Announcing the Final Examination of Jiangmin Chunyu for the degree of Doctor of Philosophy

Time & Location: October 27, 2010 at 3:00 PM in HEC 450
Title: Reactive Control of Autonomous Dynamical Systems

This thesis mainly consists of five independent papers concerning the reactive control design of autonomous mobile robots in the context of target tracking and cooperative formation keeping with obstacle avoidance in the static/dynamic environment.

Technical contents of this thesis are divided into three parts. The first part consists of the first two papers, which consider the target-tracking and obstacle avoidance in the static environment. Especially, in the static environment, a fundamental issue of reactive control design is the local minima problem (LMP) inherent in the potential field methods (PFMs). Through introducing a state-dependent planned goal, the first paper proposes a switching control strategy to tackle this problem. The control law for the planned goal is presented. When trapped into local minima, the robot can escape from local minima by following the planned goal. The proposed control law also takes into account the presence of possible saturation constraints. In addition, a time-varying continuous control law is proposed in the second paper to tackle this problem. Challenges of finding continuous control solutions of LMP are discussed and explicit design strategies are then proposed.

The second part of this thesis deals with target-tracking and obstacle avoidance in the dynamic environment. In the third paper, a reactive control design is presented for omni-directional mobile robots with limited sensor range to track targets while avoiding static and moving obstacles in a dynamically evolving environment. Towards this end, a multi-objective control problem is formulated and control is synthesized by generating a potential field force for each objective and combining them through analysis and design. Different from standard potential field methods, the composite potential field described in this paper is time-varying and planned to account for moving obstacles and vehicle motion. In order to accommodate a larger class of mobile robots, the fourth paper proposes a reactive control design for unicycle-type mobile robots. With the relative motion among the mobile robot, targets, and obstacles formulated in polar coordinates, kinematic control laws achieving target-tracking and obstacle avoidance are synthesized using Lyapunov based technique, and more importantly, the proposed control laws also account for possible kinematic control saturation constraints.

The third part of this thesis investigates the cooperative formation control with collision avoidance. In the fifth paper, firstly, the target tracking and collision avoidance problem for a single agent is studied. Instead of directly extending the single agent controls to the multi-agents case, the single agent controls are incorporated with an existing cooperative control design. The proposed decentralized control is reactive, considers the formation feedback, and allows topological changes in the sensing and communication networks. Since the proposed control is based on a potential field method, its inherent oscillation problem is also addressed to improve group transient performance.

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Approved for distribution by Zhihua Qu, Committee Chair, on October 10, 2010.

The public is welcome to attend.