatiotemporal analysis of the battlefield environment, Zhu et al. (2018) proposed establishing an object-oriented spatiotemporal data organization model through a task process-driven approach.

On the other hand, helicopter operations are characterized by flexible path planning and are deeply affected by terrain obstacles and other factors. Using the AIXM dataset for obstacle and path planning pre-flight hints can provide safety information for navigation operations. Helicopter path planning, which requires a combination of start and end locations and the operational spatial environment for path planning before operation, has become a hot research topic, with scholars proposing various algorithms in 3D path planning. Cicibaş et al. (2016) summarized the main obstacles, meteorological constraints, and model objectives, such as distance and time fuel for path planning. They improved the A* algorithm and applied it to 4D path planning. Jaishankar and Pralhad (2011) used greyscale images of 3D environments as a data environment for path planning. They combined the spatial multi-criteria decision analysis (MCDA) technique with distance transformation to generate optimal paths. Hara and Tomono (2020) proposed a method to remove moving objects in dynamic 3D environments and reconstruct maps using graph search and surface grid maps for path planning. Cao et al. (2022) proposed an improved artificial potential field algorithm and extended it to 3D space to solve the problem of unmanned helicopter trajectory planning in a 3D environment.

To apply AIXM data more broadly in aeronautical information management and to enable AIXM data sets to serve additional areas of aeronautical operations, we investigated the AIXM dataset coding specification and applied the AIXM dataset in a helicopter operation scenario. First, based on the above analysis of the path specification approach, we considered that the underlying data for the path planning of helicopter operations comes from the AIXM dataset, including the obstacle and route datasets. Second, based on analyzing the spatial relationship between the AIXM obstacle dataset and the route dataset, we constructed a query algorithm for the obstacle dataset according to AIXM specifications and constructed enclosing boxes for trajectory and collision judgments. Finally, we proposed a helicopter path planning algorithm based on the AIXM dataset using an improved classical A* algorithm and conducted simulation verification.