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DISTRIBUTED ROBOTICS AND AD HOC NETWORKING

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Abstract: - Distributed robotics is an interdisciplinary and rapidly growing area, combining research in computer science, communication and control systems, and electrical and mechanical engineering. Distributed robotic systems can autonomously solve complex problems while operating in highly unstructured real-world environments. They are expected to play a major role in addressing future societal needs, for example, by improving environmental impact assessment, food supply, transportation, manufacturing, security, and emergency and rescue services.Multi-robot systems are poised for impact in the future of robotics. Robots will work together on factory floors to make manufacturing more efficient and cost effective, they will coordinate as our teammates during rescue missions in disaster zones, and they will be our eyes in places that we cannot reach such as in space and on other planets.

KEYWORDS: Agent-Based Multi-Platform Control (MPC); Automatic Mapping; Distributed Robot Architectures (DIRA)

INTRODUCTION:

Information exchange is essential for coordination with humans and with other robots. Currently, wireless communication is largely unreliable in the field; and this unreliability is keeping multi-robot teams from reaching their full impact in the real world .In WNR, the role of communication is to faster cooperation and information sharing among the devices and to permit that mission objectives and task division lead actions, communications and reasoning of the devices. Communication can be explicit when the devices exchange information with each other regarding their internal status, their roles and the target of the mission or implicit when they ground their decisions according to the sensing and observation of the surrounding devices. In both cases, communication schemes for coordination and control of groups of intelligent devices can draw inspiration from natural systems, where common objectives are pursued through the explicit or implicit interaction of single, resource constrained elements of a group. More specifically, swarm intelligence and swarm robotics offer several solutions for the coordination of devices based on direct/indirect communications. At the same time, the motion capabilities of the devices call for a new communication paradigm, where mobility is seen as a facility to exploit in order to improve the performance of the network. In this direction, the classical ISO/OSI layered approach for communications should be reconsidered in order to include the mobility of the devices among the network control primitives, as well as evolution and optimization. In fact, in WNR some or all of the devices are expected to have memory and reasoning capabilities, which allow them to use the input coming from other devices, the environment and their history to select the best behavior to assume according to mission objectives. Therefore, machine learning and cognitive networks concepts and algorithms would greatly contribute to WNR theory and algorithms.

Novel Algorithm:

A Novel algorithm for sensing communication with higher accuracy and resolution than what was previously attainable for small agile robot platforms; using only a single off-the-shelf Wi-Fi antenna and local robot motion. This results in the ability of using communication as a high-fidelity sensor. Using this capability, deriving new control algorithms that can autonomously establish and repair communication links to other robots in the network; even in unknown and unexplored environments. I will show that the ability to use communication, not only to transmit messages but also as a physical signature for each transmitting agent, opens the door to many extensions and applications for multi-robot systems. In addition to establishing adaptive ad-hoc networks, I will discuss an application to cyber security in multi-robot teams where each transmitted message by a given robot can be used to provably discern whether that robot is malicious or benign in the context of a Sybil Attack; where malicious robots can spoof or spawn false identities to gain a disproportionate influence in the network. This talk will present several experimental results in hardware for heterogeneous multi-robot systems consisting of iRobot Create and AscTec Hummingbird platforms, in indoor environments.

Agent-Based Multi-Platform Control (MPC)

The MPC program here the communications framework that included 1) guaranteed messaging with all connected platforms, 2) agents that maintained network connectivity, and 3) tele-operation of remote platforms. This layered infrastructure of wired/wireless networking services, proxy and distributed processing, agent-based behaviors, remote tele-operative services, and mixed-initiative planning and scheduling technologies that would support the planning, control, coordination, and reconfiguration across multiple robotic platforms in a distributed set of Future Combat System (FCS) platforms. The design maximized commonality, reuse, and adaptability across platform type and configurations. The design includes approaches for controlling platforms within tele-operational, semi-autonomous/ supervisory, and fully autonomous modes. This provides the remote platform operator with maximum control and flexibility over multiple platforms and vehicles. The development effort concentrated on reusable components for Army/DOD applications across multiple robotic platforms. The MPC system concept approach starts with the MPC system supporting re-supply, logistics, and other various material-handling missions. These missions are input to the MPC planning component and, with optional user interaction, are decomposed into a set of partially ordered tasks. These tasks are sent to the MPC scheduling component and merged into a schedule of multiple missions, also with optional user interaction. During execution, the progress of planned tasks must be monitored for possible deviation from the tasks' goal. Also, any coordination between the tasks must be supported by the MPC environment. If any deviation is detected, the tasks' progression/course must be dynamically redirected back on track, and if that fails, then the task needs to be halted and a new plan/task needs to be planned and scheduled. The process employed by the MPC system is to assign intelligent software agents (called Task Agents) to each task on the schedule. The MPC agents are launched or instantiated onto a processor within the network. Each agent has the purpose of controlling the execution of its assigned task, and is responsible for a successful task completion. Other agents are also instantiated and launched to monitor the Task Agents, and to aid in the coordination between tasks as guided by the schedule. The execution component consists of the active MPC agents accomplishing their assigned tasks. Some agents are assigned a specific task from the schedule (Task Agents). Some are supporting a task by collecting and supplying input data to a Task Agent. Others are created to control the coordination between tasks (Coordinated-Behavior Agents), which is also as specified in the schedule. Finally, additional agents are created to monitor the schedule execution for: valid execution, successful completion, and dynamic recovery from deviations to the expected results. As execution progresses, there may be points in a task where the robotic platform is required to be tele-operated by the human MPC operators. This could be due to defined points of tele-operation in the task that were designated by the human operator during the planning or scheduling phases. They also could be due to the MPC agents deciding that the platform's execution of the task has deviated too far from expected operation, and thus the agents will summon the human operator to intervene and take control. In either case, there is a tele-operation handoff from the agent, and then when the human operator has accomplished her part, there is a release of the tele-operation control back to the controlling task agent. Such handoff/release mechanisms provide a smooth transition between controlling entities, and are critical to effective and errorless control of the platforms.

Automatic Mapping (MRCOPS)

Placing robots in harm's way instead of soldiers is a proven, cost-effective way to reduce combat casualties; however, today's tactical robotic systems remain largely tele-operated by humans. MrCoPS is a semi-autonomous approach for improving the success and operations tempo (optempo) of search missions within urban environments by increasing the robot-to-operator ratio .MrCoPS coordinates multiple robots as they cooperatively search and map a physical structure (such as a building), exchanging map fragments between robots and the human operator(s) to rapidly develop complete situational awareness of the surveilled area. Each robot in a MrCoPS team operates autonomously to search and map an unknown area, but the robots' autonomous behavior can be overridden by the human operator(s), who may elect to tele-operate a particular robot or simply re-task the robot to search a particular sub-region. The result is faster, more accurate situational awareness .MrCoPS allows the operator(s) to guide the robots through the building as the robots autonomously, and collaboratively, search unknown spaces and build a composite map of the building. Though initially targeted at the iRobot PackBot, MrCoPS can be adapted to any robotic platform, whether terrestrial or airborne.

Challenges:

The main technical challenge is to develop an architectural framework that permits a high degree of autonomy for each individual robot, while providing a coordination structure that enables the group to act as a unified team. Our approach is to extend current state-of-the-art hierarchical, layered robot architectures being developed at CMU (TCA), TRACLabs (3T) and NIST (RCS) to support distributed, coordinated operations. Our proposed architecture is highly compatible with these single-agent robot architectures, and will extend them to enable multiple robots to handle complex tasks that require a fair degree of coordination and autonomy.

Conclusion:

I will conclude by presenting interesting avenues for future research at the intersection of communication and robotics including Wi-Fi enabled accurate indoor positioning systems, communication as a sensing medium for autonomous driving, and new communication channels for natural human-robot interaction.

REFERENCES:

[1] E. Kadioglu, N. Papanikolopoulos, "A Method for Transporting a Team of Miniature Robots," Proceedings of the 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems.
[2] P. E. Rybski, F. Zacharias, J. F. Lett, O. Masoud, M. Gini and N. Papanikolopoulos, "Building Topological Maps with Sensor-Limited Miniature Mobile Robots," Proceedings of the 2003 IEEE International Conference on Robotics and Automation.
[3] J. L. Pearce, P. E. Rybski, S. A. Stoeter, N. Papanikolopoulos, "Dispersion Behaviors for a Team of Miniature Robots," Proceedings of the 2003 IEEE International Conference on Robotics and Automation.

[4] Sascha A. Stoeter, Ian T. Burt, Nikolaos Papanikolopoulos. Scout Robot Motion Model. Proceedings of the IEEE International Conference on Robotics and Automation, Taipei, Taiwan, May 2003.

[5] Andrew Drenner, Ian Burt, Bradley Kratochvil, Brad Nelson, Nikolaos Papanikolopoulos, Kemal Berk Yesin, "Communication and Mobility Enhancements to the Scout Robot" Proceedings of the 2002 IEEE/RSJ International Conference on Intelligent Robots and Systems, Lausanne, Switzerland, Oct. 2002.

[6] S. A. Stoeter, P. E. Rybski, M. Gini, N. Papanikolopoulos, "Autonomous Stair-Hopping with Scout Robots" Proceedings of the IEEE International Conference on Intelligent Robots and Systems, pp. 721-726, Lausanne, Switzerland, September/October 2002.

[7] P. Rößler, S. A. Stoeter, P. E. Rybski, N. Papanikolopoulos, "Visual Servoing of a Miniature Robot Toward a Marked Target," Proceedings of the International Conference on Digital Signal Processing, Santorini, Greece, July 2002

[8] .Drenner, I. Burt, T. Dahlin, B. Kratochvil, C. P. McMillen, B. Nelson, N. Papanikolopoulos, P. E. Rybski, K. Stubbs, D. Waletzko, K. B. Yesin, "Mobility Enhancements to the Scout Robot Platform," Proceedings of the 2002 IEEE International Conference on Robotics and Automation, pp. 1069-1074, Washington, DC, May 2002.

[9] D. P. Perrin, E. Kadioglu, S. A. Stoeter, N. Papanikolopoulos, "Localization of Miniature Robots Using Constant Curvature Dynamic Countours," Proceedings of the 2002 IEEE International Conference on Robotics and Automation, pp. 702-707, Washington DC, May 2002.

[10] P. E. Rybski, A. Larson, A. Schoolcraft, S. Osentoski and M. Gini, "Evaluation of Control Strategies for Multi-Robot Search and Retrieval," Proceedings of The 7th International Conference on Intelligent Autonomous Systems (IAS-7), pp. 281-288, Marina del Rey, CA, March 2002.

[11] C. P. McMillen, K. Stubbs, P. E. Rybski, S. A. Stoeter, M. Gini, N. Papanikolopoulos, "Resource Scheduling and Load Balancing in Distributed Robotic Control Systems," Proceedings of The 7th International Conference on Intelligent Autonomous Systems (IAS-7), pp. 223-230, Marina del Rey, CA, March 2002.

[12] P. E. Rybski, S. A. Stoeter, M. Gini, D. F. Hougen, N. Papanikolopoulos, "Effects of Limited Bandwidth Communications Channels of the Control of Multiple Robots," Proceedings of the 2001 IEEE International Conference on Intelligent Robots and Systems, pp. 369-374, Maui, HI, October 2001.

[13] P. E. Rybski, I. Burt, T. Dahlin, M. Gini, D. F. Hougen, D. G. Krantz, F. Nageotte, N. Papanikolopoulos, S. A. Stoeter, "System Architecture for Versatile Autonomous and Teleoperated Control of Multiple Miniature Robots," Proceedings of the 2001 IEEE International Conference on Robotics and Automation, Seoul, Korea, May 2001.

[14] D. F. Hougen, M. D. Erickson, P. E. Rybski, S. A. Stoeter, M. Gini, N. Papanikolopoulos, "Autonomous Mobile Robots and Distributed Exploratory Missions," Fifth International Symposium on Distributed Autonomous Robotic Systems (DARS), Knoxville, TN, October 2000.

[15] S. A. Stoeter, P. E. Rybski, M. D. Erickson, M. Wyman, M. Gini, D. F. Hougen, N. Papanikolopoulos, "A Robot Team for Exploration and Surveillance: Design and Architecture," Proceedings of the International Conference on Intelligent Autonomous Systems 6, pp. 767-774, Venice, Italy, July 2000.

[16] N. Papanikolopoulos, S. A. Stoeter, P. E. Rybski, M. Gini, D. F. Hougen, M. Erickson, "Experiments with a Team of Miniature Robots," Proceedings of the IEEE Mediterranean Conference on Control & Automation, Rio, Greece, July 2000.

[17] P. E. Rybski, S. A. Stoeter, M. D. Erickson, M. Gini, D. F. Hougen, N. Papanikolopoulos, "A Team of Robotic Agents for Surveillance," Proceedings of the Fourth International Conference on Autonomous Agents, pp. 9-16, Barcelona, Spain, June 2000.

[18] D. F. Hougen, S. Benjaafar, J. C. Bonney, J. R. Budenske, M. Dvorak, M. Gini, H. French, D. G. Krantz, P. Y. Li, F. Malver, B. Nelson, N. Papanikolopoulos, P. E. Rybski, S. A. Stoeter, R. Voyles and K. B. Yesin, "A Miniature Robotic System for Reconnaissance and Surveillance," Proceedings of the 2000 IEEE International Conference on Robotics and Automation, pp. 501-507, San Francisco, CA, April 2000.

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