Mobile Robot Navigation and Control: A Case Study

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Introduction

Robotic systems (and in particular mobile autonomous agents) embody a complex interaction of computational processes, mechanical systems, sensors, and communications hardware. System integration can present significant difficulties to the construction of a real system, because the hardware is often built around convenience of design rather than convenience of system integration. Nonetheless, in order for robots to perform real-world tasks such as navigation, localization and exploration, the different subsystems of motion, sensing and computation must be merged into a single, realisable unit.

Our group is investigating particular problems in the domain of computational perception, in the context of mobile robotics. In particular, we are concerned with environment exploration, position estimation, and map construction. We have several mobile platforms integrating different sensing modalities, which we are able to control simultaneously from a single source.

Methodology

To support this work, we have developed a layered software architecture, that facilitates a modular approach to problems, in addition to building an abstraction of a robotic system (Dudek & Jenkin 1993). Our architecture involves three software layers: on-board real-time subsystems, off-board hardware-specific systems that abstract away hardware dependencies, and top-level "client" processes. This abstraction allows external software to interact with either a simulated robot and environment or a real robot complete with sensors. The implementation is distributed across a network, and allows software to run on remote hardware, thus taking advantage of specialized hardware available on the network.

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In appreciation of the necessity of simulation in addition to real-robot control, we have developed a graphical environment for the development of algorithms and software for mobile robotics. The environment was produced as a result of the recognition that progress in mobile robotics entails a progression from basic implementation of simple routines, through to the development of efficiently-implemented algorithms. With these considerations in mind, we have constructed a control and development interface for mobile robotics experiments that permits a single robot to be controlled and/or simulated using any combination of manual experimentation, simple automation and high-level algorithms.

Implementation

In the context of the AAAI competition, we are tapping this infrastructure by rapidly constructing a set of client processes which embody task specific objectives for the meeting scheduling problem. The client processes group simple sonar measurements into clusters used to classify regions of the map according to a simple labelling hierarchy. By recognizing and following corridors in the environment, the system travels between open spaces, or corridors using a set of simple control heuristics.

Our software tool allows us to transparently control and simulate several different types of mobile robots. In addition, our work entails the use of a variety of sensing modalities, for example, sonar, laser-range, tactile sensing (Roy, Dudek, & Freedman 1996) and video images. Furthermore, we have developed a customized video and range-sensing platform called Quadris. The Quadris sensor can be used to further refine the labelling hypotheses generated from sonar data.

Long-term Development

Our long term objectives involve using these tools to examine questions of spatial representation and exploration. In particular, we have performed image-based positioning (Dudek & Zhang 1996), model-based localisation and exploration (MacKenzie & Dudek 1994), and topological map representation and exploration. We are also working on extending this work to collaborative multi-robot exploration, with several agents performing independent exploration and fusion of spatial information (Roy & Dudek 1996).

References

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