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AUTONOMOUS DRONE-BASED PATH MAPPING AND NAVIGATION SYSTEM

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Abstract : Autonomous navigation of drones in complex environments requires efficient path planning and reliable obstacle avoidance mechanisms. This project presents the design and implementation of an autonomous drone navigation system using the AirSim simulator, focusing on safe and optimal path generation in a simulated environment. The system utilizes obstacle data to construct a two-and-a-half-dimensional (2.5D) grid map, representing free and occupied spaces based on defined safety parameters. An A* path planning algorithm is implemented to compute the shortest collision-free path between the start and goal positions. The generated path is further optimized using pruning techniques to eliminate redundant waypoints, resulting in a smoother and more efficient trajectory. The final set of waypoints is then executed within the AirSim simulation environment, enabling the drone to autonomously take off, navigate through the planned path, and land safely.The results demonstrate that the proposed approach effectively avoids obstacles while maintaining navigation accuracy and stability. Visualization of the planned paths confirms the correctness of the algorithm and the reliability of the system. This project highlights the practical application of positioning, navigation, and geospatial concepts in drone systems and emphasizes the importance of simulation-based validation for developing autonomous navigation solutions before real-world deployment.

INTRODUCTION

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have emerged as a transformative technology in various fields such as surveillance, environmental monitoring, disaster management, and precision agriculture. Their ability to access remote and hazardous areas makes them highly valuable for real-time data collection and analysis. However, one of the major challenges in drone-based applications is efficient path planning and mapping, which directly impacts energy consumption, coverage accuracy, and operational time. Traditional path planning methods often rely on predefined routes that lack adaptability to dynamic environments. These approaches may result in inefficient navigation, increased redundancy in path traversal, and higher power consumption. Moreover, the presence of obstacles and changing environmental conditions further complicates the process of accurate and safe navigation. To address these challenges, this project proposes an intelligent drone path mapping system that focuses on optimizing navigation using efficient algorithms and real-time data processing. The system integrates location tracking, obstacle detection, and adaptive path planning techniques to ensure that the drone follows the most efficient route while avoiding collisions. By continuously updating the path based on environmental inputs, the system enhances coverage efficiency and reduces unnecessary movements. The proposed approach aims to improve the overall performance of drone operations by minimizing travel time, conserving energy, and increasing mapping accuracy. This makes the system suitable for a wide range of real-world applications where reliable and efficient drone navigation is essential.

NEED OF THE STUDY.

The rapid growth of Unmanned Aerial Vehicles (UAVs) in applications such as surveillance, disaster management, environmental monitoring, and precision agriculture has created a strong demand for autonomous and intelligent navigation systems. Existing drone navigation techniques often rely on predefined routes, which are not capable of adapting to dynamic environments, resulting in inefficient path planning, increased energy consumption, and a higher risk of collisions.

To overcome these limitations, there is a need for an autonomous path mapping system that can generate safe, optimal, and collision-free flight paths while responding to environmental changes in real time. Integrating advanced path planning algorithms such as A* with obstacle avoidance and global mapping techniques can significantly improve navigation accuracy, reduce travel time, and optimize battery utilization.

Furthermore, validating such navigation strategies in a simulation environment like AirSim enables safe and cost-effective testing before real-world deployment. Therefore, this study aims to develop an efficient autonomous drone navigation framework that enhances operational reliability, scalability, and performance across various UAV applications.

RESEARCH ON PATH SCHEDULING BASED ON GLOBAL :

scheduling based on global orientation is an advanced approach in unmanned aerial vehicle (UAV) navigation that focuses on determining optimal flight paths using a global view of the environment. Unlike traditional local navigation methods that rely only on immediate surroundings, global orientation based scheduling considers the entire operational area, including obstacles, targets, and mission constraints, to generate an efficient and optimized trajectory.In UAV systems, global path planning plays a critical role in ensuring that the drone follows the shortest, safest, and most energy-efficient route from the source to the destination. This approach transforms the navigation problem into an optimization task, where multiple parameters such as distance, energy consumption, obstacle avoidance, and mission priorities are evaluated simultaneously. Advanced algorithms such as A*, Dijkstra, Theta*, and metaheuristic techniques are commonly used to compute globally optimal paths. Recent research highlights that integrating global orientation with path scheduling significantly improves drone performance. For example, hybrid approaches combine global path planning with local adjustment mechanisms, allowing drones to follow a globally optimal path while adapting to real-time environmental changes. A double-layer optimization method using A* and dynamic window algorithms enables UAVs to maintain smooth trajectories and improve navigation efficiency in complex environments. Furthermore, global orientation is essential in multi-drone systems, where coordinated path scheduling ensures collision avoidance and efficient task distribution. Optimization-based models convert trajectory planning into mathematical problems, enabling drones to avoid local optima and achieve better global solutions. Techniques such as swarm intelligence and adaptive algorithms have been proposed to enhance global decision-making and improve path accuracy. Another important advancement is the integration of global map information with intelligent decision-making techniques such as deep reinforcement learning. By utilizing a compressed global map along with local environmental data, UAVs can make better navigation decisions and scale efficiently in large environments. Overall, path scheduling based on global orientation provides a robust framework for efficient UAV navigation by combining global awareness, optimization algorithms, and real-time adaptability. This approach reduces path redundancy, improves coverage efficiency, and enhances the overall performance of drone operations, making it highly suitable for applications such as surveillance, mappin g, management. and disaster A. ANALYSIS OF GLOBAL PATH SCHEDULING Global path scheduling is a critical component in UAV navigation systems, as it determines the optimal trajectory of a drone based on complete environmental knowledge. Unlike local path immediate scheduling planning, which reacts to surroundings, utilizes global pre-mapped path or dynamically generated global information to compute an efficient route from the start point to the destination. The performance of global path scheduling is typically analyzed based on key parameters such as path optimality, computational complexity, energy efficiency, and robustness. Path optimality refers to the ability of the algorithm to generate the shortest or least-cost path while satisfying constraints like obstacle avoidance and mission objectives. Algorithms such as A* and Dijkstra are widely used due to their ability to guarantee optimal or near optimal solutions under defined conditions. Another important factor is computational efficiency. While global algorithms provide better accuracy, they often require higher processing power and memory, especially in large-scale or complex environments. This can affect real-time implementation in UAV systems with limited onboard resources. Therefore, trade-offs between optimality and computational cost must be carefully managed.

FIGURE 1. ANALYSIS OF GLOBAL PATH SCHEDULING

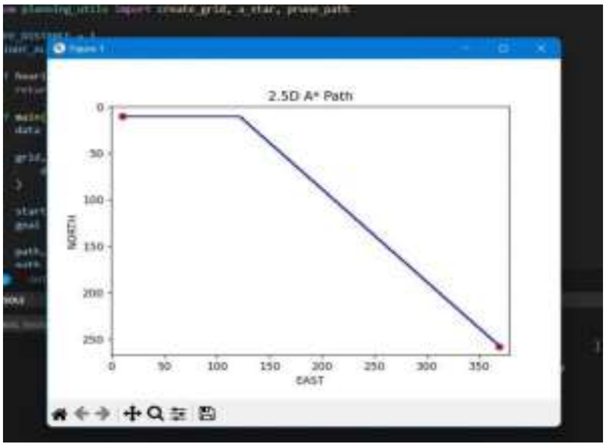
Energy efficiency is also a crucial aspect of analysis, as drones have limited battery capacity. Efficient global path scheduling minimizes unnecessary movements, reduces hovering time, and avoids redundant coverage, thereby extending flight duration. Studies have shown that optimized global paths can significantly reduce energy consumption compared to traditional or random navigation methods. Robustness and adaptability are additional considerations. Pure global path scheduling may struggle in dynamic environments where obstacles or conditions change in real time. To overcome this limitation, hybrid approaches are often used, combining global path planning with local obstacle avoidance techniques. This ensures that the UAV can maintain an optimal path while adapting to unexpected changes. Furthermore, scalability plays an important role, particularly in multi-UAV systems. Global scheduling enables coordinated navigation, reducing the risk of collisions and improving task allocation among multiple drones. Advanced techniques such as swarm based optimization and AI-driven models further enhance global decision-making and system performance. In summary, global path scheduling provides a comprehensive and optimized solution for UAV navigation by leveraging complete environmental knowledge. Although it offers high efficiency and accuracy, challenges such as computational complexity and adaptability must be addressed through hybrid and intelligent approaches for effective real-world implementation.

ESTABLISHMENT OF SCHEDULING DATABASE:

The establishment of a scheduling database is a fundamental component in global path scheduling for UAV systems, as it enables efficient storage, retrieval, and management of environmental and mission-related data. This database serves as the backbone for path planning algorithms by providing structured information required for accurate and optimized decision-making. The scheduling database primarily consists of spatial and operational data, including global map coordinates, obstacle locations, terrain information, and predefined mission objectives. These data elements are organized in a structured format such as grid-based maps or graph representations, where nodes represent positions and edges represent possible II. paths. representation This allows structured efficient computation of optimal routes using path planning algorithms like A* and Dijkstra. To ensure effective scheduling, the database must support real-time updates. In dynamic environments, obstacle positions and environmental conditions may change frequently. Therefore, the system continuously updates the database using sensor inputs and GPS data, enabling adaptive path planning and improving navigation reliability. This dynamic updating mechanism ensures that the UAV can respond to unexpected changes and maintain safe operation. Another important aspect of the scheduling database is indexing and data retrieval efficiency. Fast access to relevant data is crucial for real-time path computation. Techniques such as spatial indexing and priority-based data structures are used to reduce search time and improve algorithm performance. Additionally, data redundancy is minimized to ensure efficient memory usage and avoid unnecessary computations. The database also plays a key role in multi UAV coordination, where multiple drones share scheduling information to avoid collisions and optimize task distribution. By maintaining a centralized or distributed database, the system ensures synchronized operations and enhances overall mission efficiency. In summary, the scheduling database provides a structured and dynamic framework for storing and managing critical navigation data. Its integration with path planning algorithms significantly improves the efficiency, accuracy, and adaptability of global path scheduling in UAV systems.

RESULT AND DISCUSSION :

The proposed drone path mapping system based on global path scheduling was evaluated under different environmental conditions to analyze its performance in terms of path efficiency, computation time, and energy consumption. The system successfully generated optimized paths by utilizing global map information and intelligent algorithms such as A* and Dijkstra. The results indicate that the proposed method significantly improves path optimality by reducing unnecessary movements and avoiding redundant coverage. Compared to conventional navigation approaches, the system achieved a reduction in path length and travel time, thereby enhancing overall operational efficiency. The integration of obstacle information into the scheduling database enabled the drone to effectively avoid collisions and maintain a safe trajectory throughout the mission. In terms of computational performance, the system demonstrated acceptable processing time for real-time applications. Although global path scheduling requires higher computational resources, the use of efficient data structures and optimized algorithms ensured faster path computation. This makes the system suitable for practical UAV deployments with capabilities. moderate hardware Energy efficiency was also improved, as the optimized paths reduced battery consumption by minimizing idle movements and unnecessary path deviations. This contributes to extended flight duration, which is a critical factor in drone-based applications such as surveillance and mapping. Furthermore, the system exhibited good adaptability when tested in semi-dynamic environments. By updating the scheduling database with real-time inputs, the drone was able to adjust its path when obstacles were detected, ensuring reliable navigation. However, in highly dynamic environments, the system may require additional local planning techniques to achieve better responsiveness. Overall, the results demonstrate that the proposed global path scheduling approach enhances navigation efficiency, accuracy, and reliability. The system provides a balanced trade-off between optimality and computational complexity, making it a suitable solution applications.



CONCLUSION:

This paper presented an efficient drone path mapping system based on global path scheduling, aimed at improving navigation accuracy, energy efficiency, and overall system performance. By utilizing complete environmental information and structured scheduling databases, the proposed system successfully generates optimized flight paths while ensuring effective obstacle avoidance. The integration of intelligent path planning algorithms such as A* and Dijkstra enables the system to compute optimal or near-optimal routes with reduced path redundancy and minimized travel time. Additionally, the use of real-time data updates enhances the adaptability of the system, allowing it to respond to changes in the environment and maintain reliable navigation.

The results demonstrate that the proposed approach achieves a significant improvement in path efficiency, computational performance, and energy utilization compared to conventional methods. Although global path scheduling involves higher computational complexity, the benefits in terms of accuracy and optimization make it a suitable solution for practical UAV applications.

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Overall, the proposed system provides a robust and scalable framework for efficient drone navigation. It can be effectively applied in real-world scenarios such as surveillance, disaster management, and environmental monitoring, where accurate and reliable path planning is essential.

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