ÉCOLE POLYTECHNIQUE
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Coordination Behaviours for Formation Control of Holonomic Multi-Robot Systems

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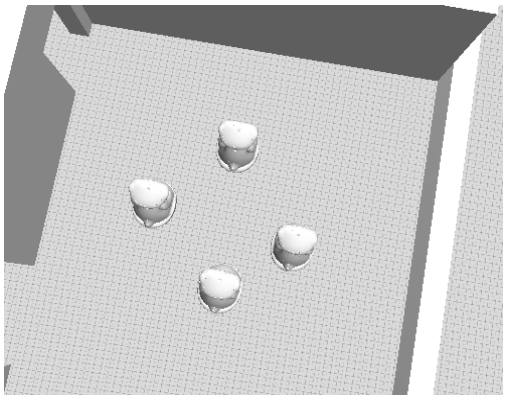
Formation control is an active area of research bridging the knowledge arising from the graph theory and systems theory. It falls under the category of consensus problems aiming at achievement of a common goal by a collection of interacting agents in multi-agent systems. The agents, or in the case of formation control – the robots, share a common protocol regulated by the interconnection topology and the initial condition of each of the network components. Resulting decentralized control over the network is more robust and cheaper than the equivalent monolithic architecture. Moreover it explores inherent for distributed systems features, such as parallelism and concurrency, providing faster and simpler solutions to consensus problems.

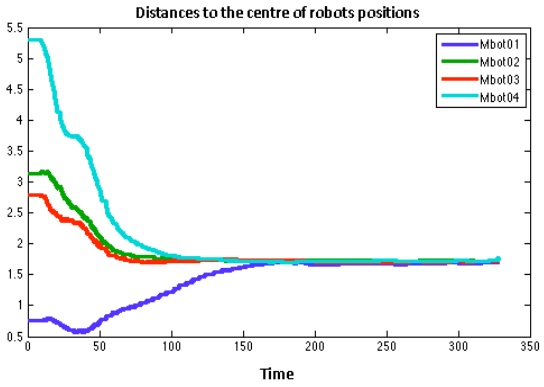


Diamond formation with the Mbot robots

Implementation a cooperative multi-robot formation control has been done in a twofold: a naïve leader-referencing formation control module with two robots using a set of existing ROS functionalities and more advanced graph-based formation control strategy. The design was developed and implemented in realistic robots simulator Webots using the Mbot robots and ROS (Robot Operating Software) packages.

Naïve leader-referencing approach served as a starting point to the formations problem. Extensive testing demonstrated productivity of the method but also manifested multiple points of failure, in most cases revealed during coexistence with other modules (obstacle avoidance) or because of limits of the positioning system.

Graph-based control has proven to be a powerful tool to solve multi-agent consensus problems. This method is robust and flexible, moreover specific manipulations allow to control directly robot's heading as well as change the response of the followers in the mobile formations. Multiple tests designed as to compare several possible improvements over the standard graph-based control algorithm resulted in a selection of the one resulting in the smallest formation error. Dynamic weights of the connection graph edges significantly decreased the delay of follower robots converging to a formation.



Convergence of four robots to a square formation

Both formation control strategies have been validated with a group of robots under different environmental conditions with various control variables, namely the trajectory of the leade and the desired formation (line, square, column and diamond). The formation control module will be tested in simulation using Webots. Finally, the designed module has been abstracted so that it can be readily implementable on a real robotic platform.