Pathfinding and Planning Using Bidirectional Late Line-of-Sight Check Weighted A* Algorithm in a 3D Environment

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Abstract

Unmanned Aerial Vehicles (UAVs) have become increasingly important in academic study as their role in military and civil applications has grown. Due to its intricacy, pathfinding is one of the most difficult optimization issues. As a result, evolutionary algorithms are favoured when it comes to finding viable solutions. However, when the number of control points and restrictions grows, computing a possible solution in a wider area consumes too much time. In this study, we propose Bidirectional Late LoS-Check Weighted A* (BLLWA*) to significantly reduce the computational time by reducing the number of Line of Sight checks. We show that BLLWA* identifies paths faster than Bidirectional A* on 26-neighbor 3D grids, with fewer line-of-sight tests, less computing time, a smoother path, with no increase in path length.

Introduction

The autonomous control module of the UAV allows the UAV to calculate the optimum path from the starting point to the destination autonomously. UAVs are most likely to operate in complex settings with a variety of restrictions, such as barriers and danger zones. As a result, path planning is critical in UAV operations.

Objective

The objective of this research project is to reduce the time of execution to find and plan a path in a complex 3D environment.

Methodology

1. Use min-heap to update discriminatively the total costs (the sum of g-values and heuristic values) of different successors after LoS-Check.

2. Use altered equation for heuristic function (Weighted) $f(n) = (1-\lambda)\times g(n) + \lambda\times h(n)$ where $\lambda \in [0,1]$; Here we use $\lambda = 0.6$

3. Use Euclidean distance as the heuristic, which satisfies both admissibility and consistency, and the two properties can guarantee optimality.

4. Use LLA* algorithm (implemented in 2D environment in [2] which is inspired from Lazy Theta*[1]) and its main notion is divided into two parts: LoS-Check should be reduced and the g-value should be updated with discrimination. Here, we use LLA* bidirectionally with updated cost function to find and plan a path in the 3D environment.

5. Use LoS-Slider algorithm for smoothing the path generated by the Bidirectional Late Line-of-Sight Check Weighted A* (BLLWA*) algorithm.

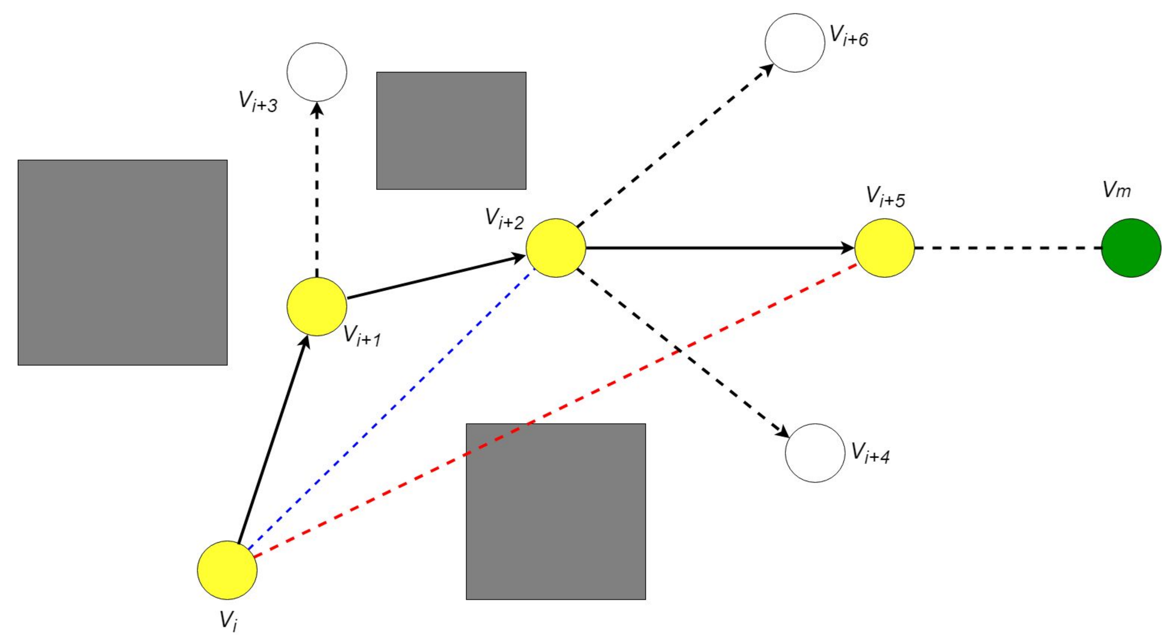

Figure 1 : Planning process of LoS Check algorithm

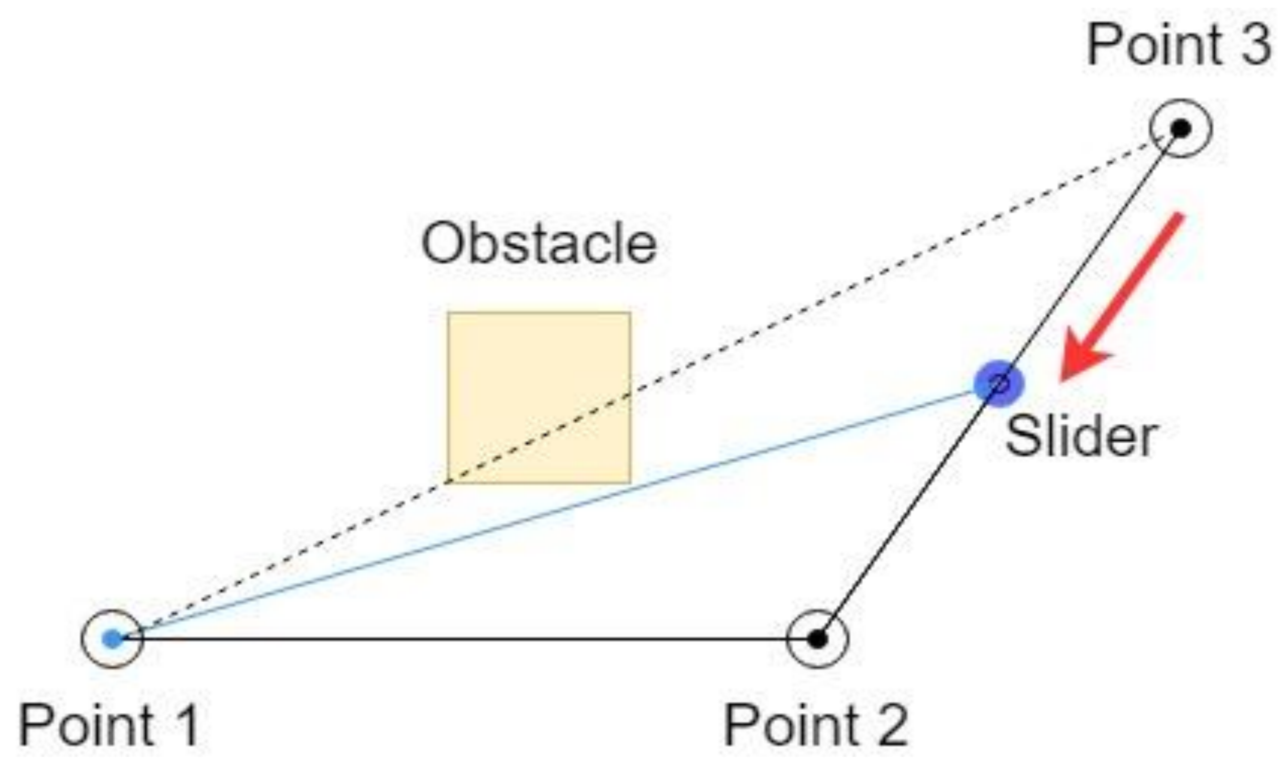

Figure 2 : LoS Slider Smoothing

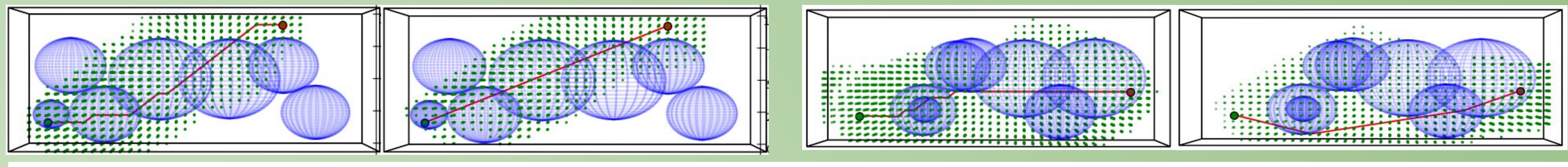

Figure 3 : Bidirectional A* vs BLLWA*

Results

We compared Bidirectional A* with BLLWA* in three instances and the results are mentioned below.

BA*	Nodes Opened	Time	Distance	BLLWA*	Nodes Opened	Time	Distance
1	5402	13.8277	25.8522	1	1002	4.5424	25.2033
2	4002	10.3763	24.5809	2	3602	11.4141	24.414
3	4602	11.5631	23.5331	3	2802	8.7787	22.305
4	5002	12.4153	26.1202	4	2202	7.5291	22.4391
5	4202	10.6584	18.5385	5	2802	8.9366	17.1275
6	802	2.5173	11.853	6	402	1.9502	10.58
7	4402	12.32	22.6793	7	3602	11.7377	22.9497
8	3802	13.585	15.9282	8	2802	9.8335	15.0549
9	2202	6.0371	20.3885	9	3002	9.9769	17.4371
10	7002	19.2111	25.1684	10	2	1.0533	23.1841
11	5002	13.9185	21.924	11	3802	12.578	20.9585
12	5402	15.3057	19.9011	12	5002	15.9627	19.3725
13	1802	5.031	13.853	13	1402	5.4108	13.4559
14	1202	3.6398	12.3889	14	1402	5.0145	11.8429
15	2202	6.4701	17.4599	15	5202	17.0646	18.35
16	5002	14.753	14.5604	16	3002	9.943	14.3251
17	1402	4.3632	18.9955	17	2	1.2874	18.6018
18	2202	6.6935	20.6096	18	402	2.3	20.1421
19	3402	9.2817	19.3669	19	3002	9.5786	18.2831
20	2802	7.73	19.3669	20	1402	5.5324	21.6331

Table 1 : Comparing Bidirectional A* and BLLWA*

Discussion and Conclusion

The path length is not reduced as we expected, but the number of control points, the time of execution and the nodes expanded were reduced significantly. With the results from 20 different scenarios in a well defined 3D environment that has obstacles, the proposed study attains 34.7996% gain in the reduction of node expansion, 19.6664% of gain in time of execution, and 3.9201% of gain in the distance of the path.

References

1. A. Nash, S. Koenig, and C. Tovey, "Lazy theta*: Any-angle path planning and path length analysis in 3d.," vol. 1, Jan. 2010.
2. C. Zhang, Y. Tang, L. Zhou, and H. Liu, "Late line-of-sight check and prioritized trees for path planning," Applied Sciences, vol. 9, p. 3448, Aug. 2019. DOI: 10.3390/app9173448.