Towards a Distributed Robotic Architecture for Autonomous Heterogeneous Platforms

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Abstract

This paper describes an early phase towards a general, holistic, distributed robotic architecture capable of supporting different domain specific tasks autonomously or semi-autonomously on multiple platforms. Rather than focusing on individual components and algorithms, we take a systems level approach striving for a task-independent architecture. From a military perspective, our ultimate goal is to employ autonomous scouts that augment a military unit with additional reconnaissance and security assets. We envision one soldier commanding and controlling a mix of three to five ground and aerial robots in contrast to one solider controlling a single robot as seen in currently deployed systems. Such a general, robotic architecture may be useful in other domains to include law enforcement, search and rescue, hospital logistics, and domestic use. From an educational perspective, we desire a general, modularized framework that can support undergraduate Electrical Engineering, Computer Science, and Information Technology capstone projects. The paper discusses the architectural design and describes current implementations that include common hardware, software, distributed control system, web-based operator control unit (OCU), and a set of heterogeneous robots to demonstrate interoperability.

Our prototypes use common off-the-shelf devices and open software interfaces targeting small, unmanned ground wheeled and tracked vehicles. The scenarios demonstrate an operator designating a destination pose for two, heterogeneous robots (one wheeled and one tracked) where each robot uses the same high-level control software and platform-dependent, low-level software. The robots navigate autonomously to the operator-determined destination in an indoor environment (i.e. without a global position system) containing both static and dynamic obstacles. The system uses common off-the-shelf devices and open software interfaces. The operator designates checkpoint locations through a web-based interface and communication occurs over a standard TCP/IP connection using an 802.11g wireless physical medium. A web-based, application tier, interprets user commands, communicates with the robot and provides visual feedback.

High-level control computations are onboard an x86 processor minimizing network traffic and enabling short-term, disconnected operations. The onboard software controller is responsible for localization, path planning, obstacle detection, and navigation. The robots localize using an adaptive Monte Carlo algorithm. An 8-bit microcontroller connects to the onboard microprocessor and is responsible for processing the sensor and servo data associated with the platform. The sensor suite includes LIDAR, quadature wheel or track encoders, and a video camera for operator feedback.

After presenting the prototypes, we propose an extended architectural design that leverages the lessons learned from previous implementations. We step back and present a more general, task-independent architecture that proposes the use of a cognitive architecture for high-level control. Since we are ultimately concerned with how one component of the architecture, whether it is hardware or software, constrains other components, we are working towards the Joint Architecture for Unmanned Systems (JAUS) compliance. We finish the paper with related work and a conclusion.

The paper is relevant to the conference, as our goals focus on applied research and education. Rather than deriving the next best hardware component or a specific algorithm, we consider the design and implementation of the end-to-end system from low-level hardware to device drivers, on board control software, and distributed command and control hardware and software.

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