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Obstacle avoidance in an unknown environment based on a coherent combination between splines-based SLAM and a bio-inspired navigation model

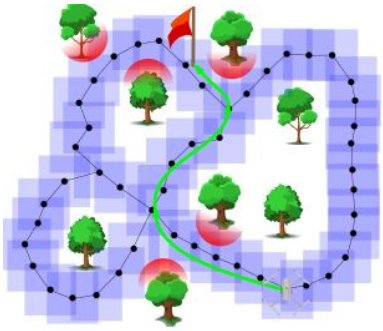
Research topic

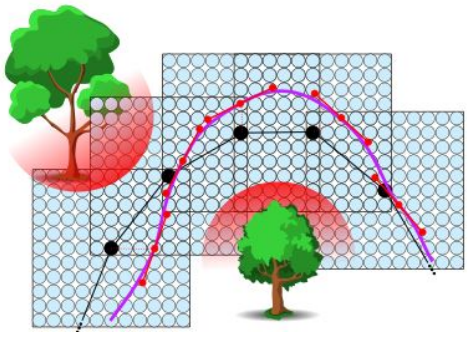
Mapping an unknown environment and navigating requires to construct and maintain a coherent model of visual cues allowing to both estimate the position of the system in space, but also to define a path/trajectory towards a destination. Several approaches drew inspiration from living beings to achieve this task. Such a bio-inspired model, mimicking the functioning of several specialized neurons of mammals' brains was developed in [1]. This model was tested in virtual environments then on robotic platforms using stereo cameras.

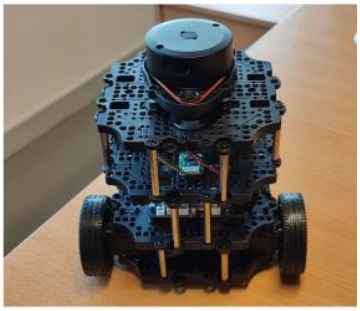
Thanks to the support of LCIS of last year, an intern student successfully tested the algorithm on a Turtlebot3 (Figure 1c) equipped with a 2D Lidar. The proposed bio-inspired model generates maps of the environment under the form of a navigation graph, while providing a local navigation around graph's nodes (Figure 1a). These properties allows the definition of navigation waypoints in an envelope around initial path and thus the definition of trajectories optimized for battery consumption and hazardous, static or dynamic, obstacle avoidance (as illustrated in Figure 1b).

Furthermore, thanks to this work, a thorough literature review has been done. This opened some interesting directions related to existing navigation algorithms and the role of B-splines and optimization-based control. The properties of B-splines proved useful for obstacles approximations in SLAM algorithms[2] and some preliminary results were obtained in simulation.

This project builds upon our previous work and aims to provide substantial enhancements of the bio-inspired algorithm through the use of B-spline for generating trajectories and approximating the obstacles. The results will be validated over multiple Turtlebots which have to avoid fixed and moving obstacles while navigating in the cluttered unknown environment.







[1] Gay, Simon and Le Run, Kévin and Pissaloux, Edwige and Romeo, Katerine and Lecomte, Christéle: Towards a predictive bio-inspired navigation model. Information, vol. 12(3), pp. 100-115, 2021.

[2] I Prodan, F Stoican, C Louembet: Necessary and sufficient LMI conditions for constraints satisfaction within a B-spline framework. 2019 IEEE 58th Conference on Decision and Control (CDC), 8061-8066

Student's work during the internship:
From a practical viewpoint, the student has to concentrate on:

- defining an optimized set of waypoints from the bio-inspired navigation model which will be further used in the trajectory planning phase;
- developing a SLAM algorithm using B-splines for obstacles approximation;
- generating trajectories with collision avoidance using the properties of B-splines;
- validate the navigation and motion planning algorithm over multiple TurtleBot3 used for navigation in a cluttered environment.

Overall, the obtained results will be synthesized into a report and a presentation at the end of the study.

Period: February to July 2024

Salary: 560 euros per month.

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Application deadline: December 2023

Application documents: CV highlighting the projects done, motivation letter and transcript of grades during the engineering years.