ON INTEGRATING AUTONOMOUS MOBILE ROBOTS IN AN INTELLIGENT ENVIRONMENT

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Abstract: *Although very few robots actually go to Mars, we continue to design these machines following an antropomorphic paradigm, as if they were organisms operating in a totally unpredictable and hostile environment. In fact, in most situations, the environment in not only predictable, but also can be manipulated to support the missions of the autonomous robot, by including sensors, actuators, computing and communication equipment. In this approach, the robot itself becomes part of a distributed control system, wherein most of the sensing and control elements are located in a manipulated "intelligent environment". This may result in drastic cost reductions of the entire system.*

This paper introduces the concept of "intelligent environment" in robot control and analyzes two case studies of the implementation thereof: one is the problem of integrating autonomous mobile robots in flexible industrial assembly lines, the other is the the general design approach for creating personal robotic assistants for the elderly and disabled.

Some simple experiments illustrating the advantages of the concept are presented.

Keywords: *Autonomous mobile robots, intelligent environment, personal robotic assistant, flexible assembly lines, PLC, HMI*

1. INTRODUCTION

The antropomorphic paradigm we use when designing robots is, sometimes, counterproductive. We tend to expect too much from the robots. They are not necessarily supposed to sense the world the way we do, and their environment is not always unknown, or even hostile. In fact, most service robots operate in an environment that is not only known/predictable, but also can be manipulated to include sensors, actuators, computing and communication equipment.

One good example of such situation is the industrial environment, where industrial robots ([1], [2]), having limited autonomy (see fig.1) are far from covering all possible applications.

Martin Hägele et al. in [3] introduce the concept of "robot assistant at manual workspace" – a sort of robotic apprentice, ideally capable to hand tools or components to a human operator. The actual implementation of this idea, called rob@work, (see fig. 2), created by FRAUNHOFER IPA (www.care-o-bot.de), consists in a robotic arm installed on a wheeled mobile platform. The resulting machine is so complex, that it remained in an experimental stage.

Fig. 1. A typical industrial robot – basically a robotic arm, located on a fixed platform, with some sensors, and strict programming rules

Another type of service robots that operate in a known and manipulable environment are the "nursing robots".

The first attempts to design such robots date back in 1985, when Borenstein and Koren ([4]) described a mobile platform, equipped with a robotic arm, intended to support persons with disabilities in hospitals, or nursing homes.

The similarities in design with rob@work are obvious. And so is the obstination in ignoring the robots environment.

Fig. 3. Rob@work from FRAUNHOFER IPA

Nearly two decades later, Pineau et al. ([5],[6]) conduct surveys about challenges and results in the research for creating nursing robots, and report more challenges than results.

To conclude this very short analysis about the state of the art in the field of service robots, we will state that one major reason we don't have yet commercially available, and really useful service robots (other than autonomous vacuum cleaners, or mowers) despite the tremendous number of paper published every year on robotics is the persistence in ignoring the environment where robots operate.

The following paragraphs propose a possible solution, by considering two case studies: one is the problem of integrating mobile robots in flexible assembly lines, the other is the general approach in designing personal robotic assistants for the elderly or disabled.

2. INTEGRATING MOBILE ROBOTS IN FLEXIBLE ASSEMBLY LINES

Most of the automation problems in industry are now efficiently solved using PLCs, connected in control hierarchies as shown in figure 3.

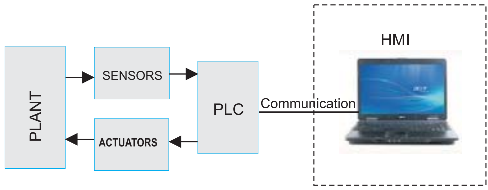

Fig. 3. A typical control system in industrial automation

On the other hand, a typical solution for controlling mobile robots is presented in fig. 4.

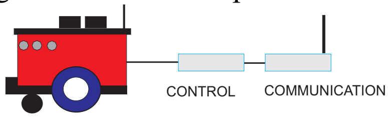

Fig. 4 A typical control system for mobile robots

The block named "CONTROL" in figure 4 is normally a computer, or microcontroller handling the kinematic control of the robot, while "COMMUNICATION" denotes the equipment dedicated to connecting the mobile platform to a remote computer for supervision and decision.

If the communication between the robot and this remote computer obeys a standard industrial protocol, accepted by most HMI software, than it would be possible to create control structures like the one presented in figure 5.

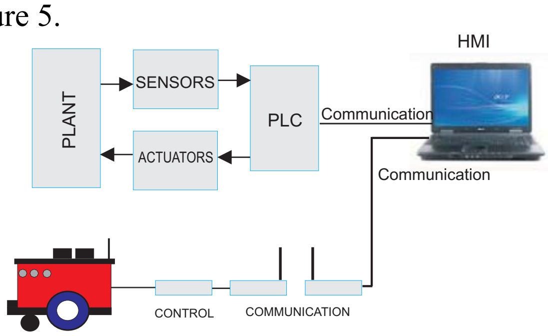

Fig. 5 A control structure capable to supervise a PLC controlled plant and a mobile robot

To prove the feasibility of this idea, we have conducted a simple experiment with a simulated robot and a low cost HMI application, namely Winlog Lite, from SIELCO SISTEMI. (www.sielcosistemi.com).

The experimental setup is shown in figure 6. The robot simulator was MobileSim, a simple and efficient softare simulator from MOBILEROBOTS. (www.mobilerobots.com)

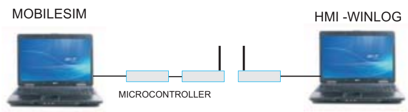

Fig. 6 Experimental setup for simulation

The microcontroller used was a low cost/low power chip, equipped with two serial communication interfaces. Its main tasks were:

- communicate with the robot, through a proprietary protocol,
- communicate with the HMI application according to the MODBUS RTU slave protocol,
- control the robot in real-time to the goal point specified by the HMI application, with obstacle avoidance.
- Report robot status information to the HMI.

Details on the actual implementation of the applications running on the microcontroller are presented in [7] and [8].

According to this approach, the robot itself is treated as an element of the environment, it is capable to react to/trigger events, and to interact with another sensors and actuators deployed in the environment.

It could easily execute tasks like transporting components between workstations, inspecting the assembly line and transmitting visual information in case of malfunction. Other functions could be performed through teleoperation.

3. ON THE IMPLEMENTATION OF COST EFFECTIVE NURSING ROBOTS

The idea of a smart environment for nursing robots is not entirely new. Park et al. describe in [9] a “smart house”, for people with physical disabilities, wherein an intelligent wheelchair, and a smart bed are capable to support the disabled for movement.

Moreover, Gharpure and Kulyukin propose in [10] a robotic system aimed to support blind people for shopping.

Based on the above mentioned literature, and on the analysis of many other projects not listed here for lack of space, we have extracted a list of distinctive features required for a low cost robotic assistant.

These requirements were previously presented in [11].

A simple and robust navigation system is an absolute requirement for such a robot..

It is highly desirable that the robotic assistant can perform the function of walking aid for persons with limited locomotion impairment. An intelligent wheelchair, or even a walker could be the ideal solution.

A robotic arm may seem desirable, but it is likely to dramatically increase the cost of the whole project

It is desirable that the robot have the capability to recognize a limited number of vocal commands. The attempts to design robots able to sustain a conversation in natural language with human operators have produced questionable results at much higher costs.

It is desirable that the robot can monitor some signals from the environment (e.g. the alarm system of the building, or some medical equipment) and control various appliances, lights, heating, air conditioner, etc.

It is desirable that the robot can interact with the communication system of the environment.

The function of cognitive prosthesis is optional, since it can be easily implemented on a stationary computer.

And, last but not least, it is highly desirable that the robot can be easily programmed.

In what concerns the actual implementation of such a machine, we proposed in [11] a distributed system of low cost microcontrollers capable to match the above listed requirements. Some of these elements must be carried by the robot, others are deployed in the environment.

Figure 7 shows the the minimal structure of the on-board equipment, while figure 8 depicts the equipment located on the ground.

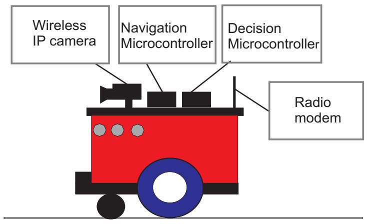

Fig. 7 The on-board equipment for a robotic assistant

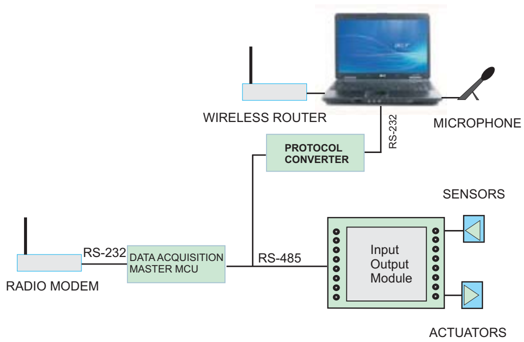

Fig. 8 The equipment deployed in the environment

Besides this, the actual vehicle contains its own on-board electronics, as shown in fig. 9.

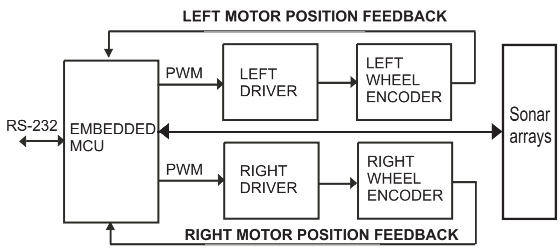

Fig. 9 Motion control electronics on vehicle

In addition to the four microcontrollers present in this structure, a regular personal computer and a wireless router connected to the Internet were included in the system. The tasks associated with this equipment are:

- Run a dedicated software for speech recognition. When a predefined voice command is recognized, this is treated like a regular digital input.
- Provide the physical interfaces for transmitting the images and sound collected by the wirelss IP camera carried by the robot through the internet.

4. CONCLUSION

It is now easy to notice that besides the low cost, there are many other advantages in the proposed solution: low power consumption, less effort to develop the software, use of regular, low cost data acquisition modules, etc.

REFERENCES

[1] Nof, Shimon Y. (editor) (1999). Handbook of Industrial Robotics, 2nd ed. John Wiley & Sons, 1999
[2] R. Tomović D. Zelenović and D. Šešlija, The role of intelligent robots in flexible assembly, Computers in Industry Volume 15, Issues 1-2, 1990, pp: 131-139
[3] Martin Hägele, Walter Schaaf, Evert Helms, Robot Assistants at Manual Workplaces: Effective Co-operation and Safety Aspects Proceedings of the 33rd ISR (International Symposium on Robotics) October 7 – 11, 2002
[4] Borenstein, J., Koren, Y, A Mobile Platform For Nursing Robots. IEEE Transactions on Industrial Electronics, May 1985, pp.158-165
[5] Pineau J, Montemerlo M., Pollack M, Roy N., Thrun S., Towards robotic assistants in nursing homes: Challenges and results, Robotics and Autonomous Systems, Volume 42, Issues 3-4, 31 March 2003, pp. 271-281.
[6] Matthews J., Engberg S., Montemerlo M., Pineau J., Roy N., Rogers J., Thrun S., Handler S., Starrett T., Ting D., and Travis R. The Nursebot project: Results of preliminary field studies during development of a personal robotic assistant for older adults.. Proceedings of the Greater Pittsburgh 14th Annual Nursing Research Conference, Pittsburgh, PA, 2002.
[7] Susnea I, Filipescu A, Vasiliu G., Filipescu S., Path Following, Real-time, Embedded

Fuzzy Control of a Mobile Platform Wheeled Mobile Robot, IEEE International Conference on Automation and Logistics, ICAL 2008, 1-3 Sep., Qingdao, China

[8] Susnea, I.; Filipescu, A., Vasiliu, G., Coman, G., Radaschin, A., *The bubble rebound obstacle avoidance algorithm for mobile robots,* ICCA 2010, The 8'th International Conference on Control and Automation, Xiamen, China, 9-11 June, 2010, pp: 540-545

[9] Kwang-Hyun Park, et al., *Robotic smart house to assist people with movement disabilities*, Journal of Autonomous Robots , Volume 22, Number 2, pp: 183-198, February, 2007

[10] Gharpure C., Kulyukin V., *Robot-Assisted Shopping for the Blind: Issues in Spatial Cognition and Product Selection*, International Journal of Service Robotics, March 2008

[11] Susnea I. Vasiliu G, Filipescu A, Coman G., *On the Implementation of a Robotic Assistant for the Elderly. A Novel Approach,* 7th WSEAS Int. Conf. on Computational, Iintelligence Man-machine Systems and Cybernatics (CIMMACS '08), Cairo, Egipt, December 29-31, 2008, pp.215-220