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THE FRENCH AEROSPACE LAB

ISAE SUPAERO
Institut Supérieur de l'Aéronautique et de l'Espace

Internship Proposal

Online planning for Safety-constrained Stochastic Shortest Path problems

Supervisors:

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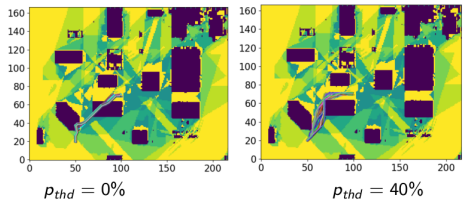
Introduction

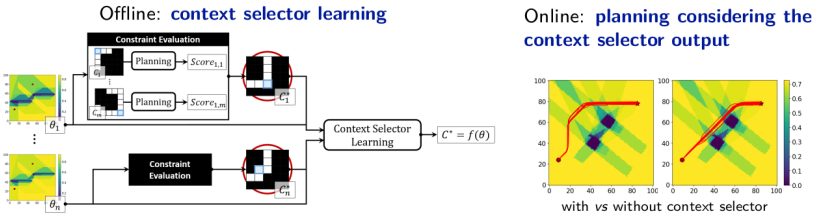
Shortest path planning problems with stochasticity are common in real-world problems, such as autonomous vehicle navigation under uncertain sensor measurements or uncertain environmental disturbances.

Stochastic shortest path (SSP) problems with dead-ends have two conflicting objectives : maximization of the goal-probability – Safety – and minimization of the expected cost (e.g. travel time or distance) to reach the goal – Efficiency. This internship project addresses online resolution of Safety-constrained SSP problems which impose a minimum goal-probability requirement to SSPs.

Although some literature propose offline methods for solving such Safety-constrained SSP problems (Steinmetz et al., 2016; Trevizan et al., 2016) their *online* resolution is yet very challenging. In our previous research, two different approaches have been explored : The first approach is to choose a dead-end penalty value in order for its optimal policy to meet the safety requirement (Delamer et al., 2021) - see Fig. 1a. It can avoid the need to explicitly consider the safety requirement in planning task. The second approach is to apply offline learning process for the aim of improving the efficiency of online policy search (Zaninotti et al., 2022) - see Fig. 1b. For a given SSP problem, we learn the state/action constraints to reduce the search space. The both approaches have been applied to a UAV urban navigation problem under uncertain GPS availability, and were proven effective for online SSP resolution of this specific problem.



(a) Figures from (Delamer et al., 2021) showing different policies regarding safety requirements.



(b) Figures from (Zaninotti et al., 2022) showing an overview of the approach offline learning for online planning.

Figure 1: Previous work illustration.

Objective

Founded on these works, the objective of this internship project is to perform more thorough evaluation and analysis of these approaches (or variants) by testing them on general SSP domains available and commonly used in the planning or robotic communities.

The work consists of:

1. Literature review, understanding SSP problems and general formalisation of the resolution approaches (1 month)
2. Simulation experiments and analysis (3-4 months)
3. Reporting and publication if feasible (1 month).

Candidate's profile

MSc student or Engineer student with programming skills (Python, C++) and a background in robotics and AI is suitable. The candidate will study/learn machine learning techniques and automated planning theory related to Markov Decision Process. The student will possibly conduct new experiments in the lab to validate the proposed model and methods. For that, the student will be located at ISAE-SUPAERO facilities.

- Interns will receive a stipend of 4.35€ net per hour. This gratification gives to approximately 580€ per month.
- Duration of the intership: Five or six months, starting in February or March 2024, with potential opportunities for a subsequent PhD.
- **Applications (CV and cover letter) must be sent to supervisors**.

References

Delamer, J.-A., Watanabe, Y., and Chanel, C. P. C. (2021). Safe path planning for uav urban operation under gnss signal occlusion risk. *Robotics and Autonomous Systems*, 142:103800.

Steinmetz, M., Hoffmann, J., and Buffet, O. (2016). Goal probability analysis in probabilistic planning: Exploring and enhancing the state of the art. *Journal of Artificial Intelligence Research*, 57:229–271.

Trevizan, F., Thiébaux, S., Santana, P., and Williams, B. (2016). Heuristic search in dual space for constrained stochastic shortest path problems. In *Proceedings of the International Conference on Automated Planning and Scheduling*, volume 26, pages 326–334.

Zaninotti, M., Lesire, C., Watanabe, Y., and Chanel, C. P. (2022). Learning path constraints for uav autonomous navigation under uncertain gnss availability. In *PAIS 2022*, pages 59–71. IOS Press.