TOWARDS ROBOTIC SMART HOMES

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ABSTRACT

The nowadays smart homes try to move from conventional remote-controlled houses to intelligent environments. The focus has been made in blending high-tech computing into the home environment and in substituting the interaction with a box on a table by different friendly & intelligent HMI devices. Nevertheless, the introduction of real robots in home environment isn't treated yet. How will be the new smart homes with robots moving among their inhabitants? This type of homes, called robotic smart homes, will be very different of the conventional smart ones. The paper deals with the state-of-the-art of personal home robots and with the homes design in which these robots will move. One of the key issues is the analysis of the nowadays home space and the adaptation of the robots' locomotion system for them. Several types of robots (mobile, climbing and bipedal) together with the new home and rooms structure have been analyzed, together with the smart homes control system.

KEYWORDS

Smart Homes, Personal Robots, Apartments Design, Human-Robot-Home Interaction

1. INTRODUCTION

The new generation of the personal home robots is coming. Most of studies show that we are in the beginning of the new mass production robotics industry. Robots will leave the factories and will enter at homes. But are the homes prepared for these robots?

The adaptation of new and existing homes for this change is one of the crucial challenges of the robotics and construction research communities. The existing smart homes concepts need to be revised in order to admit free moving robots in daily living environments.

2. SMART HOMES

The nowadays smart homes try to move from conventional remote technology to intelligent environment (ambient) through ubiquitous computing. The research efforts are focusing in four basic elements: ubiquity, awareness, intelligence and natural interaction (as declare Mrs. Harmke de Groot from Philips Electronics).

Ubiquity refers to a situation in which people are surrounded by multiple interconnected embedded systems, which are invisible in their environment. Awareness means the ability of the system to locate and recognize objects and people and their intentions, while intelligence involves a digital surrounding being able to analyze the context, adapt itself to the people who live in it and learn from their behaviour. Natural interaction, finally, relates to advanced modalities such as natural speech and gesture recognition, as well as speech synthesis, which could enable a much more human-like communication in a digital environment than is possible today.

In this context, the biggest EU project on ambient intelligent entitled AMIGO (Ambient intelligence for the networked home environment) was lunched in 2004 till 2008 [1]. This project, with consortium of 15 European companies and 24M€ budget, has the objective of research and develop open, standardized, interoperable middleware and intelligent user services for the networked home environment, which offer users intuitive, personalized and unobtrusive interaction by providing seamless interoperability of services and applications. Several demonstration domestic scenarios, formed by living room, bedroom, kitchen, bathroom, etc., had been selected in order to verify the developed technologies (Fig. 1).

The Philips' HomeLab, located in Eindhoven, is built as a two-storey house with a living, a kitchen, two bedrooms, a bathroom and a study. At a first glance, the home does not show anything special, but a closer look reveals the black domes at the ceilings that are hiding cameras and microphones (Fig. 2).

Figure 1 EU AMIGO's Demonstration Scenario [2]

Figure 2 Philips HomeLab [3]

Other well known smart homes experiments are: 1) the GeorgiaTech's Aware Home that has audio note system, automatic blinding and lights system, gray water recycling, everyday home assistant, memory aids, etc. (Fig. 3) and 2) the MIT House_n with the mission to conduct research by designing and building real living environments - "living labs" - that are used to study technology and design strategies in context.

Figure 3 GeorgiaTech's Aware Home's Living Room [4]

Figure 4 MIT House_n's Kitchen [5]

3. HOME PERSONAL ROBOTS

Service robots become to be but reality that dream. Experts predict that the next hot field will be home personal robotics. According to Bill Gates "I really have in mind … the emergence of the robotics industry, which is developing in much the same way that the computer business did 30 years ago. I can envision a future in which robotic devices will become a nearly ubiquitous part of our day-to-day lives. … We may be on the verge of a new era, when the PC will get up off the desktop and allow us to see, hear, touch and manipulate objects in places where we are not physically present." [6].

In the same way, the European Robotics Network (EURON) roadmap identifies the high priority of personal robots in home: "In the next future, in a 20/25-year perspective, domestic, chore activities are expected to be something about which we will have to worry less and less. Two trends can be easily identified: The homes themselves will become more intelligent in terms of sensors and interconnecting processing units, and they will be populated by robotic servants that operate in these intelligent houses in close interaction and cooperation with the human user." [7].

It is possible to classify the home personal robots in three gruops depends on the locomotion system they used:

1. wheeled driven mobile robots; beginning by the market successful cleaning robot Romba by iRobot (Fig. 5) [8] and finishing by the ARMAR domestic servant developed by University of Karlsruhe in Germany (Fig. 6) [9];
2. biped humanoid robots; the most advanced one is the Japanese HRP-2 able to walk and help humans in domestic environments (Fig. 7) [10];
3. climbing assistance robots like ASIBOT that helpselderly and disease people in daily tasks like washing, tooth cleaning, shaving, make-up, etc.; the robots can able to climb in the walls and ceilings (Fig. 8) [11].

Figure 5 iRobot's Romba Home Cleaning Robot

Figure 6 ARMAR Wheeled Home Robot

Figure 7 HRP2 Biped Humanoid Robot

Figure 8 ASIBOT Climbing Assistive Robot

4. HOME SPACE VS MANOEUVERING

It is clear that the home environment strongly influence on the mobility of the robots. If you have common home furniture distribution (Fig. 9) there are some areas where the robots have difficulties to move. Moreover, some areas will not accessible at all for some kind of robots.

Wheeled based mobile robots, except small dives like cleaning robots, have tremendous difficulty to move in even no cluttered domestic layout (Fig. 9). They haven't enough space to manoeuvring and can access only to the small part of the home. Only some omnidirectional wheel drives permit better manoeuvring, but its cost and complexity are very high. In general, the wheeled platforms are commonly big and non-holonomous.

Figure 9 Common Home Layout (by SmartDraw.com)

On the other side, are the bipedal humanoids that have better manoeuvring, like the humans, but have very complex stability posture control. The advantage of use robots like us in the environments design for us is clearly very big. The main drawback is the cost of this type of systems, taking in mind that most of them aren't commercial products now.

Finally, the robots which use walls and ceiling to move have a big advantage. Moving robot from one docking station to another in the wall avoid the collision with the floor standing furniture. The space used to move is commonly very empty (see the ceiling) and robots have the aces to most of the home space. In some configuration the robot is able to one room to another. The main disadvantage is the complex control against the gravity and the security of good grasping to the wall [12].

5. ROBOTIC SMART HOMES

As it was discussed, the robot locomotion system and home design have very close relationship. The development of new type of robotic smart homes needs some restrictions and improvements in the construction process. Some of them are:

1) Reinforce home's walls and ceiling to be able to support the weights of the robot and their transferring structure (Fig. 10). This reinforcement doesn't need to be very expensive and complex. It is possible to use, for example, light steel frame structure [13] and not in the entire home only in the robot action areas.

Figure 10 Home Personal Robot in the Ceiling

2) Introduce the embedded power supply system in the walls and ceiling in order to be prepared to install docking stations in the environment (Fig. 11). This wall embedded system can also be used to the communication purpose, i.e. to communicate with the central smart home computer and the distributed sensorial system. This leads to new generation of embedded wall's panels which include not only sensors and communications but also power supply, generally low amp.

3) To don't excessively increase the home's price, the architectural design and used materials must be as common as possible. This is why, we suggest some design modifications

like wider doors and corridors, rounder corners, slightly higher ceilings, etc. Although suggested robots can move more a less freely in the home environment, wider space is necessary (Fig. 12).

Figure 11 Home Assistive Robot in the Wall

Improve the smart home's communication, sensorial and processing systems in order to incorporate in the system's architecture the robot home controller. The control architecture based on the distributed concept is the most adequate one.

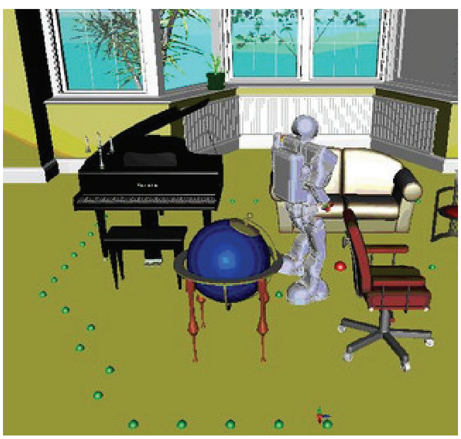

Figure 12 Humanoid Robot Walking in the Room

6. CONCLUSIONS

The analysis of the robot smart homes had been made. It is clear that robotics devices in home introduce new concept of home design and also new materials, new design restrictions and new potential applications.

The control system of the home needs to be improved beyond the actual smart homes control architectures. The integration of the robot controller, under distributed concept, the sensorial system (vision, proximity, temperature, etc.), the distributed DBs and the home controller are the key issues.

The new robotic smart homes will provide higher quality of live for the families. Specially for elderly, disease and childs. Home robots will be the new domestic appliance but with the possibility of moving around us and interact with us.

7. ACKNOWLEDGMENTS

The author wants to thanks all the members of the RoboticsLab for their help and support, and specially the research teams of the ASIBOT, Rh-1 and ManuBuild projects. Finally, thanks to CICYT, IMSERSO and EU for sponsoring our projects.

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