

UAV Airspace Management System *UAMS**

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1. UAV COLLISION AVOIDANCE

As technology advances, unmanned aerial vehicles (UAVs) are capable of more complex missions. Miniaturization results in a migration of capability from larger to smaller UAV platforms and in cost reduction. According to the DoDs Unmanned Aircraft Systems Roadmap 2005-2030, military UAVs are now required to execute intelligence, surveillance, reconnaissance, strike, suppression of enemy air defense, electronic attack, communications, aerial delivery, and resupply missions. It is therefore evident that UAV developments require a more intelligent and autonomous airspace and mission management approach than ever.

The modern battlespace may be crowded with urban buildings, manned and unmanned aircraft, restricted operational zones, and direct and indirect fire. For UAVs to avoid colliding in such a crowded environment is challenging. We suggest an intelligent way to detect potential collisions and find alternative routes. Our suggested solution is based on centralized and distributed coordination approaches. The autonomous airspace management system will choose, in real time, the suitable solution that will assure collision avoidance.

The airspace management system will consider the following approaches:

1. Centralized, in which an airspace management center detects possible collisions and applies alternative routes for them

2. UAV deconfliction, in which the airspace management center detects potential collisions but allows the UAVs to find alternatives
3. UAV detection, in which the airspace management center informs each UAV of its neighbors, thus allowing the UAV to detect and adjust its own flight plan
4. Distributed, in which the airspace management center is completely incommunicable, and the UAV must become aware of its neighbors, detecting and deconflicting prospective collisions
5. Isolated, in which there is no communication between the airspace management center and the UAVs or between UAVs

2. SYSTEM APPROACH AND PATH PLANNING

Our UAV path planning is defined by complex Bezier curves that express the physical constraints of a UAV, such as maximum speed, minimum turning radius, velocity, and acceleration. Two points and two vectors representing the entrance and exiting speed of the UAV define a Bezier curve. In this demonstration, each UAV has its own mission defined as a tuple of destination (longitude, latitude, altitude), deadline, and utility. The utility is the dimension we sum across all the UAVs to estimate the overall success. A mission is achieved if the UAV reaches its destination before the deadline. There is no partial utility, because each mission is achieved or not achieved. At the beginning of the simulation, all UAVs have a valid path (not necessarily conflict free) that meets the deadline. The first step of the algorithm is to detect if there is a possible conflict in any UAV paths. We use an octree algorithm to quickly find all conflicts. A conflict is composed of a 4D point in space (longitude, latitude, altitude) and time and all UAV paths that intersect at this 4D point. The list of conflicts is then passed to a solver that finds new conflict-free paths. This process is obviously iterative, because choosing a different path may result in one or more conflicts.

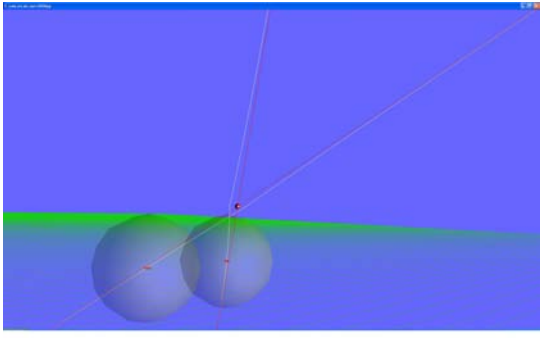
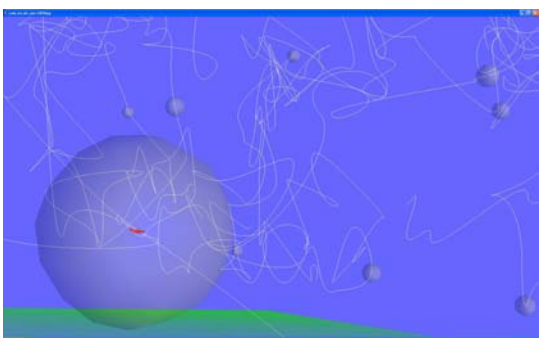
To add complexity, we have introduced a manned aircraft (controlled by a joystick connected to the system) that each UAV must avoid while maintaining the maximum number of deadlines and missions. The manned aircraft broadcasts only its position and heading, and all the UAVs must adapt their path to not collide with it. To handle the manned aircraft, each UAV considers a set of possible paths and checks all of them for possible conflicts.

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Our demonstration is composed of two laptops. One laptop runs the manned aircraft user interface with the joystick; the other laptop runs the simulation and our deconfliction algorithm. The accompanying screenshots illustrate the simulation and user interface

Table 1: default

	
Conflict detected and proposed path changes hline	Many paths, many conflicts. The sphere is the communication range.
	
Realistic simulation in downtown San Francisco	

3. ACKNOWLEDGMENTS

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