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## Obstacle Avoidance

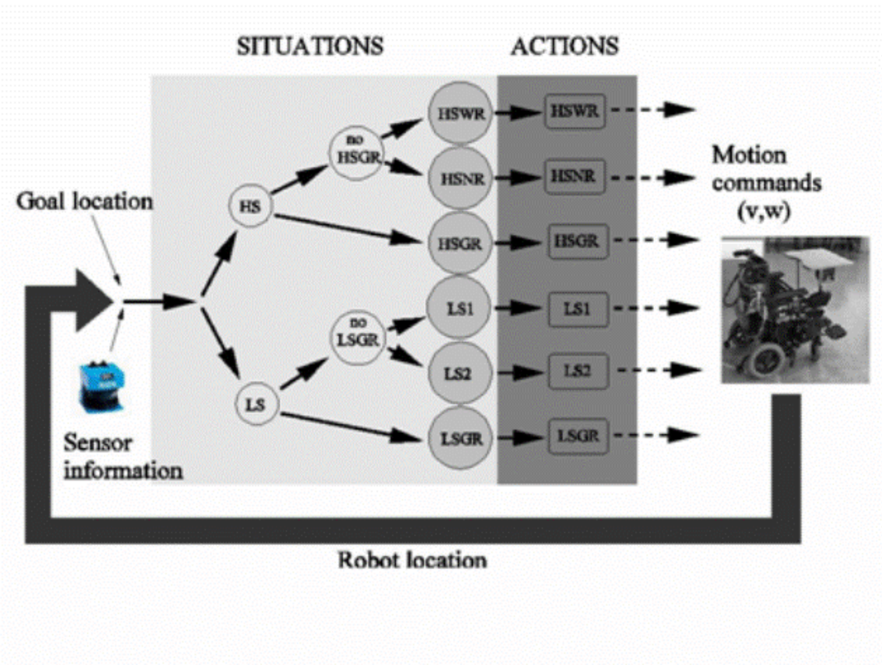
Obstacle Avoidance is a robotic discipline with the objective of moving vehicles on the basis of the sensorial information. The use of these methods front to classic methods (path planning) is a natural alternative when the scenario is dynamic with an unpredictable behaviour. In these cases, the surroundings do not remain invariable, and thus the sensory information is used to detect the changes consequently adapting moving.

The research conducted faces two major problems in this discipline. The first is two move vehicles in troublesome scenarios, where current technology has proven limited aplicability. The second one is to understand the role of the vehicle characteristics (shape, kinematics and dynamics) within the obstacle avoidance paradigm.

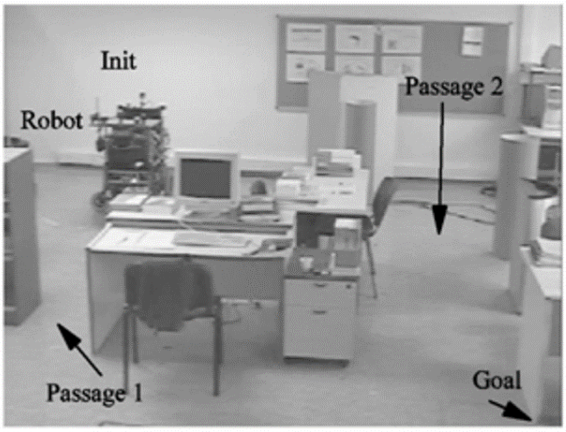
- **Motion in Troublesome scenarios**

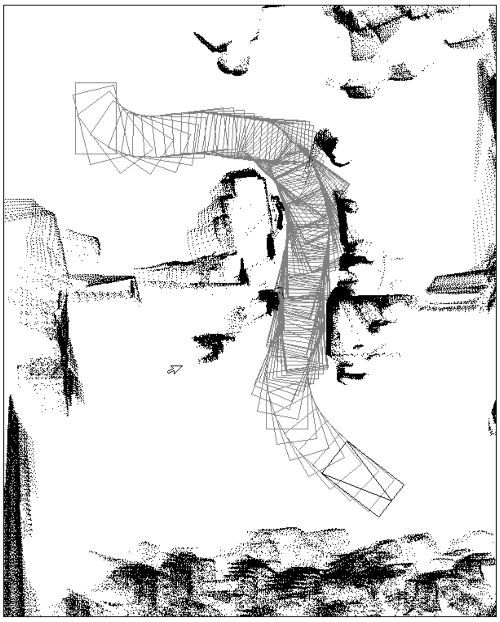
Nearness Diagram Navigation: This method addresses obstacle avoidance for vehicles that move in very dense, cluttered and complex scenarios. The method uses a ``divide and conquer'' strategy based on situations to simplify the difficulty of the navigation. Many techniques could be used to implement this design (since it is described at symbolic level) leading to new obstacle avoidance methods that must be able to navigate in arduous environments (as the difficulty of the navigation is simplified). The geometric implementation of the method is called Nearness Diagram Navigation. The advantage is to successfully move robots in troublesome scenarios, where other methods present a high degree of difficulty to navigate.

The next Figure depicts the divide and conquer strategy based on situations:




And some results with the wheelchair vehicle:



Most Relevant Related Publications:

1. J. Minguez, L. Montano. **Nearness Diagram Navigation (ND): Collision Avoidance in Troublesome Scenarios**. *IEEE Transactions on Robotics and Automation*, pp 154, 2004. (pdf)

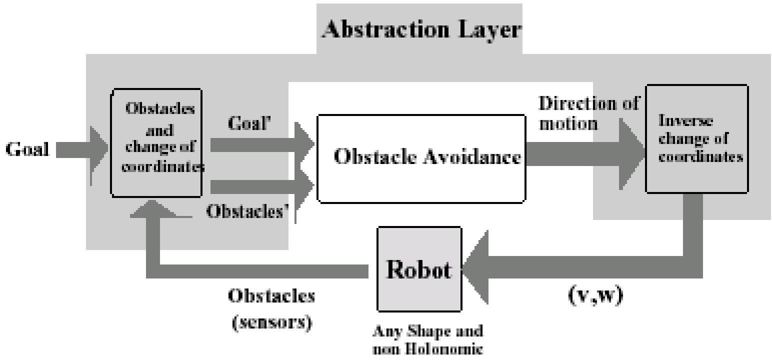
2. J. Minguez, J. Osuna, L. Montano. **A Divide and Conquer Strategy based on Situations to Achieve Reactive Collision Avoidance in Troublesome Scenarios**. In *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, 2004. New Orleans, USA. (pdf)

## Shape, Kinematics and Dynamics in Obstacle Avoidance

--- *Shape and Kinematics*

Most obstacle avoidance techniques do not take into account vehicle shape and kinematic constraints. They assume a punctual and omnidirectional vehicle and are doomed to rely on approximations. Our contribution is a framework to consider shape and kinematics together in a exact manner, in the obstacle avoidance process, by abstracting these constraints from the avoidance method usage. Our approach can be applied to many non holonomic vehicles with arbitrary shape.

For these vehicles, the configuration space is 3 dimensional, while the control space is 2-dimensional. The main idea is to construct (centred on the robot at any time) the two-dimensional manifold of the configuration space that is defined by elementary circular paths. This manifold contains all the configurations that can be attained at each step of the obstacle avoidance and is thus general for all methods. Another important contribution of the paper is the exact calculus of the obstacle representation in this manifold for any robot shape (i.e. the configuration regions in collision). Finally, we propose a change of coordinates of this manifold in such a way that the elementary paths become straight lines. Therefore, the 3-dimensional obstacle avoidance problem with kinematic constraints is transformed into a simple obstacle avoidance problem for a point moving in a 2-dimensional space without any kinematic restriction (the usual approximation in obstacle avoidance). Thus, existing avoidance techniques become applicable.




Most relevant publications:

1. J. Minguez, L. Montano. **Abstracting vehicle Shape and Kinematics constraints from Obstacle Avoidance Methods.** Autonomous Robots, 2005. (pdf draft)
2. J. Minguez, L. Montano, J. Santos-Victor. **The Ego-Kinematic Space (EKS): Shape and Kinematics of the Vehicle.** In *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, 2002. Washington, USA. (pdf)

--- *Dynamics*

This research addresses the incorporation of the vehicle dynamics into the obstacle paradigm. We present a framework specially suited to systems where the dynamics cannot be neglected: mobile robots with slow dynamic capabilities, or systems working at relatively high speeds. Rather than embedding the motion constraints when designing a navigation method, we propose to introduce the robot dynamic constraints directly into the spatial representation. In this space - the Ego-Dynamic Space - the dynamic capabilities of the robot are implicitly represented. With minor modifications, standard reactive navigation methods can be used in this space implicitly taking into account the robot dynamic constraints. To validate this framework, we show experiments with a real platform using two reactive navigation methods (the Nearness Diagram Navigation and the Potential Field method). By using the proposed framework, the vehicle dynamics are directly addressed, whereas both methods do not take the robot dynamic constraints into account.

Most relevant publications

1. J. Minguez, L. Montano, O. Khatib. **The Ego-Dynamic Space (EDS): Dynamics of the Vehicle.** In *Proceedings of the Conference on Intelligent Robots and Systems (IROS)*, 2002. Lausanne, Switzerland (pdf)

--- *Shape, Kinematics and Dynamics*

This research merges the previous works in order to deal with the three vehicle characteristics jointly,

Most relevant publications:

1. J. Minguez, L. Montano. **The Ego-KinoDynamic Space (EKDS): Shape, Kinematics and Dynamics of the Vehicle.** In *Proceedings of the Conference on Intelligent Robots and Systems (IROS)*, 2003, Las Vegas, USA (pdf)

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