Normative Multi-Robot Navigation in Crowds

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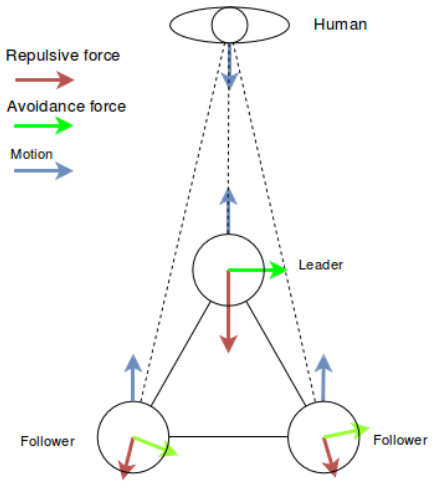
Today, as more robots leave the labs to confront the real world, considering the social interactions and the uncertainty that it implies, it is necessary to make them capable of apprehending this new universe. To be accepted by people, the agents need to translate the social norm in an appropriate way they can work with. In this work we considered a leader-follower formation that has to reach a desired position while minimizing the discomfort for the people crossed on the path. The focus of this work is to develop a local and a reactive architecture allowing this performance.

First, a literature review allowed to learn about Human-Robot Interaction and which behavior the robots need to express in order to be accepted as human. For example, the robots need to respect interaction distance and to have a smooth and predictable path in case of navigation. Then a few of the several process developed in this field were studied in order to choose the most suitable ones.

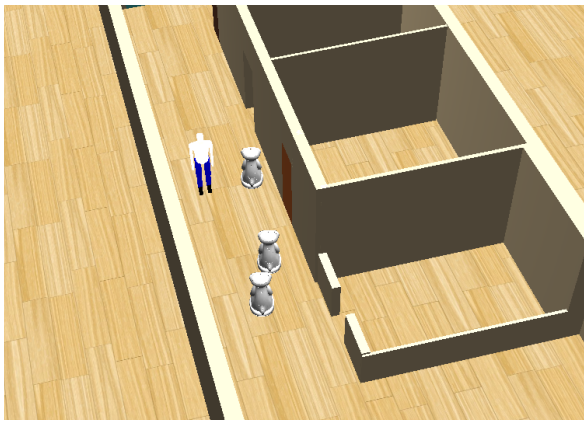


Force generate by the human applied to the robots

The general method picked was to represent the human as a combination of different potential fields. The first one is a repulsive field that managed the distances between human and the robot. The second one is the translation of the social norm “cross someone from the right”. To do that, the relative motion and position of the human and the robot are used to generate a vector field pushing the robot to the right when coming in front of the human. These two interaction are modulated with a factor quantifying the available space around the different protagonists.

Additionally, a Laplacian feedback controller is implemented to allow the robot to keep the desired formation shape. The output of the robot’s controller depends on the combination of these two factors: the "social obstacle avoidance" and the positioning error.

These behavior were tested in two scenarios. In both, one human and a formation of robots are coming to each other in opposite direction. In the first case, the area is free of obstacles and they can deviate as much as needed. In the second case, the crossing is made in a corridor with limited lateral space. For both experiences, different level of noise were added to the ground truth position of the human, in order to simulate real world data.



Scenario 2 : column formation crossing human in corridor

The results validate the design choice for the open space, whatever the noise level, but only for small noise in the corridor.