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Conference Paper · January 2020

Nafis Ahmed
Inha University

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저자 (Authors)	Nafis Ahmed, Umair Ahmad Mughal, KyungHi Chang
출처 (Source)	한국통신학회 학술대회논문집 , 2020.2, 434-435(2 pages) Proceedings of Symposium of the Korean Institute of communications and Information Sciences , 2020.2, 434-435(2 pages)
발행처 (Publisher)	한국통신학회 Korea Institute Of Communication Sciences
URL	http://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE09346361
APA Style	Nafis Ahmed, Umair Ahmad Mughal, KyungHi Chang (2020). 3D Path Planning of Unmanned Aerial Vehicles. 한국통신학회 학술대회논문집, 434-435
이용정보 (Accessed)	인하대학교 165.246.45.*** 2021/04/15 09:51 (KST)

3D Path Planning of Unmanned Aerial Vehicles

Nafis Ahmed, Umair Ahmad Mughal, and KyungHi Chang*
Dept. of Electronic Engineering, Inha University
Incheon, South Korea
22191560@inha.edu, umairm9552@gmail.com, and khchang@inha.ac.kr*

***Abstract*— Unmanned Aerial Vehicle (UAV) has been considered as one of the most emerging technology in both military and civilian for various purposes. UAVs have been employed in several application domains for various purposes, such as surveying and mapping, inspection and monitoring, civil security, disaster management, aerial imaging, smart farming and wildfire tracking. For this reason, a UAV path planning technique for dynamic environment is indispensable to get the outmost performance of UAV. This paper aims to explore and analyze the existing studies in the literature related to the various approaches employed in UAV path planning.**

Keywords*—*Unmanned Aerial Vehicles(UAV), PSO, ACO, SLAM, D* Algorithm.

I. Introduction

Unmanned Aerial Vehicles (UAVs), namely drones, have become promisingly important in both military and civilian applications in recent years, such as remote sensing, senor data collection, UAV-Enabled data collection. This can be also used for monitoring and provide security to estates [1]. However, path planning is the basic and crucial part of these autonomous flights. It should reflect various factor including dynamic target point, obstacles avoidance both in static and dynamic manner and shortest path setting. Some of the proposed path planning in three dimension are based on improved particle swarm optimization (PSO), ant colony optimization (ACO), Simultaneous Localization and Mapping (SLAM) and D* algorithm. As the hardware performance of UAV is limited, complex operations must be reduced and optimized in order to operate the path setting module in real time under limited hardware performance.

II. UAV Path Planning

Path planning plays an indispensable role for the autonomous flight system for unmanned aerial vehicles (UAVs). It refers to the optimal path planning problem of Unmanned Aircrafts. It can be formulated as an optimization problem which finds the feasible path from the source point to the destination point (Fig-1). And the optimal trajectory is usually associated with the path that maximize (or minimize) the certain optimization index (e.g., energy consumption, path length etc.) of certain mission. For this, we are going to give a short description of all the techniques mentioned above.

A. Particle Swarm Optimization

Particle Swarm Optimization (PSO) is an optimization technique, which provides an evolutionary based search. The term PSO refers to a relatively new family of algorithms that may be used to find optimal or near to optimal solutions to numerical and qualitative problems. It is a computational technique which optimizes a problem by iteratively trying to improve a candidate solution. It is inspired by group behaviors in wildlife, for example, bird flocks, honeybees, ant colonies, and fish schooling.

*Address correspondence to Prof. KyungHi Chang

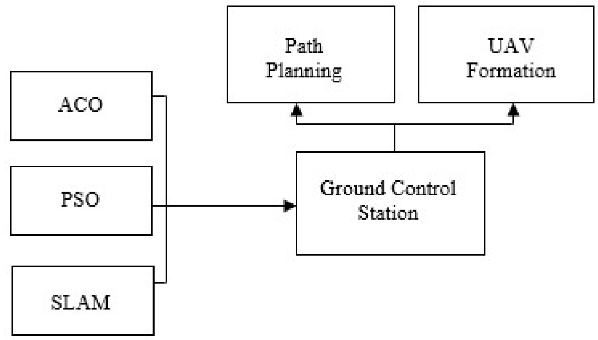

Fig.1. UAV path planning.

It has benefits, like the advantages of fast convergence speed, simple parameter settings, and easy implementation, for which the PSO algorithm has been widely used in various fields. Among them, functions optimization, neutral networks training, and fuzzy logic system control are notable. But it has some limitations too, like premature convergence, route self-crossing. The authors in [2] suggest that this problem can be solved by using the following techniques, (1) Iteratively adjust important parameters like, acceleration coefficients and inertia weight, with the aim of reducing effective path length and enhancing the robustness; (2) Premature convergence can be avoided by maintaining the strategy of random grouping inversion, that includes swarm diversity and global convergence, in order to retain precision solution. Additionally, authors also included that performance and robustness can be improved by introducing three techniques namely, linearly descending inertia weight, adaptively controlled acceleration coefficients and random grouping inversion.

B. Ant Colony Optimization

The ant colony optimization algorithm is a probabilistic technique, which is used for solving computational problems. It helps by reducing path length to find good paths through graphs. Artificial ants which stand for multi-agent methods are inspired by the behavior of real ants.

This optimization technique is suitable for path planning problem because it is a discrete optimization problem. In this technique, firstly, the UAV flying area is horizontally divided into grids according to certain interval. Ground threats are mapped into flying area. Its starting point is the origin of Cartesian coordinate system. Secondly, the yaw angle is considered to be constraint and UAV is not allowed to exceed the allowed maximum yaw angle. When the ant chooses the next path they consider the yaw angle to be constraint. Thirdly, paths visibility is calculated and it is assumed that the Radar constantly threatens on the path all the time. Thus the threat intensity is considered as the visibility for ant. Fourthly, path probability is calculated. Fifthly, ant searching task is evaluated by finding a complete path from its source to destination. Finally, path pheromone is updated. Path pheromone is updated based on evaluation function after finishing one searching task.

ACO can be used for UAV path planning as this algorithm divide the whole flying area into grids and optimizes path between grid point and destination point in order to get the shortest path. Another important thing is that ACO takes positive feedback mechanism, so its process with strong instructions to get good result. Here the authors [3] introduces threat intensity that's computational calculation is much smaller than the traditional ACO based path planning methods.

C. Simultaneous Localization and Mapping (SLAM)

SLAM is the process by which a mobile robot can build a map of an environment and at the same time use this map to compute its own location, i.e., learning the map and locating the robot simultaneously as mentioned in Fig. 2.

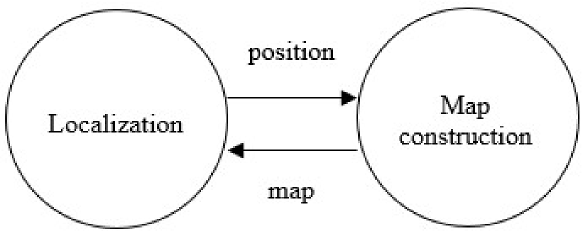

Fig.2. SLAM Modules.

Mobile robots can be used for various applications Mapping and exploration search and rescue, inspection, and surveillance. UAVs are more suitable for such tasks because they have a large field of view compared to ground robots and can be used for exploration in unknown environments. In most of the cases, paths for UAVs are quite unknown and in this scenario SLAM can be used for guiding the UAV in an unknown environment. Foe this UAV has to locate itself in a certain area in an unknown environment. Then it can use its camera for constructing a map and thus create a collision free path towards its destination. These procedures can be done in several steps. In paper [4], [5], a version of SLAM, namely Active-SLAM can be used for Path Planning based on D* Algorithm. D* algorithm implements on the principle of finding the shortest path with negative edge weights taking into account localization uncertainty. It is suitable for exploration of highly dynamic environments with moving obstacles and dynamic changes in localization demands. The path planning algorithm can re-plan the shortest path in case of change of the localization demands. Active SLAM minimizes localization and map uncertainty. Active SLAM solutions can be implemented if the information gain of a certain criterion is minimized. As we do not have future measurements prediction, this stands before the prediction in Active-SLAM.

III. CONCLUSIONS

This paper presents a comprehensive survey on 3D path planning with unmanned aerial vehicles, shedding light on various possible approaches. Among the approaches, PSO has the advantages of simple parameter settings and easy implementation. That is why standard PSO along with its various versions are getting popularity in every fields. ACO uses for short computational complexity and it converges slowly in finding an optimal path, particularly for the case when the problem domain is large. SLAM considers as one of the latest technology in the field of UAV. It is not very simple to implement due to its complex computational problem of constructing or updating a map. With our current survey and future works in path planning problems, we expect to advance the state-of-the-art in real-world mission planning approaches for autonomous aerial vehicles.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2019R1F1A1061696).

REFERENCES

[1] G. Sheng, M. Min, and L. Xiao, "Reinforcement Learning-Based Control for Unmanned Aerial Vehicles," Journal of Communications and Information Networks, Vol.3, No.3, Sept. 2019.

[2] J. Xin, S. Li, J. Sheng, Y. Zhang, and Y. Cui, "Application of Improved Particle Swarm Optimization for Navigation of Unmanned Surface Vehicles," Sensors, 2019.

[3] C. Zhang, Z. Zhen, D. Wang, and M. Li, "UAV Path Planning Method based on Ant Colony Optimization," Chinese Control and Decision Conference, pp. 3790-3792, Xuzhou, 2010.

[4] J. Carsten, D. Ferguson and A. Stentz, "3D Field D*: Improved Path Planning and Replanning in Three Dimensions," IEEE International Conference on Intelligent Robots and Systems, pp. 3381-3386, Beijing, 2006.

[5] I. Maurović, M. Seder, K. Lenac and I. Petrović, "Path Planning for Active SLAM Based on the D* Algorithm With Negative Edge Weights," in *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 48, no. 8, pp. 1321-1331, Aug. 2018.