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Project Summary

Distributed Multi-Robot Coverage in Realistic Environments

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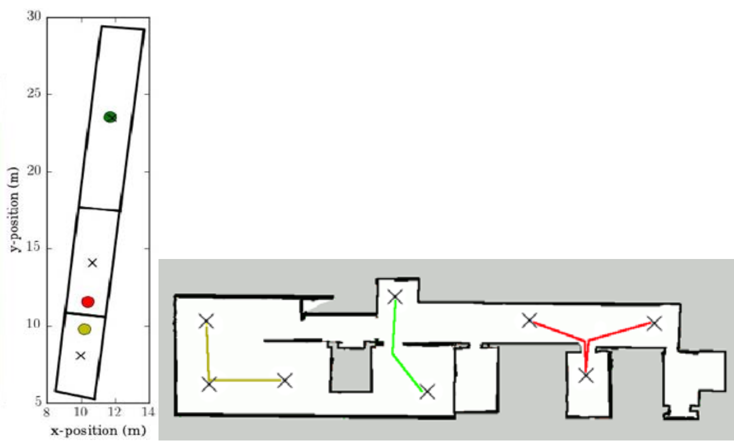
The MOnarCH project builds social robots for edutainment use in the children's ward of the Portuguese hospital IPOL. Navigation is a big part and DISAL members develop behaviors for group navigation for the MBot robots. In this project, I used centroidal Voronoi coverage methods to divide the area between a group of robots. After dividing the space between them, the robots patrol according to a greedy algorithm applied on the waypoints defined by the given map. Each robot will patrol the waypoints that are situated within the Voronoi Cell it has been assigned. There are two main cases: convex and nonconvex spaces (without or with obstacles). The convex case is usually limited to a single room while the nonconvex case can be in a full building floor.

One requirement is that the Voronoi calculation is done in a distributed manner since we cannot have a master robot which would imply a single point of failure in the system. I came up with an algorithm that allows each robot to calculate its Voronoi cell based on the positions of all the robots, by cutting away pieces of a polygon. Each robot is continuously broadcasting to the others to show that it is active, and if a robot fails to do so for 10 seconds or more, it will not be included in the division of the space. In this way, the group can handle exits/failures at run-time and redivide the space without human intervention. A robot which exited can also re-enter the group later on.



Left: Three Mbot robots performing coverage in the corridor. Right: Patrol paths for 3 robots in Webots simulation on IPOL map.

Coverage in nonconvex environments is often encountered in robotics, and I took inspiration from a recent paper to use Virtual generating points to guarantee convergence of the centroidal Voronoi algorithm which divides the space. This leads to some problems, however. Mainly, the behavior can be inefficient in how it distributes the work, depending on the shape of the map. It works better in open, well connected areas and less well in a map shaped like a U or an M. There is room for improvement in dividing the space by taking the map shape into account as well as the placement of the waypoints. Two ideas that may improve the situation are 1) to use the geodesic distance rather than the currently used Euclidean distance, and 2) to create a graph from the map and divide the space based on the graph, taking into account which areas are connected by walkable floor.