Optimal Path Planning and Coverage Control for Multi-Robot Persistent Coverage in Environments with Obstacles

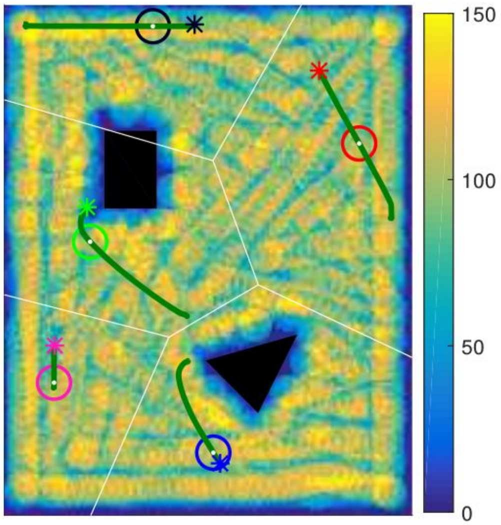
José Manuel Palacios

Professor : Alcherio Martinoli
Assistant(s) : Zeynab Talebpour

Persistent coverage aims to maintain a certain coverage level over time in an environment where such level deteriorates. This level can be associated to temperature, dust or sensor information. We propose a distributed solution in which each robot finds candidate coverage goals, i.e., points of the environment that need to be covered, and plans paths to them making use of an FMM-based planning method. In fact, these paths are optimal in terms of coverage and keep a safety distance to obstacles. Between all the candidate goals, the one that improves the coverage the most along its path is selected and followed using a navigation system that avoids unmapped obstacles. In addition, a coverage controller locally calculates the optimal coverage action and allows the team of robots to maintain the coverage level of the environment significantly close to the objective. Compared to other approaches, our solution is more flexible and robust to changing environments. Simulations and real experiments validate this and prove a significant improvement with respect to previous works.

In this work we have introduced a distributed solution that allows a group of mobile robots to persistently cover an environment in which the coverage decays over time. We have formulated the coverage problem and elaborated on the improvement function to consider the robots as points in the path planning step, where we have introduced a method based on FMM. For this method, we have proposed two speed functions: one to optimize coverage and another one to keep a safety distance to obstacles.

We have also presented a method to find and select the coverage goals to which the robots have to move to, based on the total improvement of the path. To keep the robot following their path we use a DWA. Additionally, we propose a law to control the coverage action of the robots at every time. Finally, we present simulation results and real experiments that validate our approach and compare it with our previous one. In fact, the coverage controller provides a significant improvement to reach the coverage objective and the path planning strategy deals with obstacles while optimizing the coverage of the paths.



Example of simulation: coverage level of the environment with the coverage areas of the robots in different colors for three different time instants. Colored asterisks represent the goals of the robots; green lines, the planned paths of the robots; and white lines, the Voronoi partition of the environment. Black areas are mapped obstacles.