Construction of a framework of path planning and trajectory control in real time of multiple robots

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Contents

Objective

- **Main Objective:** Build a framework of path planning, that can be executed in real time in dynamic environments. The framework is capable of control a set of robots, finding and guiding each robot for one trajectory that connects its initial poses and goal.
- **Secondary Objective:** The framework must reduce the number of collisions between robots of the set and obstacles statics and dynamics.

Motivation

Use of multiple robots

- Possibility to resolve problems that only one robot can't;
- More tolerance to errors;
- Division of jobs;

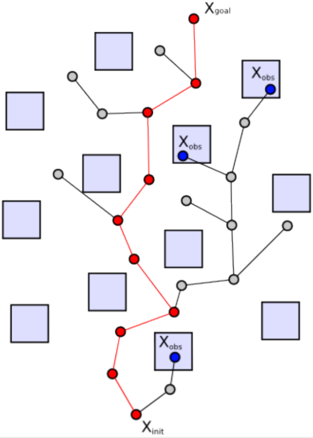
Execution in real time

- More Resilience;
- Possibility to add more functionalities in one platform;

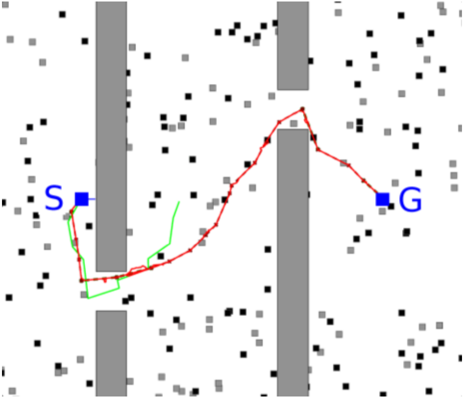
Robustness to Dynamic Environments

- More Security;

Sistemas Autônomos e Inteligentes Para Robôs Cooperativos no Ambiente Small Size League (Rodrigues, 2013)[1]



Path-Guided Artificial Potential Fields with Stochastic Reachable Sets for Motion Planning in Highly Dynamic Environments (Chiang et al, 2015)[2]



Be $R = \{r_1, r_2, ..., r_n\}$ a set of robots in a workspace W in $\mathbb{R}^2$, be $p = [x \;\; y \;\; \theta]^T$ a pose that a robot can occupy in W, be B a set of obstacles in W and $P = \{p_1, p_2, ..., p_n\}$ a path, assuming that the form of R and B are known and B has obstacles statics and dynamics.

Problem

For each $r_n \in R$, find a path P_n that connects a initial pose p_n^a and the goal pose p_n^o, avoiding collision with B and the other robots in R.

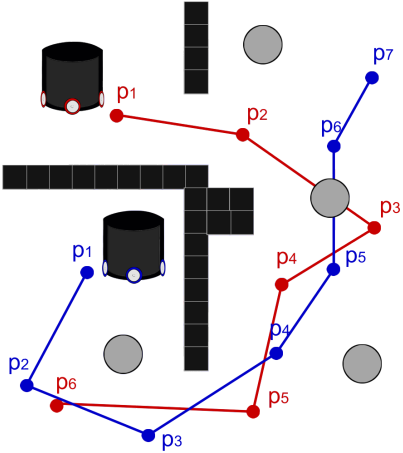
Complexity of the RRT (Rapidly Exploring-Random Trees) Algorithm for Multiple Robots

for $r = 0$ **to** R **do**
  $G[r].init(q_{init})$
end
for $r = 0$ **to** R **do**
  for $k = 0$ **to** K **do**
    $q_{rand} \leftarrow rand\_free\_conf()$
    $q_{near} \leftarrow$
    $nearest\_vertex(q_{rand}, G[r])$
    $G[r].add\_vertex(q_{near})$
    $G[r].add\_edge(q_{near}, q_{rand})$
  end
end

- Consider the complexity of $rand\_free\_conf()$ as D
- The complexity of RRT for multiple robots is $O(R(K^2 + KD))$

Path planning in real-time (Offline)

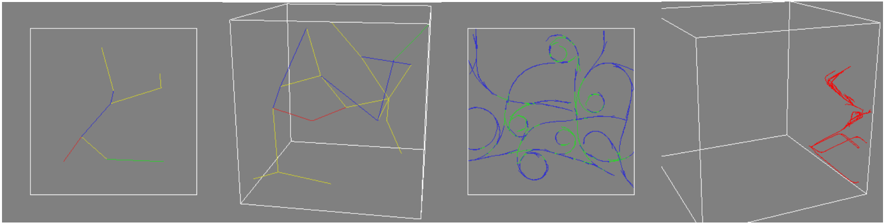
Task: For each $r_n \in R$, find a path P_n that connects a initial pose p_n^a and the goal pose p_n^o, avoiding collision **only with the obstacles statics** in B. ~~and the other robots in R.~~



Path planning in real-time (Offline)

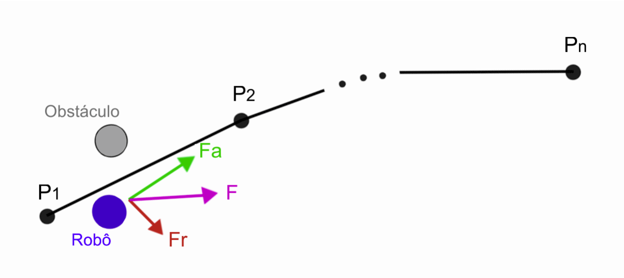
OMPL: Open Motion Planning Library (Ioan et al, 2012)[3]

- Standard in ROS;
- Has various algorithms of path planning;



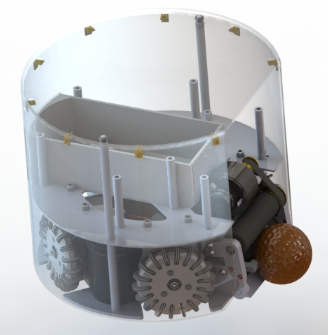
Extraction of guide vector of trajectory (*Online*)

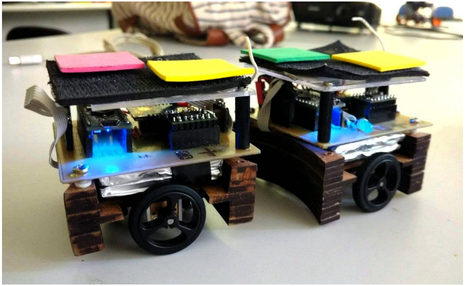
Task: Using the Artificial Potential Fields presented in (Goodrich, 2002)[4], guide the robot along the path, generating a vector of movement $\vec{F}$



Converting the vector of movement for real robots

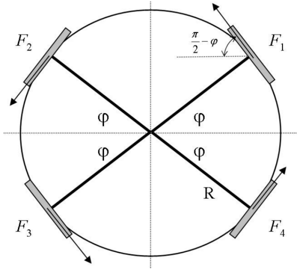
Platforms used

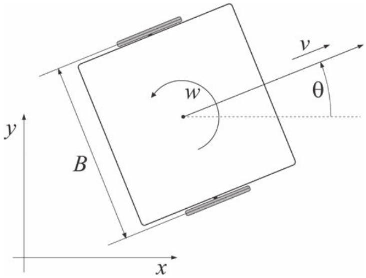




Converting the vector of movement for real robots

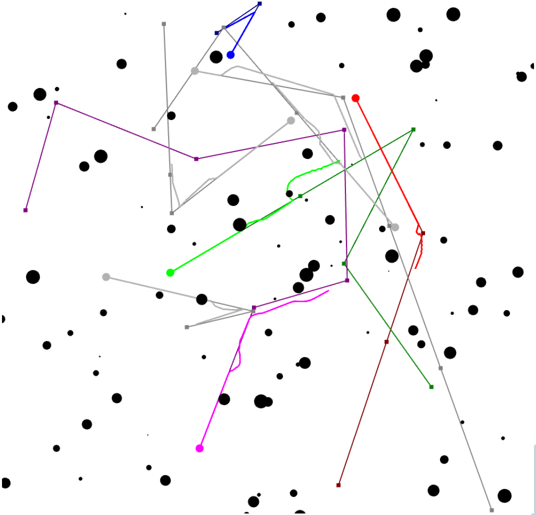
Platforms used





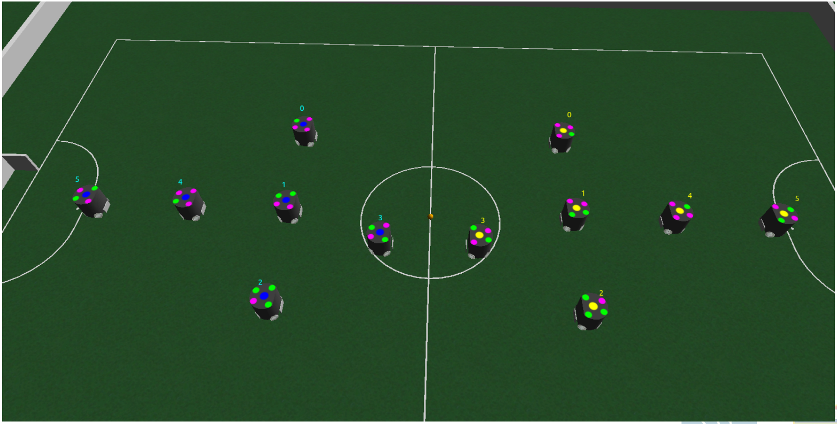
Validation simulated environment

Simpler Environment



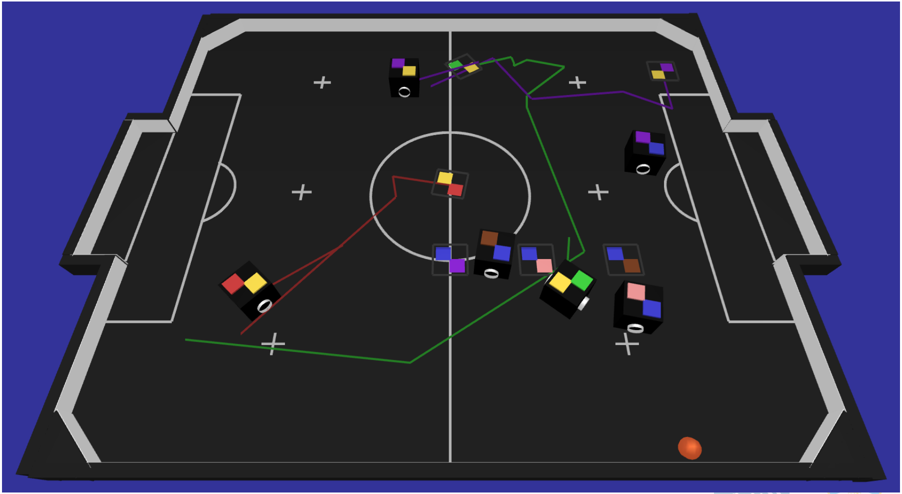
Validation simulated environment

grSim (Small Size League)



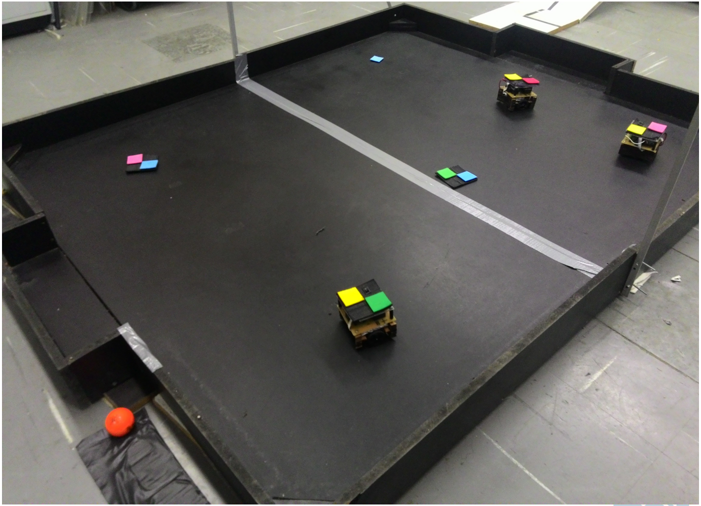
Validation simulated environment

VSS-Simulator (IEEE Very Small Size [Soccer])

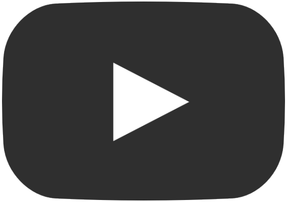


Validation real environment

IEEE Very Small Size [Soccer] Environment using VSS-SDK



Video



First simulations

	Time	Success	Collisions
5 robots	0.096s	96.4%	0.30
6 robots	0.121s	97.6%	0.46
7 robots	0.165s	97.6%	0.62
8 robots	0.188s	95.6%	0.76
9 robots	0.221s	97.2%	0.87
10 robots	0.265s	94.1%	1.00

Table: Results in the simpler environment.

	Success	Collisions
6 robots	98.0%	0.52

Table: Results in the grSim environment.

Last experiments

	Resolutions	Collision-Robots	Collision-Objects
Framework	56.2	1.7	0.6
Simpler	50.2	27.7	23.8

Table: Results in the VSS-Simulator environment (Static).

	Resolutions	Collision-Robots	Collision-Objects
Framework	57.3	2.8	4.9
Simpler	30	39.6	44.6

Table: Results in the VSS-Simulator environment (Dynamic).

Last experiments

	Resolutions	Collision-Robots	Collision-Objects
Framework	55.5	3.5	2.7

Table: Results in the real environment.

Conclusion

Conclusion

- The approach used resolves the problem of path planning in real time of multiple robots in dynamic environments. Including allows the use different types of robots.
- It's possible to plan a path in real time for a set of robots and control its, however, to remove completely collisions in dynamic environments, is required improve the algorithm.

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III WORKSHOP ON MSC DISSERTATION AND PHD THESIS IN ROBOTICS (WTDR)

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