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Abstract

We propose a method for collision-free coordination of a group of unicycle mobile robots, which can be used for transportation tasks in large warehouses. A supervisory system assigns to each robot its reference path, together with the preferable velocity profile as a function of position along the path. The reference paths and velocity profiles do not necessarily prevent collisions among the robots. Feedback controllers of individual robots coordinate the robot motions along the assigned paths to ensure collision-free movements.

To design a collision-free tracking control scheme, we make use of a standard kinematic model of unicycle robots in Cartesian space [1]. From this model we derive equations of tracking error dynamics. Unlike the error equations that are often used in the literature, e.g. [1], we present equations such as to reveal some intrinsic properties of the error dynamics. By making use of these properties, we simplify derivation of tracking motion controllers using Lyapunov's direct method. While explicitly accounting for constraints on input signals, these controllers ensure global asymptotic convergence of the tracking errors to zero values. Although derivation of the control law mimics approach proposed in [2], in our work we modify Lyapunov function in order to improve performance of the resulting motion controllers.

To accommodate specific layouts of robot trajectories in the warehouses, we prove that our controller guarantees global asymptotic convergence of the tracking errors even if the reference angular robot speeds are discontinuous. This is relaxation with respect to [2], where the uniform continuity of the angular speeds was required.

We suggest an effective feedback method for collision-free robot coordination. This method employs penalty functions to reduce reference speeds of robots of lower priority. Feedback variables are the arguments of the penalty functions. To avoid deadlocks in the transportation, all mobile robots must have non-equal priorities during execution of their tasks. Quality of the collision-free robot coordination has been verified both in simulations and in experiments. At the top in Fig.1 we present a layout of robot paths that we used in the experiments. Apparently, starting robot positions were away of the reference paths. Despite the initial errors, all the robots converge to their references and proceed along without collisions. Nonzero values of experimentally recorded distances to collision, shown at the bottom in Fig. 1, confirm collision avoidance.

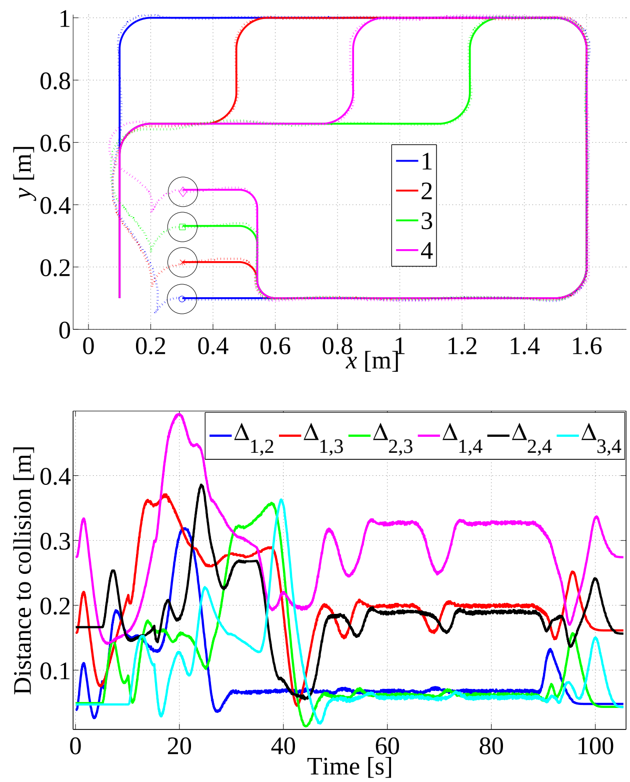

Figure 1: Top: reference (solid) and actual (dotted) paths; bottom: evolution of measured distances to collision.

References

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