Doctoral Dissertation
Doctoral Program in Computer and Control Engineering (31st cycle)

Data Fusion Methods and Algorithms in the Context of Autonomous Systems

A path planning algorithms analysis and optimization exploiting fused data

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Summary

The Goal of robotics is to improve people's quality of life in several ways as well as in different areas. In recent years autonomous systems have been conquering more and more space in our daily life. Clear examples are given by robots able to help doctors during complex surgery and robots assisting people with disabilities. Furthermore robots are changing the approach of transportation and mobility. Our cars, in fact, are becoming day by day less human dependent and the final goal is to reach a complete autonomy of the entire transportation system. Autonomous cars will improve the quality of our daily life in different ways: blind people could conquer their own freedom moving around, commuters could boost their productivity exploiting the time previously used to drive towards the workplace, traffic jam and accidents would be dramatically reduced and so on. However, the process is slow and far from completed. Current technology, in fact, is not advanced enough to handle the entire involved complexity. On the other hand end users are not yet ready for this type of change.

This work focuses on the study of path planning problems analyzed in two different realms: (1) autonomous cars and (2) service robotics. The complexity in path planning is introduced by factors like tolerance to planning errors, real time constraints, machine constraints, risk management and so on. The presented scenarios are different but they share several characteristics such as real time constraints or the strict interaction with the end user. In the former we studied the applicability of GPGPU hardware to improve the trajectory generation in a highway scenario. We show how exploiting the computational power of GPGPUs can significantly reduce the trajectory generation time and selection (15 ms for the GPGPU version against 86 ms for the CPU version in generating 3125 trajectories) and how the entire system can receive benefits from this performance boost.

While for the second domain (service robotics) we designed a framework in which a robot can semantically navigate the environment interacting with objects in the scene. Environment understanding and interaction, in fact, significantly affect the robot navigation ability. We provided a state machine model, which includes techniques for error recovery, supporting a robust navigation. As a case of study we also present an approach to the door opening problem. We evaluated our framework for navigation and door-opening approach in a challenging realistic scenario inspired by *Robocup 2018* tasks. Our results show the robustness and flexibility of our approach and its high applicability by using a standard service robot.