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Control of a nonholonomic robot in an environment with obstacles

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***Abstract*— In this paper solutions to motion control in a planar environment with obstacles are considered. The selected algorithms taking advantage of potential functions are illustrated by experimental results.**

Keywords—potential functions, navigation function, nonholonomic robots, motion control

In this paper we deal with motion control of a nonholonomic mobile robot in an environment with obstacles. Such a task can be solved by combining trajectory tracking/set-point control with local *artificial potential methods* or using a *navigation function*. In the former approach, the part that is responsible for the robot convergence to the goal is separated from the collision avoidance module. In result, the overall control system is modular, with clear responsibilities of control modules and it is easy to modify. The control signal is obtained by combining results of computations of various blocks, for example by summing them. However, it is noteworthing that functional separation becomes weakness in some situations. Namely, if robot moves in the complex, cluttered environment with obstacles of non-trivial shapes the considered architecture may lead to unappropriated behavior of the mobile platform. Even if the results of computation of functional subsystems are rational, the output of the whole controller may be invalid. In some situations trajectory tracking block and collision avoidance subsystem generates vectors that results in trapping the robot in local minima.

The reason of this, at the concept level, is that the collision avoidance module is not "aware" of the destination point. If the results of subsystems are opposite, the output of the controller my be zero vector that which means 'stop'. The solution of this problem is a combination of trajectory tracking with collision avoidance in a single module or making collision avoidance block "aware" of target location.

Navigation function is an example of this approach. The information about the goal and obstacles is merged in a single function, called *navigation function*. Its output is scalar value depending on the robot's location with respect to goal and obstacles. Classic *navigation function* [1] is based on the quotient of the components responsible for attraction to the goal and the ones associated with the collision avoidance.

This approach is much more computationally complex and requires exact knowledge of the environment, including goal location. These properties are not always known in real applications, but if they are known, the navigation function approach provides a solution for almost all initial positions. An example of the experiment is shown in Fig. 1. In this case one of the obstacles is non-convex, star-shaped. It is transformed to the circle and the path is computed in auxiliary space containing only circles. Then, resulting vector being the expected direction of motion is transformed into the real space.

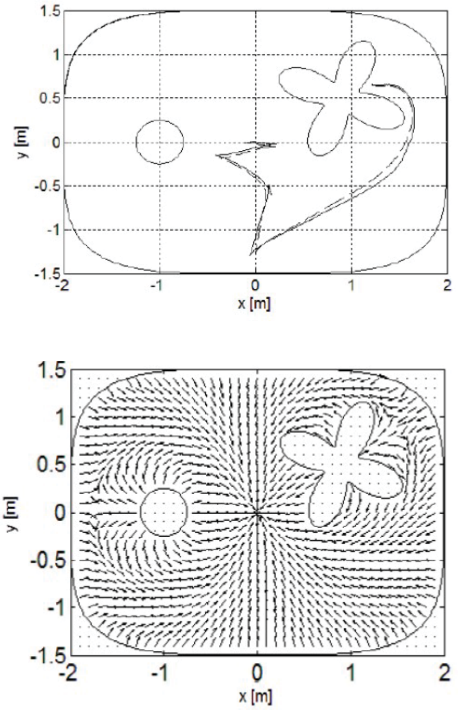

Fig. 1. Robot's path in the environment with obstacles (solid line – experiment, dashed line - simulation); vector field.

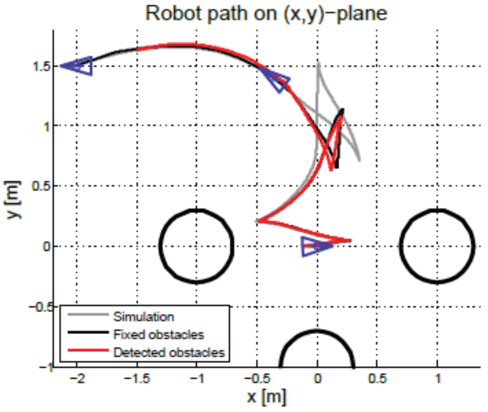

Fig. 2. Robot's path in three experiments: numerical simulation, fixed obstacles (their locations were known a'priori), obstacles detected using laser range finders and used to reconstruct the model of the environment

Presented concepts were practically tested (Fig. 2) in the Institute of Automation and Robotics at Poznań University of Technology using various mobile platforms: MiniTracker, MTracker, Kuka youBot and RobReX, [2], [3], [4], [5], [6].

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