UNMANNED AERIAL VEHICLE FOR SMART AGRICULTURE

Parameswari P[1], Ramya S[2], Sritha R[3], Tusita M[4]

[1]*Assistant Professor, Department of CSE, Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu, India*

[2,3,4]*Student Department of CSE, Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu, India*

Abstract: A UAV drone for smart agriculture, often referred to simply as an agricultural drone, is an Unmanned Aerial Vehicle (UAV) equipped with various sensors. Unmanned aerial vehicles, or UAVs, are becoming increasingly popular in a variety of applications, including field mapping, agriculture, and obstacle avoidance. Path planning, which entails creating ideal trajectories to move through surroundings effectively while avoiding obstacles, is a crucial component of UAV operation. A MATLAB simulation framework for UAV path planning is presented. A simulation-based method for assessing UAV path planning tactics for agricultural areas is presented in this paper. The main goal is to create and evaluate path planning algorithms that maximize UAV paths for effective data gathering and surveillance in agricultural environments. Furthermore, the platform enables users to adjust factors like obstacle density, mission objectives, and UAV speed to evaluate the effectiveness of various path planning algorithms in varied scenarios. All things considered, this MATLAB simulation framework is a useful resource for engineers, academics, and practitioners that plan UAV routes.

.Keywords: UAV; MATLAB; Path planning; Obstacle avoidance**;**

I. INTRODUCTION

In the rapidly advancing field Unmanned aerial vehicles (UAVs), commonly referred to as drones, have transformed several sectors in recent years, including aerial photography, videography, emergency response, and infrastructure assessment. However, the effective deployment of drones requires the development of a well-organized system that incorporates a few essential components and concerns. Path planning is one of the many variables that must be carefully considered when integrating UAVs into agriculture to ensure effective navigation in agricultural fields. Finding the optimal route for the UAV to travel over the field is known as path planning. Effective path planning is essential for maximizing the UAV's coverage area, cutting down on flight time, and saving energy reserves. In recent years, the agricultural sector has seen a remarkable transformation through the integration of cutting-edge technology.

The primary focus of this work is on the setup and simulation (using MATLAB) of UAVs for path planning in agricultural fields. Developing and evaluating path planning algorithms that optimise UAV routes in agricultural fields is the primary objective. Path planning, which determines the optimal course a UAV should take in each area to minimise obstacles and maximise efficiency, is crucial to the accomplishment of UAV missions in agriculture.

Effective path planning algorithms extend the spatial coverage of data collection while reducing flight time, maintaining battery life, and lowering operational costs. Furthermore, path planning algorithms must be adaptable enough to change course in response to shifting field conditions to take into consideration the dynamic character of agricultural landscapes.

The setup process involves not only hardware but also software configuration and calibration, which are necessary to enable self-piloting and execute pre-programmed missions. Flight planning software, telemetry systems, and ground control stations make up the digital infrastructure that facilitates seamless communication and control between the operator and the UAV.

The UAV uses an optimised path-finding algorithm to get to its target safely. For the shortest path, two algorithms have been selected. Specifically, the Minimum Traversal solver algorithm and the Exhaustive solver algorithm.

The process of using the Exhaustive Solver Algorithm essentails discretizing the environment into a grid or graph, conducting an exhaustive search to find every possible path, and assessing each option according to predetermined criteria including path length, obstacle clearing, and energy consumption.

The Minimum Traversal Solver Algorithm is commonly used in robotics, navigation systems, and pathfinding applications to find efficient routes while minimizing resource consumption and traversal time. Its effectiveness lies in its ability to systematically explore and evaluate paths, ultimately selecting the optimal route for reaching the destination.

II. PROPOSED METHODOLOGY

In the proposed methodology This UAV discusses the Quad copter design in detail by breaking the design down by components requirement, construction and testing of both hardware and parts of the project. The system's design may be broken down into three sections: User Control, Drone, and Monitor. The transmitting telemetry device and the laptop (base station) comprise the user control portion. The drone's components include a Li-Po battery for power supply, electronic speed controllers, brushless DC motors, a flight controller, and radio telemetry receivers. Path planning methods include the exhaustive solver and the minimum traversal solver.

The robotics system toolbox and the UAV toolbox are two examples of the toolboxes that are used to build up the environment for simulation in MATLAB. Algorithms for detecting obstacles are used so that the drone can identify and avoid obstacles during flight.

Drone movements and planned routes can be visualised in the simulation environment. Metrics like calculation time and path length are measured in performance evaluation.

Processes of optimisation and refinement adjust parameters and methods for better performance while resolving any problems found. User manuals, reports, and thorough documentation of the system design, implementation, and simulation results are supplied.

However, the deployment of UAVs heavily relies on robust path planning algorithms and robust setup processes to guarantee safe and effective operation. This problem statement discusses the objectives and challenges associated with MATLAB path planning simulations and drone setup. Users can test various algorithms, iterate on designs, and check the system's performance prior to deployment using MATLAB simulation, ensuring the system's durability and reliability in real-world applications.

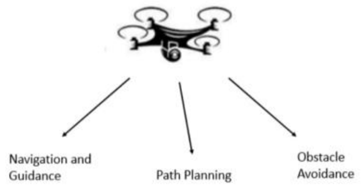

Fig 1: Working principles of Drone

III. RELATED WORKS

A. Initialization of UAV parameters

An agricultural drone's hardware configuration consists of putting together several necessary parts that are suited to the requirements of crop management and monitoring. The first step in this arrangement is usually choosing a drone platform that can hold the required payload while taking stability, flight duration, and payload capacity into account. Real-time data transmission and remote piloting are made possible by dependable communication and control systems, such as radio transmitters, receivers, and telemetry systems.

During flight missions, a navigation system—typically GPS or GNSS receivers—ensures precise positioning and waypoint navigation. Long-duration flights are made possible by a reliable power supply system, which typically consists of fuel cells or rechargeable lithium-ion batteries that power the onboard sensors and electronics. Additionally, mission planning, flight monitoring, and other tasks are made easier by a ground control station with a computer or tablet interface. Developing procedures for data processing, transport, and storage guarantees effective administration and use of gathered agricultural data. By carefully choosing and integrating these hardware elements, an agricultural drone system can offer insightful information on how to maximize crop management techniques and raise total farm output.

Fig 2: Final Drone setup

B. Implementation of path planning algorithms in the simulation

The MATLAB simulation for UAV path planning in agriculture fields employs both the Exhaustive solver algorithm and the minimum traversal algorithm to optimize routes for unmanned aerial vehicles (UAVs) covering vast agricultural areas.

Results indicate that the Exhaustive solver algorithm systematically evaluates all possible paths, ensuring the identification of the most efficient route. This exhaustive search approach guarantees optimal coverage while considering factors like field size, crop distribution, and obstacle avoidance. However, it may become computationally expensive for larger areas due to the exhaustive nature of the search.

In contrast, the minimum traversal algorithm efficiently determines a path that minimizes traversal distance, leading to reduced flight time and energy consumption. This algorithm is particularly effective in scenarios where obstacles are sparsely distributed or the field layout is relatively simple.

Discussion revolves around the complementary nature of these algorithms. While the Exhaustive solver guarantees optimality, it may be impractical for large-scale applications. In such cases, the minimum traversal algorithm offers a more efficient alternative without sacrificing much in terms of coverage quality.

By combining these algorithms, the simulation provides a versatile solution adaptable to various agricultural settings. This approach maximizes the UAV's effectiveness in optimizing farming practices, enhancing productivity, and promoting sustainability in agriculture.

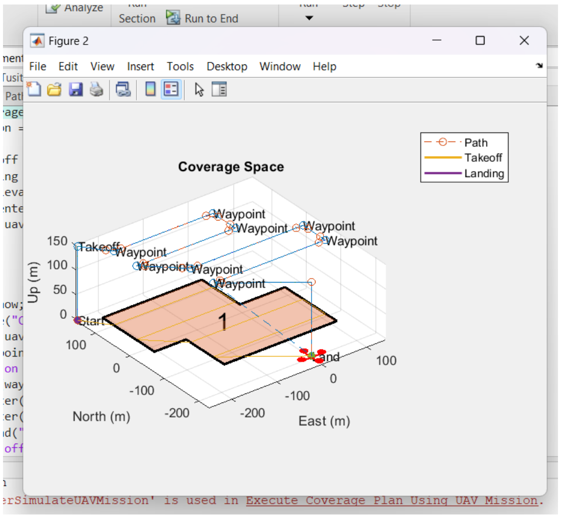

Fig 3: Final Simulation

EXHAUSTIVE SOLVER ALGORITHM

We methodically investigate every potential path in the MATLAB simulation of UAV path planning using the Exhaustive solver algorithm to determine the best course for the unmanned aerial vehicle (UAV) to traverse an agricultural field.

Initially, we depict the agricultural field as a grid, with a unit area corresponding to each cell. Next, we specify where the UAV starts and list every route it might possibly take to go over the whole grid while considering limitations like avoiding obstacles and minimising traversal

The algorithm known as the Exhaustive solver repeatedly goes through every potential path combination and assesses it according to predetermined standards including energy consumption, obstacle avoidance, and coverage efficiency. This thorough search ensures that we identify the best course that maximises coverage while minimizing traversal time and energy usage.

Plan UAV routes with MATLAB using an exhaustive solver approach. Define a discrete grid that represents the surroundings, where a possible waypoint is represented by each cell. Go through every conceivable combination of waypoints, considering limitations like barriers and mission objectives. Consider factors such as time, distance, and safety when evaluating each route. Use exhaustive search strategies to minimise a cost function and optimise the path. Use effective algorithms and data structures to manage big search spaces. Use performance analysis and simulation to validate the solution. Lastly, use the optimised route to provide dependable and effective trajectory planning for UAV navigation in the actual world.

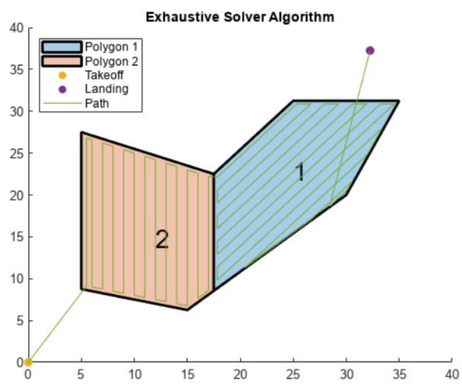

Fig 4: Exhaustive solver algorithm

MINIMUM TRAVERSAL SOLVER

There are various benefits to using a minimum traversal solver technique using MATLAB for UAV path planning. First off, during UAV flights, our method effectively reduces traversal distances, saving time and energy. It is the best option for jobs like aerial mapping, surveillance, and monitoring since it allows pathways to be generated that prioritise effective coverage of the surroundings.

Furthermore, the adaptability of MATLAB makes it simple to integrate and customise limitations like mission objectives, dynamic impediments, and no-fly zones. In comparison to exhaustive search techniques, the algorithm's optimisation focus lowers computational complexity, improving scalability for bigger environments.

Reliability and safety are ensured by the extensive evaluation and verification of planned courses made possible by MATLAB's extensive toolkit. Additionally, its intuitive interface shortens development time by making parameter adjustment an implementation simpler. Lastly, the visualisation features of MATLAB facilitate intuitive comprehension.

Dijkstra's algorithm is a frequently used minimum traversal approach in MATLAB Simulink for UAV path planning. This approach maintains a priority queue based on the estimated distances from the start node and iteratively explores neighbouring nodes to efficiently find the shortest path between nodes in a network. Except for the start node, which is given 0, all nodes are initially allotted unlimited distances. After that, until the target node is reached, the algorithm keeps choosing the node with the shortest tentative distance, updates the distances of its neighbours, and so on. This makes sure that the shortest path is determined gradually to each node, which leads to the finding of the shortest path from the starting point to the destination node.

In MATLAB Simulink, Dijkstra's algorithm can be implemented using custom MATLAB functions or blocks specifically designed for graph traversal and path planning. Its versatility and effectiveness make it a valuable tool for UAV path planning, enabling efficient navigation through complex environments while considering obstacles, terrain, and other constraints.

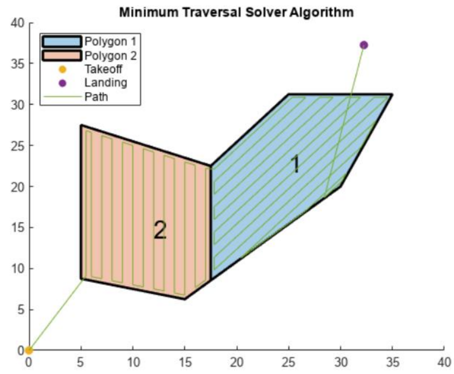

Fig 5: Minimum Traversal solver algorithm

Data collection and fielding mapping:

Gathering relevant information about the terrain, crop distribution, and field layout is necessary for data gathering and field mapping in agricultural fields for UAV path planning. Surveys and ground-based sensor measurements can also be used to supplement remote sensing data. After the data has been processed and analysed, complex maps of the agricultural area are created, which are then used by path planning algorithms. Accurate field mapping is essential to optimise UAV flight routes and ensure efficient data collection and monitoring.

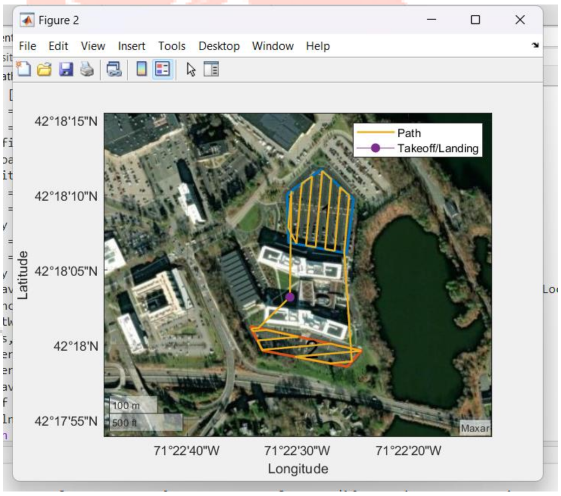

Fig 6: Field mapping

An overview of the environment used for simulation:

When planning a UAV path in an agricultural area, the simulation environment includes digital representations of the ground, crops, and weather. It makes use of models and algorithms that consider a variety of characteristics, including crop density, obstacles, and pesticide dispersion patterns, to enable the testing and improvement of flight paths. Realistic simulations aid in the improvement of navigation techniques, UAV performance evaluation, and effect assessment of various scenarios on crop monitoring and management.

This environment facilitates accurate and efficient aerial operations, increasing agricultural yield and sustainability through informed decision-making. number of error correction modules varies based on the size of the multiplier and the number of columns approximated.

IV. APPLICATIONS

The computer system for identification, classification, and flight planning has been elaborated using the suggested manner. The route planning method can be used to schedule the launch of a drone, its flight around a field of crops, and its return to a vehicle cruising the field or passing close to it. In practical settings, this system has been utilised to create the best flying path for UAVs in two different scenarios (flybys). In the first flypast, a drone with an RGB camera is used to collect photos that can be used to solve identification and classification challenges. The second kind of flyby uses a multirotor drone equipped with a multispectral camera to capture multispectral photos that may be used to overlay the field map and assess the vegetation's health. The computer system's recommended itineraries served as the basis for both flybys. These flybys are less expensive than flybys that are conducted without earlier optimisation.

A vehicle may utilize techniques like grid-based coverage, where the field is divided into grids and the vehicle traverses each grid cell methodically. Alternatively, it might employ techniques like potential fields or artificial potential fields, where the vehicle moves towards predefined targets while avoiding obstacles based on attractive and repulsive forces.

In MATLAB Simulink, such path planning algorithms can be implemented using a combination of predefined functions, custom scripts, and Simulink blocks designed for robotics and automation. These tools enable the vehicle to autonomously navigate the field, effectively covering the entire area while executing designated tasks with precision and efficiency.

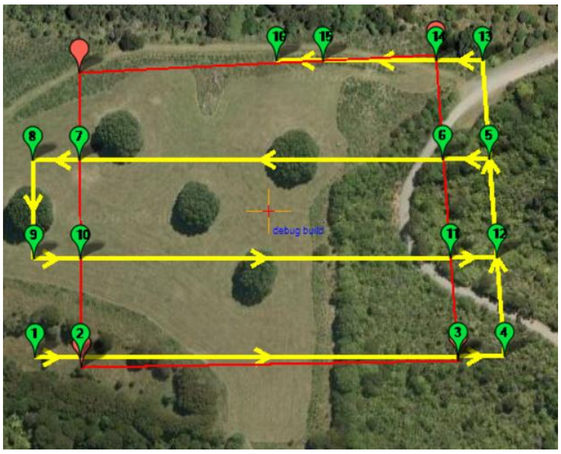

Fig 7: Path planning agriculture field

V. RESULT AND DISCUSSION

Using an agricultural drone system for modern farming techniques has many benefits. Drones with specialist sensors and imaging technology can provide farmers with valuable information on obstacle detection, path planning and navigation. By lowering the need for equipment and manual effort, drone use also helps farmers save time and labour expenses.

When all is said and done, the application of drone technology in agriculture represents a significant advancement in farming practices, offering There are many benefits to using an agricultural drone system for contemporary farming methods. Farmers can receive important information about crop health, soil conditions, and insect infestations via drones equipped with specialised sensors and imaging equipment.

Drone use also helps farmers save time and labour costs by reducing the demand for equipment and manual labour. The MATLAB simulation's conclusions regarding UAV route planning in agricultural environments were instructive. In the MATLAB simulation for UAV path planning in agricultural fields, both the exhaustive solver algorithm and the minimum traversal technique are utilised to optimise routes for unmanned aerial vehicles (UAVs) traversing huge agricultural areas.

The simulation also enabled efficient crop health monitoring since UAV trajectories covered significant interest zones and provided analysable high-resolution sensor data. Trajectories were visualised and overlayed onto agricultural field plans to enhance understanding and expedite the decision-making process.

The MATLAB simulation yielded informative results about UAV path planning in agricultural settings. Both the exhaustive solver algorithm and the minimum traversal technique are used in the MATLAB simulation for UAV path planning in agricultural fields to optimise routes for UAVs flying over vast agricultural areas.

Since the UAV trajectories spanned substantial interest zones and offered analysable high-resolution sensor data, the simulation also made efficient crop health monitoring possible. To improve understanding and speed up the decision-making process, trajectories were visualised and superimposed onto agricultural field layouts.

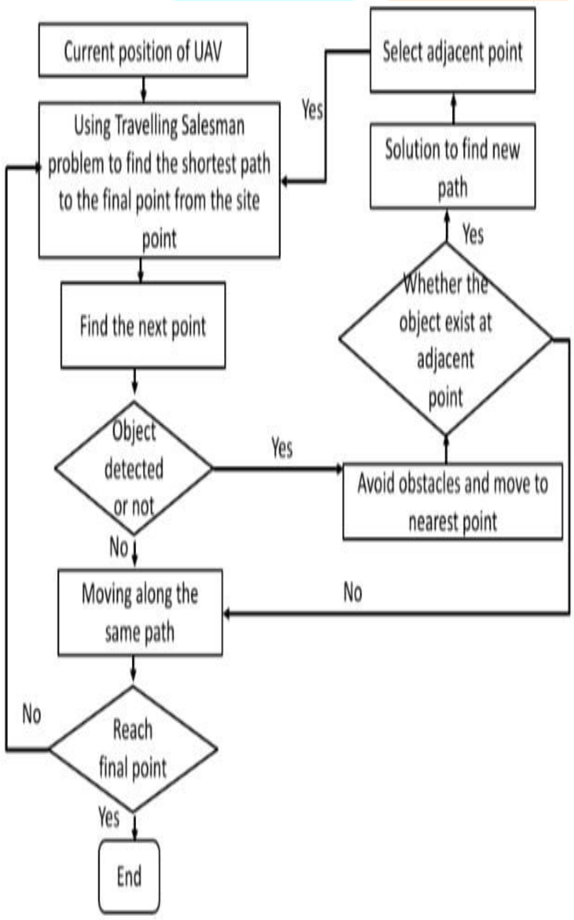

Fig 8: The shortest taxiing path of the aircraft

VI. CONCLUSION

Drones for agriculture offer various benefits over modern farming practices, including crop monitoring, path optimisation, and obstacle avoidance. Setting up an effective agricultural drone system requires selecting the right drone platform, attaching sensors for data collection, establishing communication and control systems, and installing data processing tools for insightful analysis.

Drones can be used by farmers to carry out targeted interventions that will increase agricultural output, limit environmental effect, and optimise resource allocation.

UAV route planning is a crucial part of mission fulfilment across a range of applications, including mapping, search and rescue, surveillance, and monitoring. Using any of MATLAB's exhaustive or minimum traversal solver approaches yields significant benefits. These techniques offer the best or most economical paths while considering constraints like mission objectives, and obstacles. The flexibility, customisable possibilities, and rich toolkit of MATLAB provide thorough validation, efficient execution, and easy display of anticipated trajectories, all of which further enhance the planning process.

By using MATLAB's features, stakeholders can ensure the stability, security, and scalability of UAV navigation solutions. The solid platform of MATLAB combined with ongoing research and innovation in UAV route planning techniques will be crucial in enabling the seamless integration of new technologies as issues arise.

VII. REFERENCES

[1].Shin'ichiro Kako i , Tomoya Kataoka j , Gil Gonçalves Drones for litter monitoring on coasts and rivers: suitable flight altitude and image resolution ,oct 2023, 195:115521.

[2]. RAVIL I. MUKHAMEDIEV, KIRILL YAKUNIN ,Coverage Path Planning Optimization of Heterogeneous UAVs Group for Precision Agriculture, VOLUME 11, 2023.

[3]. Giovanni Campuzano , Eduardo Lalla-Ruiz, “The drone-assisted variable speed asymmetric traveling salesman problem”, vol 176 ,(2023)

[4]. Juan P. Vasconez , “Comparison of path planning methods for robot navigation in simulated agricultural environments”, vol 220 (2023)

[5]. Shengmin Zhao, “Complete coverage path planning scheme for autonomous navigation ROS-based robots “, vol 1, (2023)

[6] Seno Darmawan Panjaitan, Yohana Sutiknyawati Kusuma Dewi, “A Drone Technology Implementation Approach to Conventional Agriculture Fields ”, vol. 10, 2022

[7]. Sara Cavani , Manuel Iori, “Exact methods for the traveling salesman problem with multiple drones”, vol 130 , (2021)

[8]. Amalia Utamima*, Arif Djunaidy , “Agricultural routing planning: A narrative review of literature”, vol 197,(2021)

[9]. GEOVANNI FLORES-CABALLERO, “Optimized Path-Planning in Continuous Spaces for Unmanned Aerial Vehicles Using Meta-Heuristics”, vol 8, (2020)

[10] Kshitij Srivastava, Prem Chandra Pandey, “An Approach for Route Optimization in Applications of Precision Agriculture Using UAVs”, vol . 9, 2020

[11] Jeongeun Kim, Seungwon Kim, “Unmanned Aerial Vehicles in Agriculture: A Review of Perspective of Platform, Control, and Applications” vol. 7, 2019

[12]. UM Rao Mogili and B B V L Deepak , “Review on Application of Drone Systems in Precision Agriculture”, vol 133, (2018)