Internship Project for Undergraduate Student
Path planning for eVTOL aircraft using potential field

Contact: Jiwon Son (forscing@gmail.com, representative student)

Intern project 2023-1-1 deals with path planning for UAM eVTOL aircraft using the potential method. Two tasks must be done at the end of the spring semester: 1) Programming of the potential field-based path planning code, 2) Simulation of time-accurate path planning of multiple eVTOL aircraft.

For those of you who want to work in our laboratory for this subject, please feel free to contact us. (contact email: forscing@gmail.com)

1. Project schedule

Step	Task	Detail instruction	Period
1	Background study	- Potential flow / Panel method (aerodynamics) - Path planning program using panel method [1-4]	2 weeks
2	Programming a path planning code	- Programming of the panel method (source / sink / vortex) * It's preferable to use open source program.	4 weeks
3-1	Urban path planning of single eVTOL aircraft	- Path planning of single eVTOL aircraft	4 weeks
3-2	Urban path planning of multiple eVTOL aircraft	- Path planning of multiple eVTOL aircraft - Time accurate simulation	8 weeks
4	Program improvement	- Available to parallel computing	4 weeks
Bonus 1	Modeling the turbulence effect	- Suggest the method of considering the gust / building wind effect	
Bonus 2	Modeling the aircraft effect	- Suggest the method of considering the aircraft itself (not by point source)	

* Preferred programing language: C^{++}, FORTRAN, and Python
** Please take full advantage of existing open source library

2. Prerequisite

- ✓ Fundamental of aerodynamics (especially in potential theory)
- ✓ Basic programming skill (Python, C/C++, Matlab, Fortran, …)

3. Submission list

- ✓ Source code
- ✓ Report
  - ■ Within 30 pages (font size of 11pt, free form)
- ✓ Summary presentation
  - ■ Oral presentation (ppt, 30 minutes)

4. References

* As relevant references to carry out this project, the following papers are recommended.

[1] Zeynep Unal, and Ilkay Yavrucuk. “Panel-Method-Based Path Planning for eVTOL in Urban Environment.” Vertical Flight Society 77th Forum, 2021.

[2] Uzol, Oguz, Ilkay Yavrucuk, and Nilay Sezer-Uzol. "Panel-method-based path planning and collaborative target tracking for swarming micro air vehicles." *Journal of aircraft,* Vol. 47, No. 2, 2010, pp. 544-550.

[3] Zeynep Bilgin, Murat Bronz, and Ilkay Yavrucuk. "Experimental Evaluation of Panel-Method-Based Path Planning for eVTOL in A Scaled Urban Environment." Vertical Flight Society 78th Forum, 2022.

[4] Zeynep Bilgin, Murat Bronz, and Ilkay Yavrucuk. "Experimental Evaluation of Robustness of Panel-Method-Based Path Planning for Urban Air Mobility." AIAA Aviation 2022 Forum. 2022.

* Basic concepts of path planning using potential field

1) Why path planning using potential field?

Electric Vertical Take Off and Landing (eVTOL) aircraft offer an attractive solution to reduce traffic congestion and emissions in densely populated urban areas. Air taxi services in the future will likely use fully autonomous vehicles, which will require path planning as there won't be a pilot to operate them. It is challenging to determine a collision-free path in urban environments, which are filled with complicated environments such as buildings. There may be a great number of eVTOL aircraft operating simultaneously, particularly in crowded cities, and the conventional path planning problem is usually mathematically complex and computationally expensive. Thus, the eVTOL aircraft path generation algorithm, which provides a collision-free trajectory for multiple aircraft, should be efficient.

2) How?

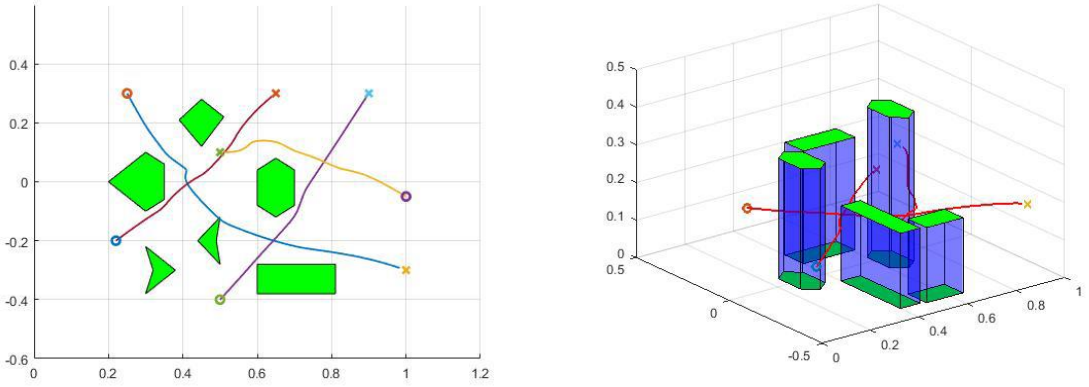
A potential field-based path planning algorithm can be a good alternative for the eVTOL aircraft path generation algorithm. As the results of the potential field, the streamlines, which are not tangled, can be used as a collision-free trajectory. Departure and destination points can be modeled as source and sink, respectively. Obstacles such as buildings or other aircraft can be modeled as vortex panels. The strength of elementary potentials, such as source, sink, and vortex, can be adjusted for collision-free robustness.

3) Advantages

- ✓ Fast calculation of collision-free path of multiple eVTOL aircraft
- ✓ Easy to model the obstacles, aircraft, and location by combining elementary potentials

4) Challenges

- ✓ Solver efficiency enough to conduct real-time simulation
- ✓ Turbulence effects such as gusts and building wind



Examples of results (Ref. [1])