HYBRID SYSTEM BASED DESIGN FOR THE COORDINATION AND CONTROL OF MULTIPLE AUTONOMOUS VEHICLES

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In recent years, the use of unmanned aerial vehicles (UAVs) has gained considerable attention for applications where manned operation is considered dangerous or infeasible. As the number of UAVs in operation rises, it will become necessary to coordinate these vehicles. It can be shown that a real-time system can be modeled using a hybrid automaton provided that certain guarantees can be made about the temporal properties. By using the hybrid automata to model the system composed of a multi-modal dispatcher and waypoint/motion controller in addition to a real-time UAV controller, we show that the hybrid system can bisimulate a timed automata model created using a tool called UppAal, which can verify specifications about a given system. We thereby coordinate multi-robot movement while ensuring that certain constraints have not been violated.

In this thesis we present a design methodology for developing autonomous vehicle controllers using a model-based approach and a hybrid automata to represent the closed-loop control system. The vehicle system is composed of an outer system and an inner system. A nonlinear controller is designed for the outer system based back-stepping and differential flatness methods. The inner controller is designed based on the inner model that is identified by using sub-space method. The system state estimate is provided by an Extended Kalman Filter. A multi-modal system is constructed by switching between various closed loop dynamics based on high-level commands. This system is modeled as a hybrid system that is bisimular to the timed automata, the performance of which can be verified with model-checking tools. In addition, the high level commands generated as a result of the specification verification are used to drive the system.

In addition, we present the Vanderbilt Embedded Computing Platform for Autonomous Vehicles (VECPAV). The automated development platform greatly speeds the controller and system development and deployment phases by reducing the programming and compilation burden on the lab researchers, and eliminating the risks associated with translating code manually.

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