Dynamic path planning system for UAV remote sensing in urban environments

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Abstract

UAVs today are extensively used for remote sensing applications. Relying on IMU and GPS based sensors they can precisely navigate through obstacle free environments. Real-time obstacle avoidance is found to have low range and reliability due to complexity involved in proximity detection and visual positioning systems making them impractical to deploy. Hence, most modern UAV systems find it difficult to accurately fly through urban areas, especially metropolitan cities.

This paper introduces a path planning algorithm that uses open-source elevation data of objects in urban environments to detect and avoid obstacles in planned path by rerouting the UAV to an alternate path while making sure that all the desired waypoints are visited in the same order.

The proposed system successfully implements the path planning algorithm on an open-source UAV platform – QGroundControl. Flight simulations confirm the feasibility of the proposed system in an urban environment with multiple heterogenous obstacles.

Key words: UAV, Autonomy, Navigation, path-planning

1. Introduction

Remote sensing has been proven extremely useful in the past few decades, primitively carried out by reconnaissance aircraft and satellites over large areas for surveillance and weather applications. Due to the high availability and modularity of Unmanned Aerial Vehicles (UAVs) remote sensing can be carried out over small areas at low altitudes providing unprecedented resolution at a fraction of cost.
As UAVs fly at low altitudes, they are prone to collide with obstacles such as skyscrapers and buildings in urban environments making it nearly impossible to carry out missions in metropolitan cities. Active or real-time obstacle avoidance is still in its infancy due to expensive hardware and high computational cost and thus cannot be relied upon for large-scale missions.
The proposed system provides with a simple but efficient way of avoiding static obstacles if data is available.

2. Methodology

The algorithm uses geometry and properties of vectors to determine possible collisions.

Pre-processing

First the minimum flying altitude (MFA) for the UAV is decided. All the obstacles with height lower than MFA are discarded. Any obstacles with height greater than MFA are circumscribed in circles and the radii are noted.

Detecting collisions

Possible Collisions are detected by checking if the straight-line path between two consecutive waypoints intersects any of the above-mentioned circles.

Generating the intermediate waypoint

If an imminent collision is detected between waypoints P_1, and P_2 the point of collision is calculated using co-ordinate geometry. The entry point (P_1') of the collision is considered and the exit point (P_2') is discarded.

The vector P_1P_1' is then rotated by an angle such that the generated waypoint Pi clears the obstacle by some minimum distance (2 meters based on testing observations)

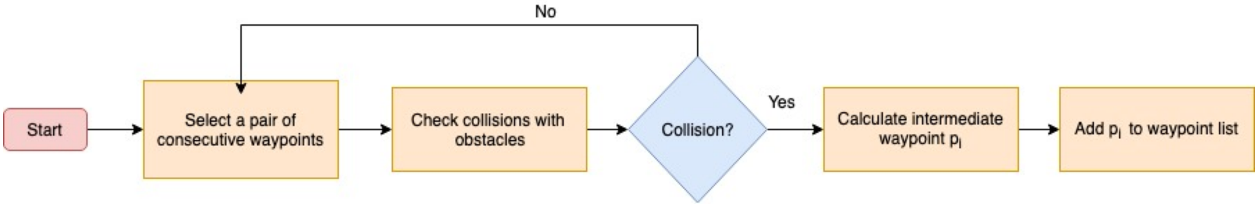

Figure 1 - Methodology Flowchart

3. Result

Various simulations and real-world tests show that the algorithm efficiently and reliably generated a new path provided the environment has a low to moderate clutter of obstacles.

For example, in the diagram given below, the planned path includes waypoint 1 and 18. An obstacle (orange circle) is present in the direct line of sight and hence the UAV cannot fly from waypoint 1 to waypoint 18. After applying the mentioned algorithm, intermediate waypoints (2 to 17) are generated. As the generated path is as close to the obstacle as possible it is safe to say that the algorithm reroutes the UAV efficiently.

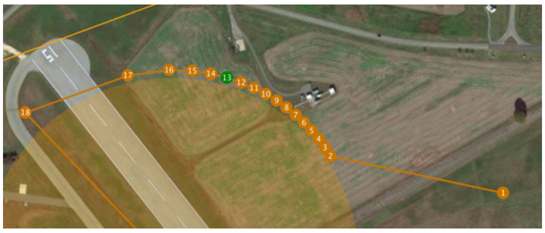

Figure 2 - Result

4. Conclusion

The problem of active or real-time obstacle avoidance faced by UAVs flying at low altitudes in urban environments is addressed in this paper. The algorithm proposed in this paper provides a simple yet efficient way of avoiding static obstacles if data is available. The path planning algorithm gives consistent results in an environment with low to moderate clutter of obstacles. The proposed system successfully implements the path planning algorithm on an open-source UAV platform – QGroundControl. Flight simulations confirm the feasibility of the proposed system in an urban environment with multiple heterogenous obstacles. Future work includes improving the system to work in an environment with high clutter of obstacles while being able to update the flight path in real-time to compensate for sudden changes in the environment.

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6. References

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