Some Issues and Applications of Multi-robot Cooperation

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Abstract

There are many applications of multi-robot cooperation. They include factory floor, emergency response and rescue, homecare, natural resource monitoring, and outdoor industrial operations such as fault diagnosis and repair. This talk will address several relevant issues in such applications of cooperative robotics, particularly: sensing and instrumentation, control, and networked operation. Two specific domains of application will be given primary focus. They are outdoor emergency response and homecare robotics.

In one application, a cooperative multi-robot system provides emergency services such as clearance, cleanup and human rescue in a disaster situation in an urban environment. In this application it is assumed that the available robots are heterogeneous with different types and levels of resources and capabilities and are not specifically designed for the emergency application. The robots will have their regular tasks for which they are designed (e.g., trash clearing, traffic control, providing assistance to the elderly and the disabled, surveillance, environmental monitoring, fault diagnosis and repair of a material distribution network). Also it is assumed that there is a means for communicating with robots from any location (e.g., wireless sensor network). When called upon to carry out an emergency operation, the available robots in the neighborhood will quickly navigate to the site and will negotiate the necessary tasks based on the needs, the robot capabilities, and the available material and other resources. Then they will carry out cooperative tasks to provide appropriate assistance (e.g., construction of a carriage or cart, rescuing humans, providing first aid).

The second application concerns homecare robotics. This may involve autonomous robots that provide basic and routine assistance to the elderly and the disabled in a home setting (e.g., serving food and medicine, cleaning, bathing, and aiding mobility); and bilateral teleoperation of a robot from a hospital control room to provide professional assistance (e.g., first aid) while the traditional emergency help is forthcoming. The vast majority of the elderly and the disabled prefer to maintain independent households. A significant fraction of the public cost for supporting the disabled and the elderly goes into homecare and related expenses. In this context, the benefits of homecare robotics are tremendous. In particular, the quality of life of the elderly and the disabled will improve, allowing them more flexibility and comfort, in the presence of round-the-clock and reliable care. Also, other members of the household will have increased freedom and peace of mind to pursue their normal activities including employment and education. Furthermore, the related public spending will be more uniform, fair, and cost effective. In the application scenario, one or more robots will be available with their local sensors and a range of networked global sensors in the home environment. Adequate robotic intelligence is crucial for autonomous operation while haptic feedback is important in teleoperation. Sensory, mobility, grasping, manipulation, and control capabilities are needed for both categories of operation. The needed basic technologies of robotics, networked communication, control, and teleoperation are sufficiently mature and are available at reasonable cost. Further development is needed in assistive technologies, specialized end-effector devices, and haptics.

The talk will particularly highlight key technologies of sensing, instrumentation, object identification and localization, detection and evaluation of abnormal motions in humans, robotic navigation in the presence of static and dynamic obstacles, grasping and manipulation, networked intelligent sensor fusion and feedback, impedance control in haptic teleoperation, and stable operation, which are pertinent in both application domains. An integrated intelligent approach may be used for the coordinated operation and control of a multi-robot system. In particular, a common system architecture with optimally self-adaptive, intelligent, and dynamic agent network may be implemented for multiple engineering applications. This is an innovative paradigm. The operation of the networked multi-robot system may be optimized by sharing resources among the applications. Dynamic/mobile sensors will receive “feedback” from themselves, to improve their sensing effectiveness (e.g., data/information quality, relevance of their data, speed, confidence). The networked agents will possess some degree of “intelligence” to facilitate autonomous operation and to achieve the desired performance. The system will be able to predict, detect, and diagnose malfunctions and faults in it and accommodate or self-repair them.

978-1-5090-1915-1/16/$31.00 ©2016 IEEE