A Multi-Agent System Approach for a Mobile Robot Navigation Among Movable Obstacles

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Navigation Among Movable Obstacles

Navigation Among Movable Obstacles (NAMO)[3] is an important step in successfully designing a robot capable of maneuvering around crowded indoor environments. The main goal of this research area is to develop robots for personal assistance, e.g. in structures which accommodate the elderly and fragile (such as in hospices and hospitals) and robot vacuum cleaners in crowded places, etc. Despite significant efforts over the past two decades, the current results are not yet strong enough for use in a real environment. The major difficulty is threefold:

1. How to model a dynamic and crowded environment in the form of a data structure which allows the facilitation of the application of algorithms.
2. Find efficient trajectories to move obstacles safely.
3. Find a compromise between moving obstacles or circumvent them.

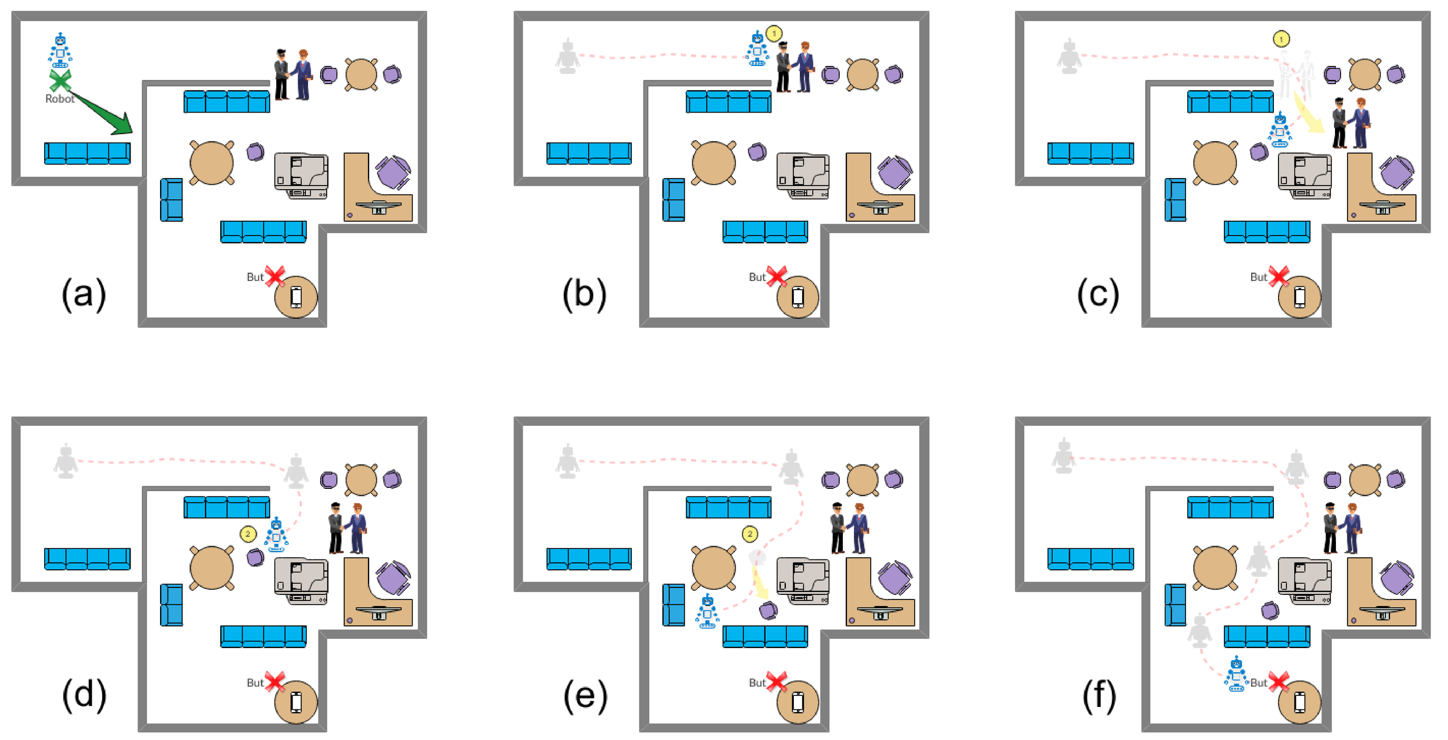

Figure 1. Example (a) The robot receives instructions from the user, an approximate direction and the object to find (here the phone on the table). (b) The robot must take the only path that brings it as close as possible to its goal. (c) The management of obstacles here consists in asking people to give way to it. (d) The robot is again confronted with obstacles. (e) The robot's choice must be to move the chair rather than the table. (f) The robot has reached its goal

Concepts of Simplexity

We propose here to apply the concepts of simplexity, described by physiologist Alain Berthoz [1] to address the NAMO problem. This physiologist describes the brain as a predictor and a simulator of actions. The simulation resembles a prediction of the movement in the environment. Subsequently, it applies the simulated movements in the real environment and checks if the results correspond to predictions. If they are different, the brain adjusts the movement. We propose in this article to implement this mechanism by using a simulation system based on multi-agent systems (MAS) [2].

Berthoz's simplexity definition

To cope with environmental complexity, human and animal brain rely on simplifying principles that allow adaptive behavior.

Rapid processing of complex data

Alain Berthoz

Robotic Architecture for NAMO

We propose a robotic architecture with:

1. A *global planner* which allows the robot to plan the optimal path to reach its objective, without considering obstacles.
2. A *local planner*, which allows the robot to manage the obstacles which block its passage on the path.
3. A *cost function* that allows for the selection of the appropriate planner according to the situation, in order to optimise the path and the robot's actions. Each of the two planners is able to give an estimate of the action before its execution, which allows the cost function to decide.

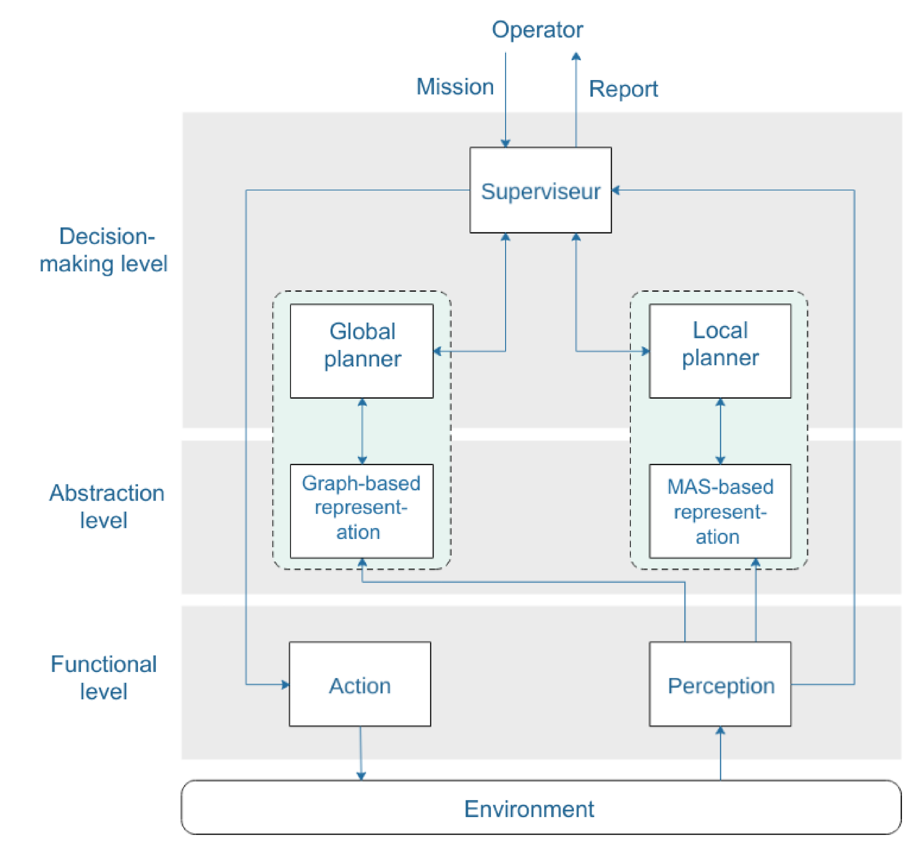

Figure 2. Hierarchical Robotics Architecture for NAMO

Global planner

The global planner operates in a partially unknown environment. It is essentially based on the free spaces to build a graph. A path finding algorithm makes it possible to indicate the direction to follow to reach the goal. This phase is based on a bug algorithm. The aim is to drive the robot closer to the goal until reaching a situation in which it can no longer move forward because of the obstacles, or when the obstacle circumvention requires an important additional cost. This will allow to the local planner to clear the path.

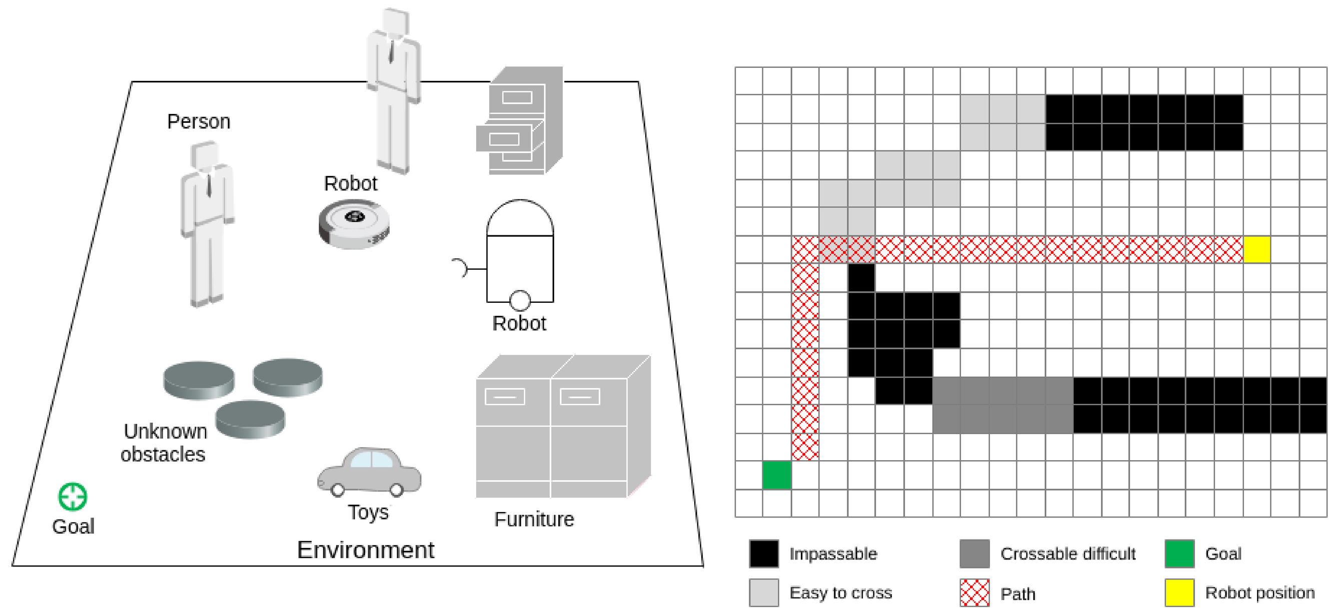

Figure 3. Global planner

Local planner

The aim of the local planner allows the management of obstacles by pushing them (the robot pushes the obstacles to remove them from the passage) or by interaction (asking to give way). The planner creates a MAS representation of the immediate (near) environment. Each obstacle is represented in a reactive agent. This process is called *agentification*. There are different types of agents; (1) static (obstacles that the robot cannot move e.g. furniture, fragile, heavy objects, etc.), removable (e.g. chairs, etc.), interactive (objects with which the robot can interact and ask to give way, e.g. humans or other robots).

The generation is based on the models (*templates*) predefined for each type. The robot represents itself in the form of a cognitive agent. The cognitive agent performs simulations in order to determine the possible actions and also determine the costs of desired actions. During the action, at each moment of the movement, the system will check the state in which some of the sensors must be, to reinforce its learning or call into question the action it is performing.

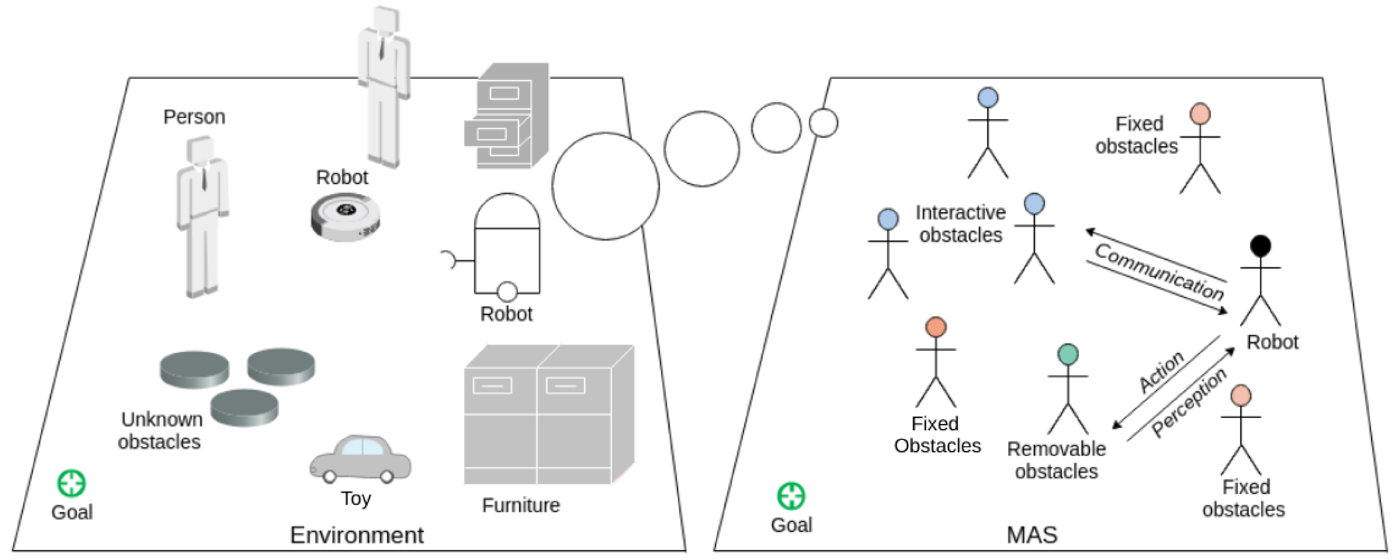

Figure 4. MAS environment abstraction for local planner

Implementation

The implementation is carried out and tested on the *Turtlebot3* robot.

Figure 5. Implementation in Turlebot 3 robot

References

[1] Alain Berthoz and Jean-Luc Petit. *Complexité-simplexité*. Collège de France, 2014.

[2] Halim Djerroud and Arab Ali Cherif. Environment engine for situated mas. In *ICAART (1)*, pages 129–137, 2019.

[3] Mike Stilman and James J Kuffner. Navigation among movable obstacles: Real-time reasoning in complex environments. *International Journal of Humanoid Robotics*, 2(04):479–503, 2005.

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