International Journal of Computer Applications (0975 – 8887)
Volume 119 – No.3, June 2015

Shortest Path Selection for UAVS using 3-D Coordinates with Collision Avoidance System

Shivani Dhiman
Dept. of IT
CGC Landran, Mohali

Mandeep Singh
Dept. of IT
CGC Landran, Mohali

ABSTRACT

UAV (Unmanned Aerial Vehicle) also known as Drones and classified as Autonomous Aircraft and Remotely Piloted Aircraft. An UAV is an aircraft without having a human piloted aboard. It is usually used for the military and special operation application but also used in growing number of applications. UAV referred for the mission that are too deadly, unclean or the risky one. There are different names for the aircraft like UAS (Unpiloted Air System), UAV (Unpiloted Aerial Vehicle), RPAS (Remote Piloted Aircraft Systems) and model aircraft. In the existing solution there is a routing problem in UAV that has been addressed. The problem is referred to as the CCURP i.e. communication constrained UAV Routing Problem. To solve the CCURP problem, the shortest paths between targets are computed by mean of a graph transformation system. The major problem with the existing system is that, it is not capable to calculate the shortest path between the two points. Also, it is does not evaluate the points of collision and the existing solution is not compatible with the 3-D position of the UAVs. The existing routing algorithm and collision avoidance method does not evaluate the 3-D positions of the UAVs. The proposed algorithm will calculate the shortest path and helps to evaluate the 3-D position of the UAV. The point of collision will be clearly defined and avoided. The parameter used while observations are Delay, Accuracy, Probability of failures, and Throughput.

General Terms: Shortest Path Algorithm, Routing.

Keywords: UAV routing, UAV collision avoidance, Fuel-based routing, 3-D path evaluation, Graph-based routing.

1. INTRODUCTION

An UAV the unmanned aerial vehicle, which is commonly known as a drone and it also referred to as an unpiloted aerial vehicle and a remotely piloted aircraft (RPA) launched by the International Civil Aviation Organization (ICAO), it is an aircraft without a human pilot. ICAO classifies unmanned aircraft into two types under Circular 328 AN/190:

- <u>Autonomous aircraft</u> – it is currently considered as an unsuitable for the regulation due to the legal and the liability issues;
- <u>Remotely piloted aircraft</u> – it is subject to the civil regulation under the ICAO and under the relevant national aviation authority.

There are many different names for all these aircraft. The first one is UAS (Unpiloted Air System), second is UAV (Unpiloted Aerial vehicle), third RPAS (Remote Piloted Aircraft Systems) and the model aircraft. It has also become very popular when it is called as drones. The flight is controlled either autonomously by computers or by the remote control of a pilot on the ground or in another vehicle. The typical launch method and recovery method of an unmanned aircraft is the function of an automatic system or an external operator on the ground base.

Historically, the UAVs are simple remotely piloted aircraft, but the autonomous control is increasingly to being employed. One of the best known aircraft and widely used types was the Nazi-German V-1 that flew autonomously i.e. powered by a pulse jet. Its next version was the Nazi-German V-2 and it is also autonomous but powered by a rocket and it is partly functioning as ballistically.

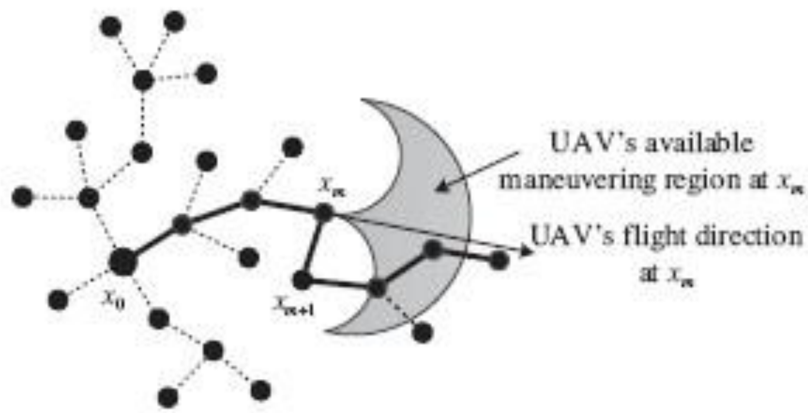

Figure 1: The UAV routing and direction selection. The above figure signifies the possible connected points to form the path of flight. The path of flight is signifies the prominent points in the super bold and other points in bold normal. The dotted lines signify the possible path options, whereas the bold line indicates the selected path of the flight by UAV

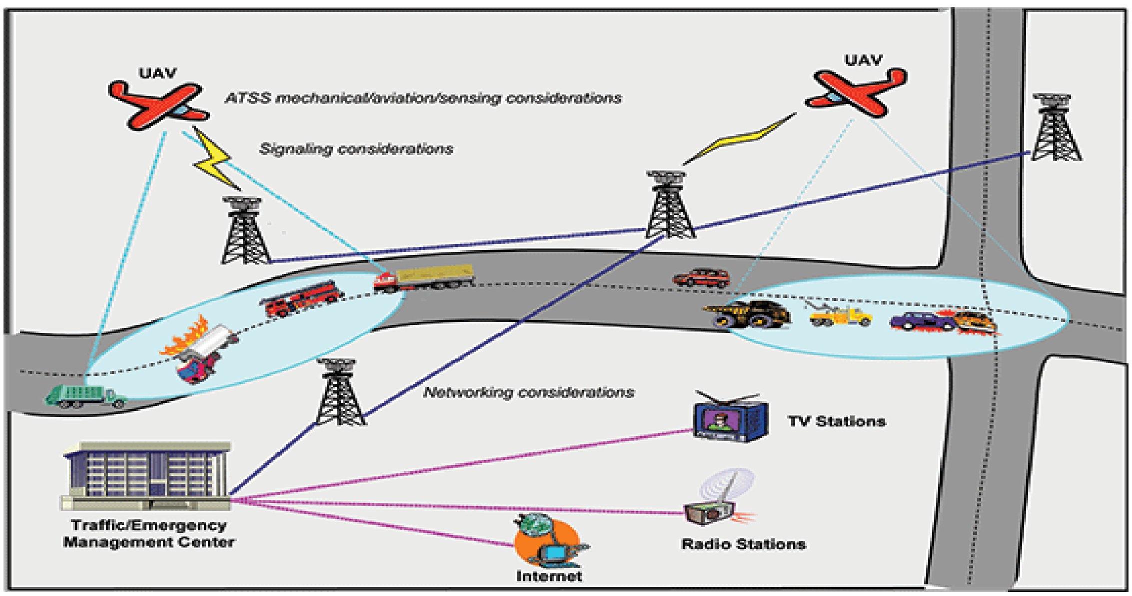

Figure 2: The UAV surveillance application and communications with the base stations. The above figure shows the applications of drones (unmanned aerial vehicles) in the urban surveillance.

Unmanned aerial vehicles (UAVs) are actively used for military operations and considered for civilian applications such as environmental monitoring. Technological advances in this area have been impressive, and it seems now that a major challenge for future developments will be to increase the degree of automation of these systems. For this we need a solution with an acceptable level of the performance to difficult the optimization problems, such as the variants of the weapon-target assignment problem. Often, the problems solved are the static combinatorial optimization problems which resulting in an open loop policies. Yet, for the more applications of UAVs, which involving the surveillance and the monitoring, it would like to factor into the decision making process the (stochastic) evolution of the environment, which results in even the harder stochastic control problems.

Path planning for small Unmanned Aerial Vehicles (UAVs) is one of the research areas that have received significant attention in the last decade. Small UAVs have already been field tested in civilian applications such as wild-fire management, weather and hurricane monitoring, and pollutant estimation where the vehicles are used to collect relevant sensor information and transmit the information to the ground (control) stations for further processing. Compared to large UAVs, small UAVs are relatively easier to operate and are significantly cheaper. Small UAVs can fly at low altitudes and can avoid obstacles or threats at low altitudes more easily. Even in military applications, small vehicles are used frequently for intelligence gathering and damage assessment as they are easier to fly and can be hand launched by an individual without any reliance on a runway or a specific type of terrain.

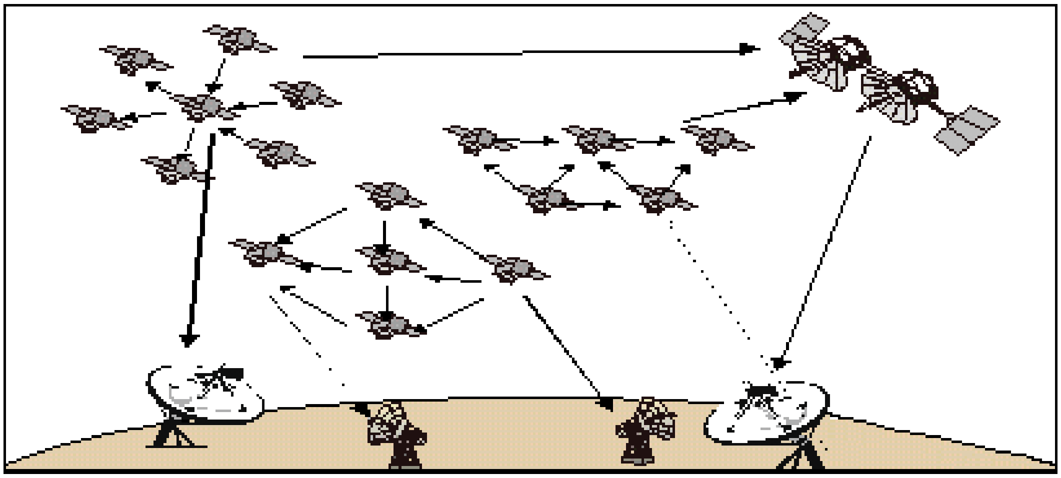

Figure 3: The UAV communication with satellites and base stations on earth. The above figure signifies the internetworking of the UAV via satellites deployed in the space orbit and earth.

Even though there are several advantages with using small platforms, they also come with other resource constraints because of their size and the limited payload. Hence the small UAVs typically have a fuel constraint, so that it may not be possible for an UAV to complete the surveillance mission before the refueling the vehicles at once from the depots. For example, let consider a typical surveillance mission where a vehicle starts from the depot and it is required to visit a set of all the targets by the vehicle. To complete the mission, the vehicle may have to start from the depot, and visit a subset of the targets and then reach to the one of the depots for the refueling before starting from a new path. One can reasonably assume that once the UAV reaches a depot, it will be refueled to full the capacity before it leaves again for visiting the remaining targets. If the goal is to visit each of the given targets at least once, then the UAV may have to visit some depots repeatedly in order to again refuel before visiting all the targets.

2. DRAWBACKS IN EXISTING SYSTEM

- Existing solution is not capable of direct path selection between two points for the purpose of efficient UAV routing.
- Existing solution is also not capable of providing any collision prediction mechanism based on the movement analysis of the UAV nodes.
- The existing solution does not evaluate the path selection for the multiple UAV objects flying together in a UAV cluster.

3. PROBLEM FORMULATION

In the existing solution, the routing problem in unmanned aerial vehicles (UAVs) has been addressed to facilitate the cooperation of two UAV automatically in order to provide the smooth movement in the uninterrupted and non-collision manner. The GPS has been used to get the position of the UAVs through an UGS (unattended ground sensors). The UGS stations are liable to maintain the two UAV at safe distance and in the correct direction through its routing mechanism. This problem is referred to as the Communication Constrained UAV Routing Problem (CCURP).

To solve the CCURP, shortest paths between targets are computed by means of a graph transformation to compute the shortest paths between targets. The system is comprised of approximation algorithm and the travelling salesman problem (TSP) algorithm. The major problem of the existing system is that it is not capable of calculating the shortest direct path between the two points. This means the UAVs are taking the longer paths due the falsified or non-detailed path selection by the existing solution. Also the existing solution does not evaluate the points of collision to perform the UAV path optimization. The existing solution is not compatible with the 3-D position of the UAVs.

4. PROPOSED SYSTEM

The existing algorithm approximates the path but the path direction is according to the line of path connecting the grid points in the graph grid for path selection. The existing routing algorithm and collision avoidance method does not evaluate the 3-D positioning of the UAVs. The proposed algorithm will calculate the shortest UAV path, which will direct the UAV to fly from one point to other point as straight as maximum possible. Also the routing algorithm will evaluate the 3-D position of the UAVs, which will allow them to overpass the UAVs without being confused with the points of collision. The points of collision will be clearly defined and avoided in the proposed model.

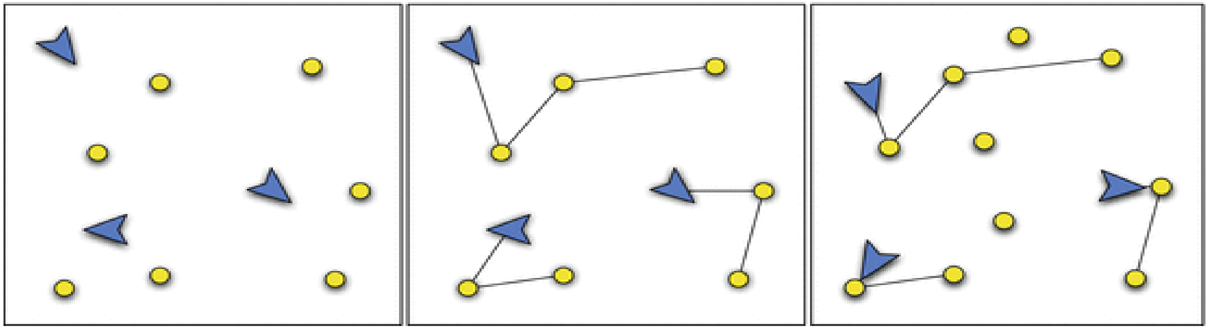

Figure 4: The UAV Routing steps, where the UAVs are looking for path options, selected the path and following the path respectively in the above images.

5. SCOPE OF THE STUDY

The continuous research is leading us towards the era of unmanned aerial vehicles (UAVs). Some of the unmanned aerial vehicle systems have been deployed in the controlled environments like the weather monitoring, military operations etc. The UAV network must establish a mechanism for the uninterrupted movement and collision avoidance. The proposed mechanism will add up all of the nodes in the UAV cluster, and grab the information and will evaluate the various properties of their movement in order to protect them against the collisions, fuel-out situations and other similar threats. A number of researches are based upon all these, out of which a few are working at the core issues. This research also addressed the core issues of the UAV path selection, collision avoidance and fuel-based routing. There are many UAV routing and collision avoidance mechanisms available, but none of them is enough intelligent and foolproof solution. This research is based upon the development of the robust and powerful collision prediction and avoidance mechanism for the UAVs.

6. METHODOLOGY

This research will begin with literature survey of existing UAV routing schemes. In the literature study, we will study the existing UAV routing algorithms for various Defense operations and mechanisms against the collision avoidance based UAV path management applications. Literature study will lead towards the implementation of all of the above mentioned solution which will be further implemented in NS2. It also becomes quite important to conduct a detailed literature review about the performance analyzing parameters. The Simulation will be done in NS2. A thorough performance and feature testing model would be formed and utilized to analyze the performance of the new UAV routing scheme in the unmanned aerial vehicles based network.

7. CONCLUSION

The unmanned aerial vehicles are the aerial vehicle used for the various real-time applications like military applications, weather application, aerial imagery application and various other applications. The unmanned aerial vehicles calculate their routes automatically using the routing algorithm. The major points to keep in the mind while routing for the UAVs is their remaining fuel and targets. The route towards the target should be the shortest and the safest one and must be within the flight limit according to the remaining fuel. This means the routing solutions must select the shortest path, while keep the fuel under track, and must watch the possibilities of collision and provide such mechanism to avoid the collision. The existing algorithm is not capable of electing the shortest path and collision avoidance. The proposed model will be designed to fill the gaps of the existing solution. The proposed model make it feasible to select the shortest path and avoid the collision he multiple UAVs sharing the aerial space.

8. FUTURE WORK

We have already implemented the vehicle ad-hoc network where we have worked with the movement hazards and the collision avoidance using the general position based alerts in the active state. The proposed is the advancement of the previously done work, where we will work upon the path of flight selection using the graph and shortest path theory. The proposed model will be implemented and verified using the NS-2 simulator. Afterwards the gaps in the proposed model will be found and fixed.

9. REFERENCES

[1] Collins, Gaemus E., James R. Riehl, and Philip S. Vegdahl. *"A UAV routing and sensor control optimization algorithm for target search". In Defense and Security Symposium, pp. 65610D-65610D. International Society for Optics and Photonics, 2007.*

[2] C. E. Corrigan *et al.*, "Capturing vertical profiles of aerosols and black carbon over the Indian Ocean using autonomous unmanned aerial vehicles, "*Atmospheric Chem. Phys.*, vol. 8, no. 3, pp. 737–747, 2008.

[3] E.W. Frew and T. X. Brown, "Networking issues for small unmanned aircraft systems," *Unmanned Aircraft Syst.*, pp. 21–37, 2009.

[4] G. L. Feithans, A. J. Rowe, J. E. Davis, M. Holland, and L. Berger, "Vigilant spirit control station (VSCS)-The face of counter," in *Proc. AIAA Guidance, Navigation and Control Conference and Exhibition*, Honolulu, HI, USA, Aug. 2008, AIAA Paper Number 2008.

[5] Hernandez-Hernandez, Lucia, Antonios Tsourdos, Hyo-Sang Shin, and Antony Waldock. "Multi-Objective UAV routing."*In Unmanned Aircraft Systems (ICUAS), 2014 International Conference on, pp. 534-542. IEEE, 2014.*

[6] J. O. Royset, W.M. Carlyle, and R. K.Wood, "Routing military aircraft with a constrained shortest-path algorithm," *Military Operation. Res.*, vol.14, no. 3, pp. 31–52, 2009.

[7] Klein, Daniel J., Johann Schweikl, Jason T. Isaacs, and Joao P. Hespanha. *"On UAV routing protocols for sparse sensor data exfiltration". In American Control Conference (ACC), 2010, pp. 6494-6500. IEEE, 2010.*

[8] Karman, S., and E. Frazzoli. *"Linear temporal logic vehicle routing with applications to multi-UAV mission planning". International Journal of Robust and Nonlinear Control 21, no. 12 (2011): 1372-1395.*

[9] Manyam, Satyanarayana G., Sivakumar Rathinam, Swaroop Darbha, David Casbeer, and Phil Chandler. *"Routing of two Unmanned Aerial Vehicles with communication constraints."* In *Unmanned Aircraft Systems (ICUAS), 2014 International Conference on, pp. 140-148. IEEE, 2014.*

[10] Ny, Jerome Le, Munther Dahleh, and Eric Feron. *"Multi-UAV dynamic routing with partial observations using restless bandit allocation indices." In American Control Conference, 2008, pp. 4220-4225. IEEE, 2008.*

[11] P. B. Sujit and D. Ghose, "Two-agent cooperative search using game models with endurance-time constraints," *Eng. Opt.*, vol. 42, no. 7, pp. 617–639, 2010.

[12] P. Oberlin, S. Rathinam, and S. Darbha, "Today's traveling salesman problem," *IEEE Roboti. Autom. Mag.* vol. 17, no. 4, pp. 70–77, Dec. 2010.

[13] Quintero, Steven AP, Francesco Papi, Daniel J. Klein, Luigi Chisci, and João Pedro Hespanha. *"Optimal UAV coordination for target tracking using dynamic programming". In Decision and Control (CDC), 2010 49th IEEE Conference on, pp. 4541-4546. IEEE, 2010.*

[14] S. Yadlapalli, W. Malik, S. Darbha, and M. Pachter, "A Lagrangian-based algorithm for a multiple depot, multiple traveling salesmen problem," *Nonlinear Anal.: Real World Appl.*, vol. 10, no. 4, pp. 1990–1999, 2009.

[15] Sundar. Kaarthik, and Sivakumar Rathinam. *"Algorithms for routing an unmanned aerial vehicle in the presence of refueling depots." (2014).*