

# Abstract

The increasing interest in the collaboration between humans and machines has led to the development of collaborative robots, called cobots, both in manufacturing plants, to help the workers with their tasks, and in the medical sector, to improve the effectiveness of physical therapy. Most of these robots have to interact and move in unknown environments that are often crowded. Such operations are non-trivial, because the knowledge that the robot has about its surroundings is often limited; moreover, they require complex control strategies that work only in very specific conditions.

This thesis tackles this problem with an innovative approach. A controller for a differential drive robot is designed to track and follow a target in a moving multiple-obstacles environment. The control structure is composed by three layers:

1. Machine learning-based identification of obstacles and target;
2. DS-based motion planner for target tracking;
3. Model Predictive Control (MPC) low-level controller.

To continuously map points cloud data (LIDAR) to a probability distribution of the obstacles over the 2D motion space, two algorithms have been implemented: a first one using a Gaussian Mixture Model, and a second one using a K-means clustering algorithm. A DS-based motion planner, relying on the modeling of the obstacles distributions, generates feasible trajectories for reaching and following the target while avoiding obstacles. The MPC-based low-level controller is in charge of generating the control law to follow the desired trajectories.

Evaluation of the whole system architecture and control has been performed in simulation using Python and with raw data of moving people. Results show that the proposed approach is feasible for real-time control implementation, with the main limitation being the computational cost for the non-linear MPC.

From this study it is possible to conclude that the control architecture presented in this work has the following advantages:

- the implementation of Machine Learning algorithms for the obstacles detection guarantees high performances, responsiveness and stability;

- the DS-based motion planner provides a reactive and robust to perturbation behaviour with instantaneous trajectory re-planning based on the robot spatial location;
- MPC-based controller guarantees optimality of the proposed control-law for trajectory following;
- the modular structure allows for fast adaptation to different robotic systems.

The main disadvantage of this solution consists in the computational timing, because, in order to have consistent control inputs from the MPC, the prediction horizon has to be large enough, which causes the computational cost to be quite high.