Tea Table, Come Closer to Me

Vikas Reddy Enti, Rajesh Arumugam, Krishnamoorthy Baskaran, Liu Bingbing
Foong Foo Kong, A.Senthil Kumar, Kang Dee Meng, Goh Waikit and Wu Xiaojun
A*STAR Data Storage Institute, Singapore
Vikas_reddy@dsi.a-star.edu.sg

ABSTRACT

We present a new concept (named DA vinCi) of distributed agents, sensor networks and an intelligent server catered to the home environment. Instead of a single multi-tasking human-like robot, we propose a team of networked task-specific robotic agents that interface with each other and the environment through a spatial map built by the server. We also highlight how our server will be a proxy for all the human-robot interactions (HRI) in the system and discuss the challenges involved. The paper's title captures the jist of our system where even a *tea table* can be inexpensively mobilized and interacted with via the DA vinCi architecture.

Categories and Subject Descriptors: I.2 [ARTIFICIAL INTELLIGENCE]: Robotics

General Terms: Design.

1. INTRODUCTION

Research funding in personal robotics has increased considerably in the last three years in response to the perceived market size of US$12B by 2015, [2]. Human-like robots are being designed to perform basic household tasks such as cleaning, elderly caring and others. While there are obvious benefits of using a human-like robot in terms of HRI, it is non-scalable and expensive. Also, we speculate that in the near future the boundary between appliances and robots will be non-existent, which thus imposes additional requirements on HRI where a single system will be capable of handling the various modes of interaction. In light of this, we present our DA vinCi architecture where HRI takes place through a proxy which is scalable and multi-modal. Prior work in scalable HRI has been presented in [6] and a very good analysis of current network robotics systems has been provided in [4]. However, there is not much literature available on a system that deals with both.

2. THE DA VINCI CONCEPT

DA vinCi comprises a server, an indoor localization system and task-specific robotic agents as shown in Figure 1. Besides networking robots, DA vinCi's primary purpose is to create a global spatial representation of its environment by fusing all available sensor data with the possibility that no two sensors are on the same agent. Once the spatial map has been constructed, every agent will have access to this data. This has major implications for domestic robots. Let us consider a home which has a vacuuming robot, a floor scrubbing robot, a WiFi enabled camera robot and a robotic toy with an arm. While each robot is fully functional in its own right, these robots still require human intervention and an operating context. The robotic toy with the arm is unable to help move a ball so that the vacuuming robot can clean the corner, where the ball occupies. The camera robot is unable to guide the floor scrubber away from the carpet. We could overcome these shortcomings either by fusing the capabilities of the above robots into a single, multi-tasking humanoid inherently making it complex and expensive or by networking these robots and making each other's resource available to the entire team which is what DA vinCi does.

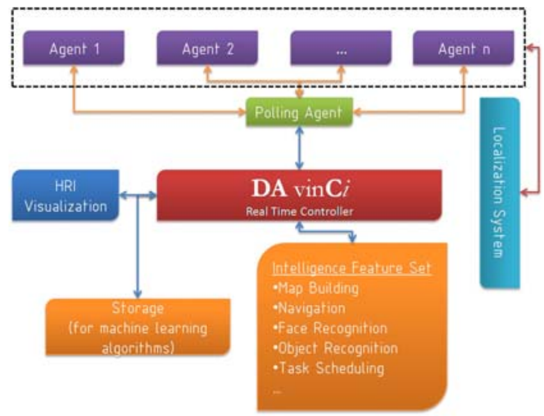

Figure 1: *DA vinCi System Diagram.*

Traditional networked robot architectures were message board architectures that have been successful to some extent in allowing for interfacing sensors across robots, [5]. However, all the communicating robots are required to have sufficient computation power to process the received sensor data. In DA vinCi, the robots can have PCs on board or just a simple embedded controller with WiFi/Zigbee connectivity. Our software architecture, as described later in Figure 2, allows for all the processing to be done on the server, thus requiring the robot to only execute the motor commands transmitted by the server. This implies that robot team members can be designed with just the bare motors, embedded controller and wireless connectivity as long as the server has a sensor source to create its spatial map. The obvious benefit of this is cost reduc-

HRI'09, March 11–13, 2009, La Jolla, California, USA.
ACM 978-1-60558-404-1/09/03.

tion in creating mobile platforms. Hence, trash cans, flower pots, tea tables can all be motorized with low cost DC motors, with microcontroller, localization tag and a Zigbee modem equipped. DA vinCi will then provide these robotics agents the ’intelligence’ to perform their tasks thus making it a very scalable and cost-effective model for automating a home or structured environment with mobile agents. One of major requirements to make such a distributed system feasible is the knowledge of every agent’s location, which is discussed next.

2.1 Localization

For any mobile robot, localization ability is one of the most crucial functions for the robot to carry out any other task. A localization system consisting of cost-effective components and sensors is developed for common home mobile robots, to provide reliable, accurate and long term position information. This localization system utilizes an ultra-wideband radio frequency based indoor GPS system for the reason that the whole group of robots shares the same set of accurate localization system and thus reduces the cost. In order to achieve more reliable localization ability for one single robot, a low-cost dead reckoning sensor, such as an optical wheel encoder, is used together with the indoor GPS tags to provide even more optimal localization results.

2.2 Software Architecture

The software architecture of DA vinCi comprises of a few elements as in Figure 2, with the materialization of the robotic hardware, the Player ([1]), component serves as a network interface between the sensors’ hardware and our core–the server. Player supports multiple concurrent client connections to devices that fulfills our concept in implementing distributed and collaborative robot control applications. While interfacing has been taken care of, a brain module is needed to control and to make intelligent decisions. Drools, a forward chaining inference rules based engine, comes into the picture and handles these sophisticated communications. With object-oriented approach in mind, Drools encourages more natural expression of rules with regards to objects. Lastly, the Java Agent Development Framework (JADE) platform is also utilized in our multi-agent system for distribution of intelligence among the robots.

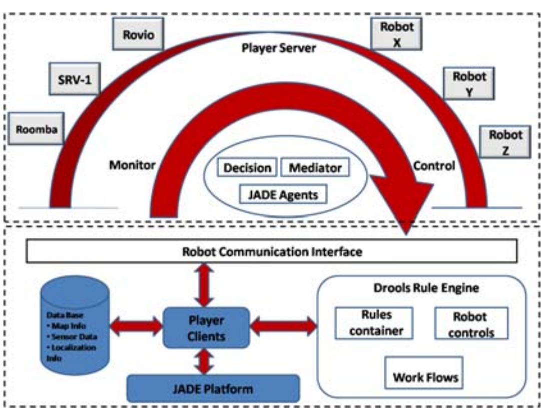

Figure 2: *DA vinCi’s Software Architecture.*

2.3 HRI

Our system is a very good testbed for HRI due to diversity of the available robot population and their modes of interaction. We plan on using existing open source algorithms for gesture tracking, face tracking and the CMU Sphinx ([7]) speech recognition module. We are also working on our data fusion algorithms for spatial layered map visualization for clickable interfacing. Irrespective of the mode used, we foresee challenges in the many to one and many to many interaction scenarios. These scenarios have been well established for the clickable interface but have been poorly demonstrated for gesture and speech recognition, [3]. Since the server is our proxy for all HRI with the system, we envision a rule based command interpretation and polling scheme. Also, since the server is the proxy, greater importance has to be to understand the context of the verbal command. For example, the verbal cue “Tea table, come closer to me” has to be first understood by Sphinx and then given a context by the server with the help of the speaker’s location, identification of the Tea table robot and the conversion of the phrase ‘come closer’ to the corresponding motor command. The obvious benefit of having a proxy is the multi-modal scalability while the major hurdle in our scenario is that all this needs to be done while the server is still keeping track of the entire robot ecosystem and acting as a proxy to other interaction queries.

3. CONCLUSIONS

We have presented our concept of distributed agents in a home environment which will allow for cheaper, task-efficient robots to cooperate and function seamlessly. The same idea can be extrapolated for search, rescue and cooperative surveillance applications. We have elaborated on the usage of the server as a proxy for HRI and discussed the challenges. While there is a perceived benefit of using our system, we have to ascertain its real benefit which is hinged on the cost of implementing a reliable localization system.

4. REFERENCES

[1] The player project. [online], 2009. http://playerstage.sourceforge.net/.

[2] N. Fabris. Major personal robotics components will represent a $12 billion market by 2015. Technical report, ABI Research, 2008.

[3] P. Lapides, E. Sharlin, and M. C. Sousa. Three dimensional tangible user interface for controlling a robotic team. In *HRI ’08: Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction*, pages 343–350, New York, NY, USA, 2008.

[4] A. Saffiotti and P. Lima. Two “hot issues" in cooperative robotics: Network robot systems and formal models and methods of cooperation, 2008.

[5] A. Sgorbissa and R. Zaccaria. The artificial ecosystem: a distributed approach to service robotics. In *IEEE International Conference on Robotics and Automation*, 2004.

[6] A. D. Tews, M. J. Matarid, and G. S. Sukhatme. A scalable approach to human-robot interaction. In *IEEE International Conference on Robotics and Automation*, 2003.

[7] J. Xavier and U. Nunes. The artificial ecosystem: a distributed approach to service robotics. In *LangRo’ 2007 - Symposium on Language and Robots*, 2007.