PLAYING WITH ROBOTS AND AVATARS IN MIXED REALITY SPACES

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Abstract: We propose a hyperpresence system designed for broad manipulation of robots and avatars in mixed reality spaces. The idea is to let human users play with robots and avatars through the internet via a mixed reality system interface. We make a mixing between hardware and software platforms for control of multi-user agents in a mixed reality environment. We introduce several new issues (or behaviors) as "Remote Control", "Augmented Reality" for robots, making robots "Incarnating" avatars and user humans connected through the Internet. A human user can choose which role he/she wants to play. The proposed system involves a complex implementation of heterogeneous software and hardware platforms including their integration in a real-time system working through the Internet. We performed several tests including experiments using different computer architectures and different operating systems, in order to validate the syustem.

1 INTRODUCTION

According to the Computer-Supported Cooperative Work (CSCW) aproach, Moran and Anderson (Moran et. al., 1990) discuss three fundamental ideas: Shared Workspaces, Coordinated Communication and Informal Interaction. Shared Spaces can represent CSCW applications in terms of spatiality, transportation and artificiality (Milgram, 1994; Benford, 2000). Unlike usual applications in Virtual Reality it replaces the physical world. Augmented reality explores seamlessly applications or applications that mix virtual and real features. Ressier (Rssler, 2000) presents an environment for collaborative engineering. This environment integrates a multiuser synthetic environment with physical robotic devices. The goal is to provide a physical representation of the 3D environment enabling the user to perform direct, tangible manipulations of the devices. The implementation uses robots constructed with LEGO kits and join VRML and Java technologies to it. It also uses a vision processing system for computing orientation and position of the robots in the real environment. The Augmented Reality (AR) paradigm (Moran et. al., 1990) enhances physical reality by integrating virtual objects into the physical world, which becomes, in the visual sense, an equal part of the natural environment. The Collaborative AR Games project is a good example of these (Moran et. al., 1990). This kind of work has been designed for demonstrating the use of AR technologies in a collaborative entertainment application. It is a multi player game simulation where the users play with cards. Game goal is to match object that logically belong together, such as an alien and a flying saucer. When cards containing logical matches were placed side by side, an animation is triggered involving the objects on the card.

We propose a system that is more general and closer to reality than the above ones, possible of applications in remote working spaces where (real-time) interaction is a requirement. We use autonomous robots with proper perception and decision and provide a way for them to, on-line, interact with people and objects in the real and virtual world. In certain cases, the human, through an avatar, would interfere in the robot autonomous, attentional behavior guiding its motion, as for example to closer examine an object detected in a certain environment place. In other cases, the robot would guide the human user through the real environment (as in a museum). Other humans could enter the environment and also interact with the robot or other human users, through their avatars. In this way, robots, avatars and human users can live in this environment, interacting to each other as neces-

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sary. The system perception of the world is constantly updated to reflect the current world status.

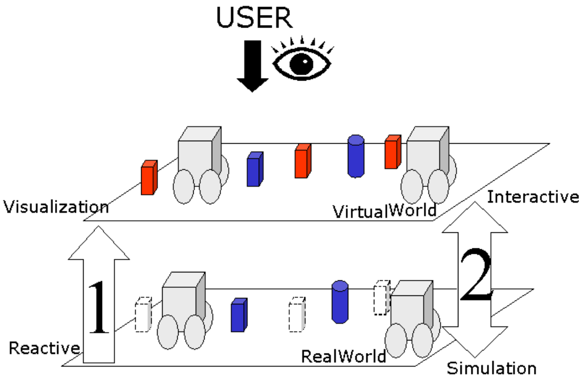

Figure 1: HYPERPRESENCE overview.

2 THE HYPERPRESENCE SYSTEM

Figure 1 illustrates the conceptual model of the HYPERPRESENCE system. It follows the basic idea of having real and virtual worlds representing the same situation. In phase 1 (arrow 1 in the left of figure) we have an unidirectional flow from real to virtual environment. The virtual interface is used for visualization of reactive or intended actions performed by real objects or robots. The second step is to promote interaction between these two worlds. Arrow 2 (in the right) illustrates this phase where we have interactive options for users that can create and manipulate virtual objects that will be perceived in the real world and influencing actions of the agents. In this case, we have a platform for simulating the behavior of the agents in the real world.

Our robots operate in real environments that could be any place providing interactions with its virtual version. We adopted here an arena, a robot soccer game, and a Museum (Casa da Ribeira) located in Natal city, Brasil. All environments are closed places in the real world limited by walls in which we can have real objects as robots and obstacles. The robots are autonomous vehicles implemented by using the hardware technology developed by LEGO consortium. In this implementation, the obstacles are colored cubes or cylinders. We can have more than one robot in the environment so a robot could be a dynamic obstacle for another one. With this hardware setup, we can stimulate many kinds of tasks as: (1) moving around and avoiding obstacles; (2) looking for special objects (as colored cubes or cylinders); (3) identifying and catching special objects, (4) manipulating objects.

For representing the real world and the objects, we implemented a virtual version of the above real environments using VRML (see Figure 2. The virtual version of Casa da Ribeira includess all gallery and cultural works being exposited. The resulting model is put in an Internet site where virtual users can visit, look around, and interact with the material (evaluating and sending comments). Each real object is represented in the 3D interface by using a corresponding avatar. Communication between the real and any (restricted) number of virtual versions is provided through an Internet connection. So avoiding sending images and other massive information is one of the key restrictions we must pay attention.

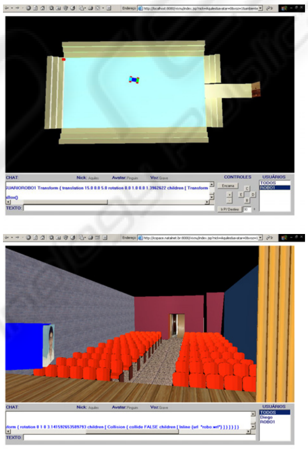

Figure 2: Virtual versions of: Robot soccer and arena (top), Casa da Ribeira cultural space (middle) , and its Theater (bottom).

2.1 The architectural model

Figure 3 illustrates the design of the Hyperpresence system, relating the main architectural components and connectors. Briefly, the 3D Interface Component represents the 3D virtual interface and the 3D objects. The major function of the 3D Interface component is the real-time visualization of events in the real environment. The VRML Multi-User Client is the observer of events for the 3D Interface. For each event generated for an avatar in the virtual environment the VRML Multi-User Client sends a message to the VRML Multi-User Server component, which controls the VRML MultiUser Client components. For each real object (robot or obtacles) it provides its geometric 3D representation - an avatar. Each avatar is treated by the VRML Multi-User Server as a client connected in this server. The VRML Multi-User Server feeds each client with the corresponding information (position and orientation) from the Visual Server and Hardware Server components, so it can keep the syncronization between both environments. Also, if a virtual avatar representing an user enters the scene its position and orientation is constantly updated. The Hardware Server Component is responsible for getting and sending information in real-time to the autonomous real entities, that is, to the robots in the real world. Although, the robots are implemented as reactive units the Hardware Server can send messages to each robot and update their inputs according to application needs. This component also sends messages for the VRML Multi-User Server. The functionality of the Visual Server Component is to acquire/determine position and orientation of the real objects and to send them to the other components. To do that, the Visual Server component has a video camera system, and uses image processing and recognition algorithms (discussed later) for mapping colors marks contained in each object in position and orientation, for each real object. The Real Environment Component is the physical environment and the real objects system represented by robots, cubes, cylinder and walls. Each robot can have its own implementation code and this depends on the task goal to be achieved. Also, we can run different tasks for each robot, for example one robot can move and/or pick up a can. We note that all of the above components and connectors must operate in real-time. Some of them operate in synschronous way, as the visual server, and some of them in assynchronous way.

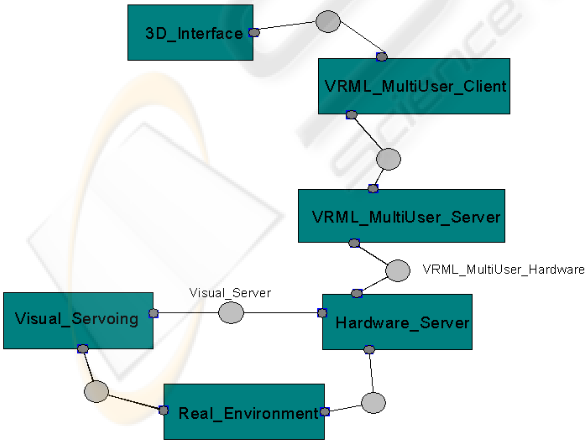

Figure 3: System Architecture.

3 EXPERIMENTS, DEMONSTRATIONS AND RESULTS

In the first experiment, an user operating a remote computer, located far away from the robot place runs the remote control behavior for controlling the robot through an open internet connection with the robot hardware. The real and virtual robots could perform the same remote controlled motion, following the same path. In this case, the control was under a human user command. In the following a point in the environment (the red ball in the top-left part) is set for the robot to design a trajectory, and to follow it in order to reach that point. Both real and virtual versions of the robot could be seen moving while the trajectory is traversed in real-time. We did next an experiment in which the real robot encarnates the virtual one. In this case, the virtual robot is performing a motion from one point to another, commanded by the human user (this is different than remote controling, since a virtual point is given to the virtual version). The virtual robot performs a motion from one place to another. The real robot could perform well this task in the real side. In the next experiment, we simulate remote visualization in the cultural space Casa da Ribeira. The aim of Casa da Ribeira is to improve cultural activities specially using its gallery and theather. In its gallery people can see photos, pictures or sculptures. The multiuser server allows each user to note the presence of other virtual users in the same way as in the real cultural center. With this, virtual users can even communicate to each other during the visit.

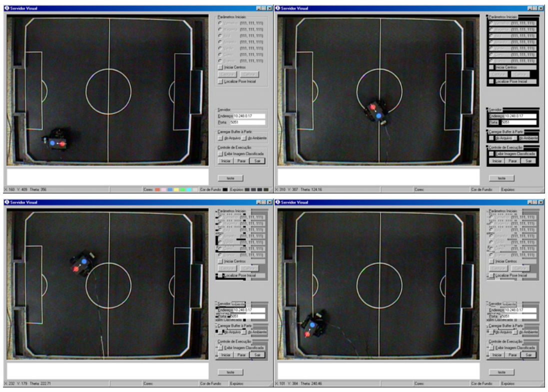

Figure 4: Real robot performing in the Lab ground.

The multiuser server is used in order to control robots in the real environment. That is, an autonomous robot can be in the real Casa da Ribeira room interacting with the real environment and a syncronous version for this robot can be in the virtual side. Figures 4 and 5 show the robots running this experiment. In this case we used the the robot located in our lab ground as representing the real theater and the avatar of it in the virtual theather room. We are planning soon the other side of this experience: using the robot located in the Casa da Ribeira real theater. Note that we can use the same infrastructure implemented on the theather for improving a mixed reality play, where we can envolve real actors (people) interacting with virtual actors (robots). This virtual actors can be any person located in anywhere incarnating a robot avatar. Other intersting application of this structure is to improve a real-virtual bridge, im other words, to improve a communication tool for connecting people located in different spaces. In that way the robots will be used as the connection channel.

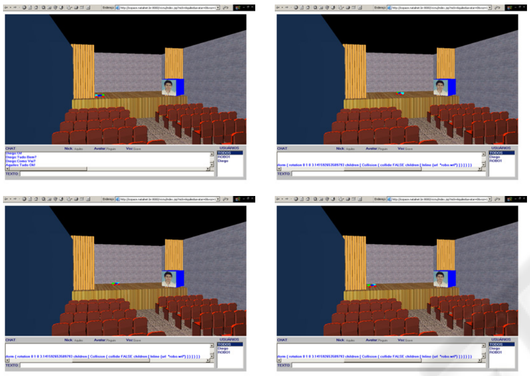

Figure 5: Virtual robot performing in the theater, in a synchronized way.

4 CONCLUSIONS AND PERSPECTIVES

We developed and tested several tools for allowing control of both virtual and real versions of robots and users connected through internet. The developed tools allow us to provide interactions with users, robots and avatars through the WWW in several ways. An example of an application devised involving both real and virtual sides is to have a robot as an avatar in a real museum for a human connected through the internet in a virtual museum. In this case, the robot could have an autonomous behavior (to follow a given museum route tour), learned through several trials were the robot takes user preferences. Then, as a human enters the virtual museum, a robot is allocated to it in the real version of the museum. The robot starts following the traced route, according to the user preference. As the robot approach a picture, the human user may use the remote control, for example, to examine a given picture with more detail. Note that several robots could be present representing several humans. As the number of robots expires, a new user could be represented by a virtual avatar (without phisical entities representing it). In this case, the robots must know that there is another user (avatar) close to them (augmented reality for the robots). We will shortly run experiments involving robots performing as actors in the Casa da Ribeira Theater. Besides the above applications, several other involving a mix between real and virtual parts could take place. As a future application example, we plan to use this system in order to transmit, through the internet robot contests. This will include robot soccer and other versions of games for robots.

REFERENCES

S. Ellis. What are Virtual Environments? IEEE Comp. Graphics & Applications, 14(1):17-22, Jan 1994

Moran, T.P. and Anderson, R.J. The Workaday World as a Paradigm for CSCW Design. In Proceedings of the Conf. on Computer-Supported Cooperative Work, CSCW ’90. (Los Angeles, CA), pages 381-393. ACM Press, New York, 1990.

P. Milgram and F. Kishino. A Taxonomy of Mixed Reality Visual Display, IEEE Transactions. on Information & Systems.,Vol. E77-D, No.12, pp.1321-1329, 1994.

S. Ressler, B. Antonishek, Q. Wang, and A. Godil. Integrating Active Tangible Devices with a Synthetic Environment for Collaborative Engineering. National Institute of Standards and Technology. 2000.

Anil K. Jain. Fundamentals of Digital Image Processing. Prentice Hall, 1 edn, 1989.

K. R. T. Aires. Desenvolvimento de um sistema de visão global para uma frota de mini-robôs móveis, Master’s thesis, Federal University of Rio Grande do Norte, Natal, RN, Brasil.

Shared Spaces: Transportation, Artificiality, and Spaciality. Steve Benford, Chris Brown, Gail Reynard and Chris Greenhalgh. Department of Computer Science, University of Nottingham. NG7 2RD, UK. E-mail: sdb, ccb, gtr, cmg@cs.nott.ac.uk

BRICOS. BricOS Operating System and Compiler ”C” and ”C++” for RCX. brickos.sourceforge.net.

LNP: LegOS Network Protocol. legos.sourceforge.net/HOWTO/x405.html