International Journal of Emerging Technologies and Engineering (IJETE)
Volume 1 Issue 5, June 2014, ISSN 2348 – 8050

OPTIMIZED UAV FLIGHT MISSION PLANNING USING STK & A* ALGORITHM

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Abstract—This paper titled "Optimized Flight Mission Planning Using STK & A* Algorithm" presents an application that allows maps, charts, weather, intelligence and aircraft performance data to be used in developing navigation solutions (e.g. routes, approaches, terminal procedures), communication settings, flight/mission calculations (fuel, leg times, etc), and other pertinent aircraft operational data. This applicationincludes visual software tools optimizedfor specific aircraft roles, and automate the computations associated withaircraft specific flight/mission planning. The main aim during a mission planning is to plan an optimized route for the UAV to avoid detection by enemy radars. The UAV route planned must cover maximum area over a desired area of interest. STK (Systems Tool Kit) and A* algorithm is used optimize the mission route.

I. INTRODUCTION

A mission is a sequence of procedures that utilize aircraft performance models to define the vehicle's route and flight characteristics. The mission can be organized into phases, which are logical constructs that allows the user to vary the performance models being used to suit different elements of the mission.

STK (Systems Tool Kit) is software developed by AGI (Analytical Graphics Inc.) that offers a physics-based software geometry engine that accurately displays and analyzes dynamic objects in real or simulated time. STK models moving objects and the dynamic relationships of those objects in space. It also considers complex constraints such as terrain, sensor fields of view, angle restrictions and even weather. It supports advanced analysis as well as 2D and 3D visualization.

A* algorithm is used for path finding and graph traversal which is the process of plotting an efficiently traversable path between points (nodes). A* is a faster version of Dijkstra's algorithm, for finding shortest paths in the graph. A* algorithm combines the features of uniform cost search and pure heuristic search to efficiently compute optimal solutions. A* algorithm guides an optimal path to a goal if the heuristic function is admissible, which means that it never over estimates actual cost.This application interfaces A* algorithm with STK and displays the output on the 3D-globe and 2D-globe.

II. LITERATURE SURVEY

The path planning problem is still an active area of research, it entails finding collision-free paths for one or multiple UAVs from their current position to their goals and avoid detection by enemy radars in a dynamic environment. The mission planning algorithm must incorporate UAV performance model to ensure optimized mission route.

In UAV mission planning there is generally a significant amount of uncertainty in what is known about the environment. For example, targets and obstacles may be moving and/or their exact position may be unknown.Real-time planning considerations generally imply that an algorithm must be able to compute a solution fast enough to avoid collisions while generating a plan that is long enough to account for the overall mission performance.

III. APPLICATION DEVELOPMENT

A. Systems Tool Kit's Environment

STK consists of 3-D globe and 2-D map for visualizing the mission environment. Figure 1 and 2 shows the 3-D globe and 2-D map having enemy facilities with radars.

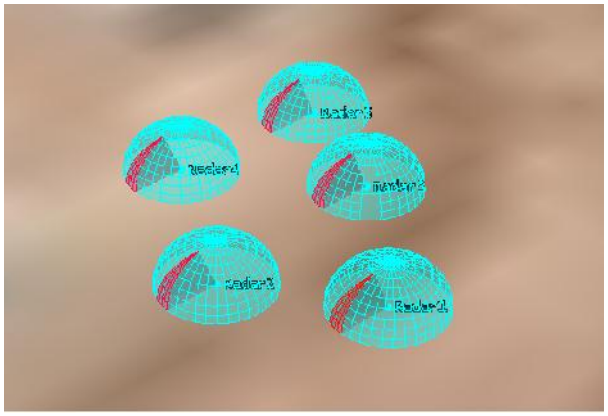

Figure 1:3-D View of Enemy Facilities with Radars

The blue colored domes represent radars with its beam shown in red color.

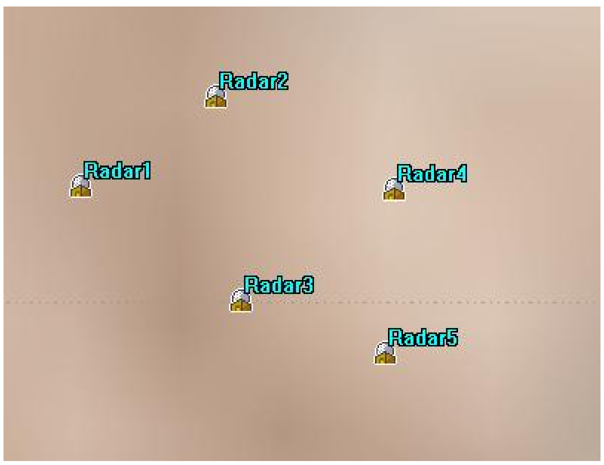

Figure 2: 2-D View of Enemy Facilities with Radars

B. Aircraft Mission Modeler (AMM)

Aircraft Mission Modeler, a module of STK provides an enhanced method for modeling aircraft – more accurate and more flexible. With AMM, the aircraft's route is modeled by a sequence of curves parameterized by well-known performance characteristics of aircraft, including cruise airspeed, climb rate, roll rate, and bank angle. The precise state of an aircraft at any given time can be computed analytically - swiftly and without excessive data storage needs.

An aircraft using AMM is defined by the type of aircraft and by the mission it performs. This structure allows the user to utilize an aircraft for much more than simple linear travel. You can select the aircraft from a number of pre-defined and user-defined aircraft types. Each aircraft type can be customized by changing the built-in performance model settings of the aircraft, the 3D model used to represent the aircraft, and by adding, changing, and removing custom performance models. Various procedures, such as takeoff, enroute, holding procedure and landing are available using which selected aircraft can be maneuvered.

C. A Algorithm*

The geodetic locations of enemy facilities from STK are exported to A* algorithm. The desired geodetic location of UAV's start point and stop point are fed to A* algorithm to calculate the optimal route for the UAV that can cover maximum area. Figure 3 shows the A* algorithm application window with green colored boundaries representing radar boundaries. The dark green node represents the UAV's start point and the red node represents the UAV's stop point.

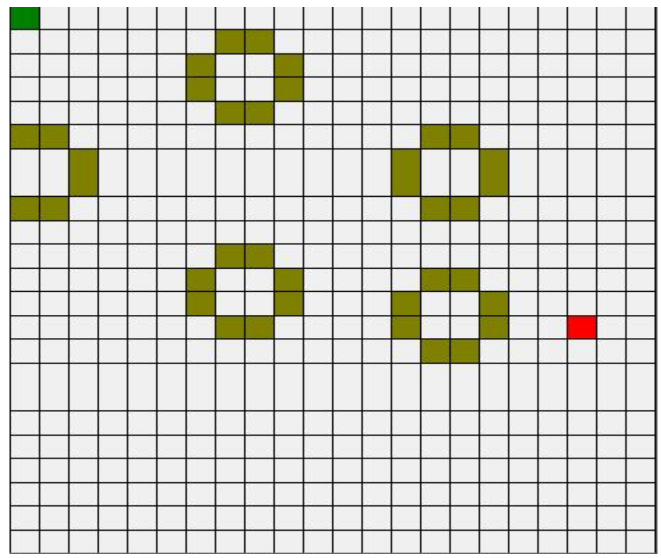

Figure 3: Radar Boundaries and UAV Stat-Stop Point in A* Application Window

The optimized route computed for the UAV is shown below.

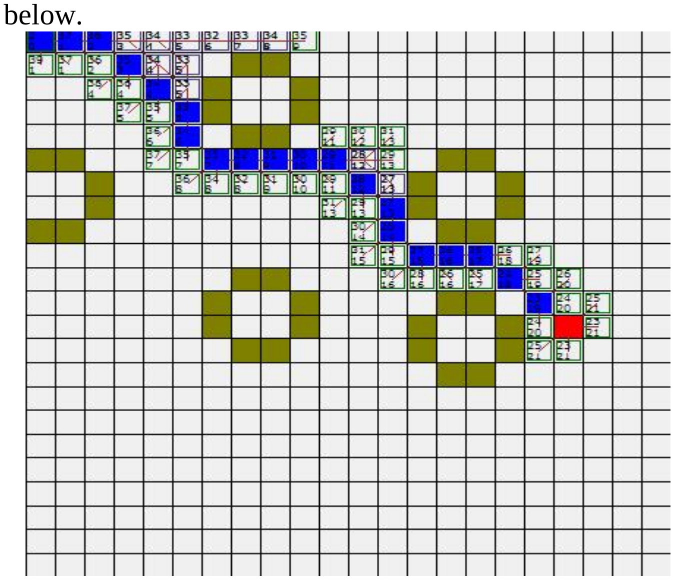

Figure 4: Computed optimal route in A* Application Window

The computed optimal points are exported to STK to propagate the route considering the actual performance model of UAV using Aircraft Mission Modeler module of STK.

D. UAV Route Propagation on STK

Figure 5 shows the route for UAV propagated considering the actual performance module using AMM module of STK.

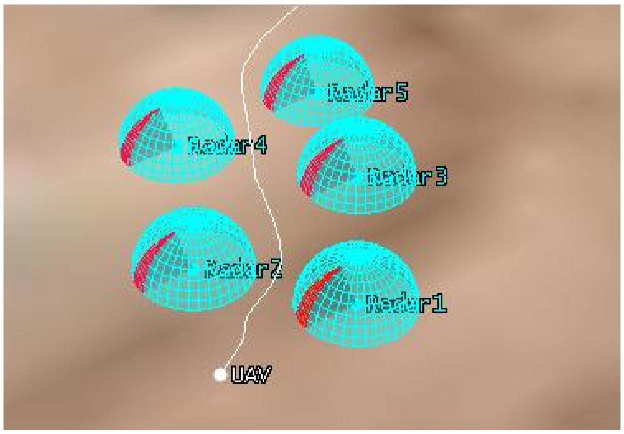

Figure 5: Propagated Route for UAV on STK using the Optimal Points Computed by A* Algorithm

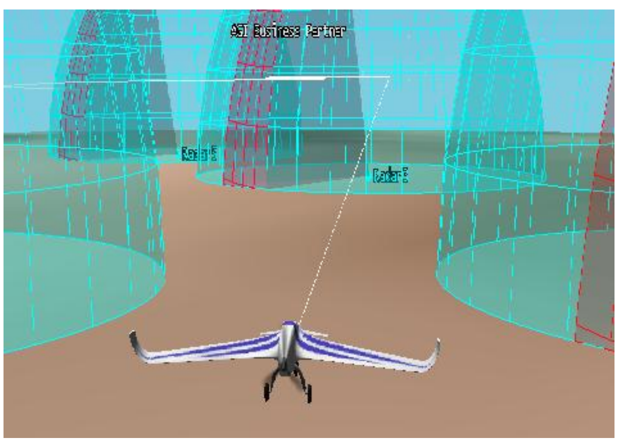

Figure 6: Close-Up View of Propagated UAV Route on STK

IV. CONCLUSION

UAVs will continue to have an important role in current and future military and civilian operations. As multiple UAVs are organized intoswarms, new challenges need to be addressed and new command and control techniques be developed to effectively manage the swarms. To facilitate efficient mission planning for UAV, this paper proposed a centralized-distributed hybrid framework. A central controller assigns ready tasks in the mission to UAVs that have the minimum estimated costs. The UAVs then locally schedule those tasks into their task queues based on different policies. As a proof-of concept, a multithread simulation framework is implemented in STK.

V. FUTURE DEVELOPMENT

- Incorporate more realistic aspects of UAV flight into the framework, such as collision avoidance and variable speed.
- Add more scenarios from real world swarm operations into the framework, such as communication lost between a UAV and the central controller, and task failure on UAVs.
- Find re-routing problem for the UAV which takes the aircraft around the area of interest.

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