Collision-free motion coordination of unicycle multi-agent systems

Dragan Kostić,[1] Sisdarmanto Adinandra,[2] Jurjen Caarls,[3] and Henk Nijmeijer[4]
Department of Mechanical Engineering
Technische Universiteit Eindhoven
P.O. Box 513, 5600 MB Eindhoven
The Netherlands
Email: {[1]D.Kostic, [2]S.Adinandra, [3]J.Caarls, [4]H.Nijmeijer}@tue.nl

Abstract

We propose a collision-free motion coordination of a group of unicycle agents. The agents are characterized by nonholonomic kinematics of a unicycle, such as wheeled mobile robots and unmanned aerial vehicles. While the reference trajectories of interacting agents make a time-varying formation, our control strategy achieves globally asymptotically stable tracking of these trajectories and coordination between the interacting agents, both under constraints on the actuator inputs. The coordination takes care that after perturbation of one or several agents, the formation is recovered even before the tracking errors of all individual agents converge to zero. The proposed strategy is an extension of the control design presented in [1], in terms of mutual coupling of motion controllers of the individual agents. The controller couplings yield robustness of the formation to perturbations.

Robustness is further strengthened by means of an algorithm for collision avoidance. This algorithm runs at each agent locally and is based on the concept of the artificial potential functions. The algorithm achieves collision avoidance by real-time modifications of the reference trajectories of the individual agents.

Quality of the collision-free motion coordination is experimentally verified. A layout of robot paths is shown at the top in Fig.1. To verify formation keeping, we perturb the formation three times, by manual robot repositioning. Each time a robot is repositioned, the other ones start moving away from their reference trajectories aiming to restore the prescribed formation. After recovering the formation, the robots continue tracking their own reference trajectories. At the bottom in Fig.1, we show the tracking errors together with errors in keeping the formation. This figure confirms that the transients of the formation errors are faster than the transients of the tracking errors.

The main contributions are: *i*) Lyapunov based design of saturated feedback tracking controllers that achieve global asymptotic stable motion coordination of multi-agent unicycle systems, *ii*) global asymptotic tracking of time-varying formations, where the forward and steering velocities of the individual agents can all be mutually different, while the steering velocities can even be discontinuous, *iii*) flexible controller tuning and intuitive adjustment of robustness of motion coordination with respect to perturbations, *iv*) real-time collision avoidance, and *v*) experimental verification.

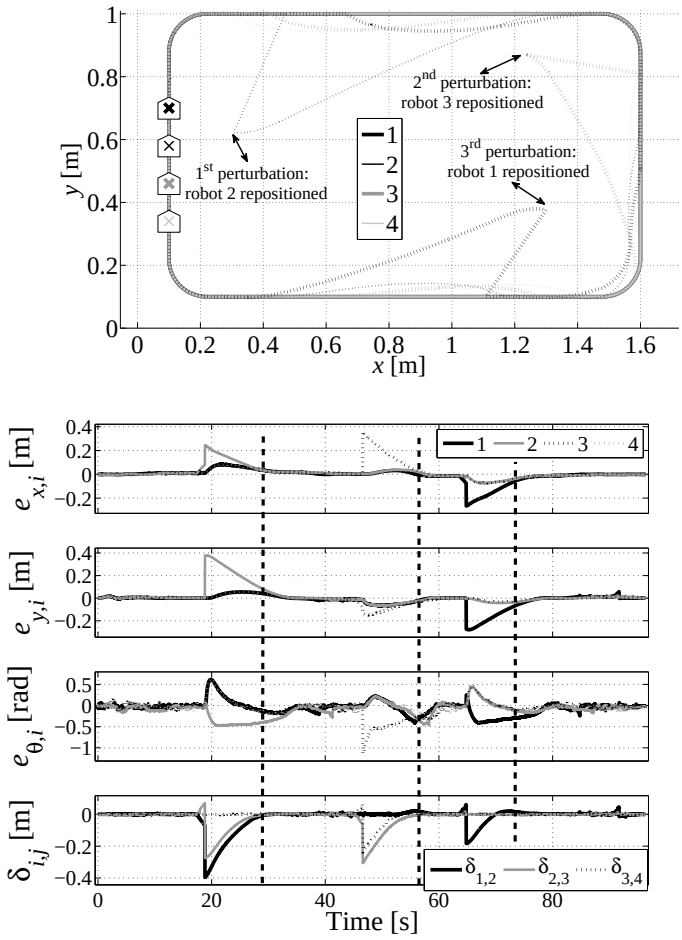

Figure 1: Top: reference (solid) and actual (dotted) paths; bottom: errors in tracking and formation keeping.

References

[1] D. Kostić, *et al.*, "Collision-free Tracking Control of Unicycle Mobile Robots," *Proc. IEEE Conf. Dec. and Control*, pp. 5667-5672, Shanghai, China, 2009.