INTERNET - BASED ROBOT CONTROL

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Abstract: This paper presents a result of an effort of designing a virtual classroom that will enable conversation in the classroom as well as a robot control over the Internet. The design of the virtual classroom includes two components: a chat-room server (Espernet network) and a robot server (Probotics).

Some examples of moving a robot through the corridors in a building of South Carolina State University, USA, from a building of Institute of Informatics, University of Skopje in Macedonia are also presented.

The experiments that we carried out show that there are emerging potentials of using web based robot control for educational purposes. Furthermore, the web based control of robots can be extended to other useful applications.

Key words: Robot control, Internet based control, Robot server, Cognitive map, Virtual Classroom

1. Introduction

New information technologies, among them being the Internet technology, are already present in almost all areas of education and research. Although those technologies were present in artificial intelligence and robotics education since the beginning of Internet, a new challenge currently observable is to control robots via Internet. This paper describes the concept of robot server and the concept of robotics lab virtual classroom [2], that are useful for implementation of an Internet based robot control.

2. Robotics, AI and cognitive model of the world

There are two basic metaphors of describing phenomena in the artificial intelligence: *information processing metaphor* and *agent – environment interaction metaphor* [1, 7, 8].

The first metaphor is also known as disembodied AI. Its basic framework is presented on Figure 1.

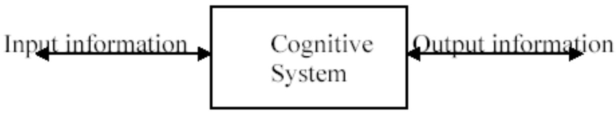

Figure 1: Disembodied AI metaphor

The disembodied AI metaphor considers *intelligence as computation*. For example, linguistics is computational, cognition is computational, etc. It's assumed that the computation operates over *representations*. The representations are given by *symbols*. For this metaphor the basic models are *programs*

The second metaphor, the one which we use in this paper, is the embodied AI metaphor. Its framework is presented in Fig.2.

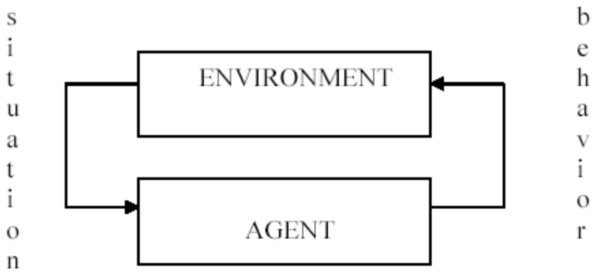

Figure 2: Embodied AI metaphor

According to this metaphor, the *models are agents* (robot, organism, software agent), rather than programs. The concept of an agent cannot be considered separately from its *environment*. It receives input information (signals, material, and other) by which it determines the situation it has to deal with. The agent outputs a behavior to deal with the encountered situation. This metaphor observes the intelligence in the *interaction* between the agent and its environment.

An intelligent robot has (or is able to build) a model of the local and possibly of the global environment it functions in. This can be achieved by learning (self – exploration of the environment), or by programming (a human programs the model into the robot memory). At today's stage of technology, the latter method is faster and more accurate.

In this paper we will consider a control of an embodied agent, a robot, which has a preprogrammed model of its world. For a given goal point, the robot computes a trajectory in its internal model and executes a behavior in its real environment. The robot carries a camera so that its behavior can be observed remotely.

3. Internet controlled robots

There are several ways of controlling a mobile robot, and in our research we explored some of them, examples being Moore automata representation and multitasking control, [3, 6], tropistic guidance [4], and bioelectric control from the electrical signals produced by the human head, [5], among others. Internet is now entering the robot control and this is a report on utilizing this new technology. Among many servers on Internet, a class of robot servers is now emerging and developing rapidly. The concept of a robot web server is shown in Figure 3.

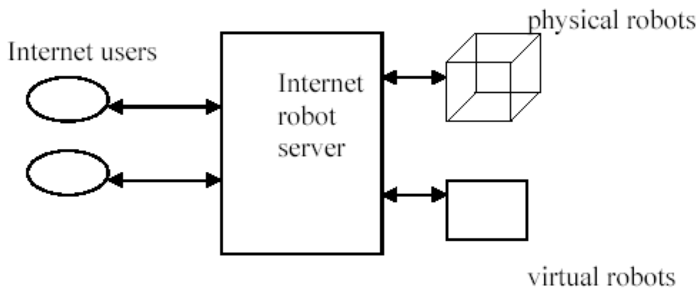

Figure 3: The concept of a web server for robots

As Figure 3 shows, a robot server on the web can offer control of both real physical robots and virtual animation robots. A robot can exist in some place like for example a robotic lab, and an Internet user would be able to control the robot, taking into account the restrictions imposed by Internet. In essence, the Internet based robot control is kind of the well-known concept of remote (teleprocessing) control.

4. An example of Internet based robot control

Here we will describe a session of working with a robot server for a distant robot control. Figure 4 shows the session setup. The robot is positioned at AI/Robotics Laboratory in Orangeburg, SC, USA. It is a cye type mobile robot, named Adriel-8, and its control is maintained through Web – bots robot server in Pittsburgh, PA, USA. In this particular setup, we have an example scenario where a robot control is carried out between geographically very distant places: Institute of Informatics, Skopje, Macedonia, and Mathematics and Computer Science Department, Orangeburg, SC, USA.

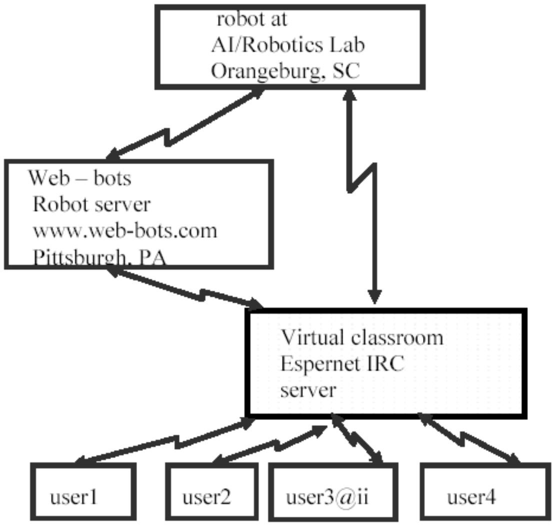

Figure 4: Example of a session setup for Internet based robot control

As Figure 4 shows, we use the www.web-bots.com robot server. That server offers a control of their mobile robots. The robot itself is connected to its control computer via wireless connection (Figure 5).

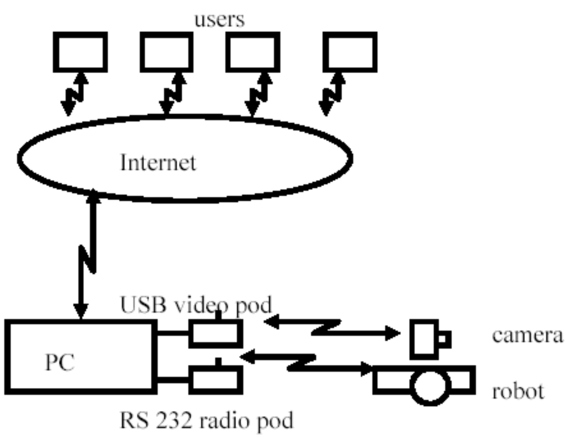

Figure 5: Wireless control of the robot

A camera is mounted on the robot. If user requested, it sends photos of the environment it's moving in to the robot server. The user connected on the server's web page has an opportunity to actually see the movements it makes (Fig. 6).

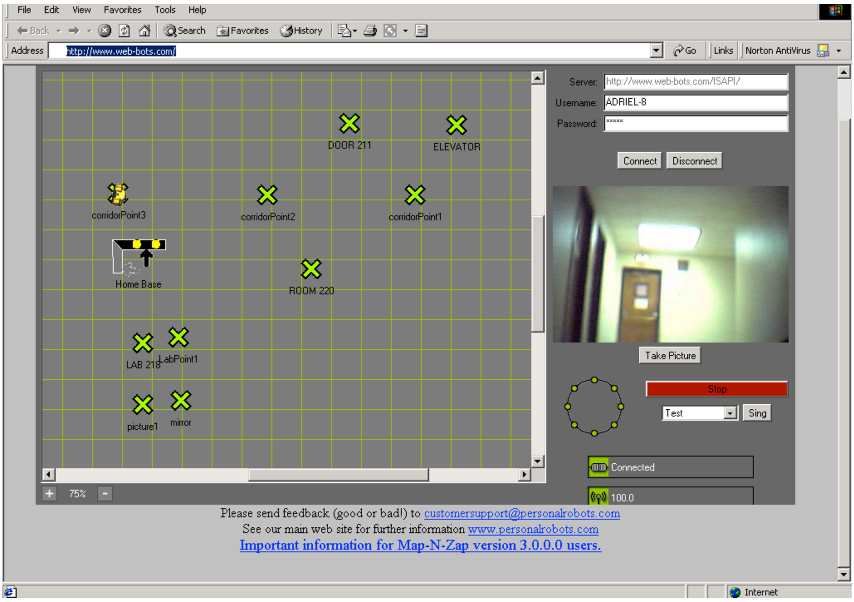

Figure 6: The movement of the robot can be seen of the robot server web page

5. Cognitive robot map as method of robot control

The robot we use in the lab has its own software which allows robot programming by ways of marking distinct points in its cognitive map. This robot also has a built in (programmed) ability to learn from its environment. Figure 7 shows the cognitive model of the world used in our experiments with the setup as described in Figure 6.

As Figure 7 shows, the robot cognitive map is divided into square tiles. The tiles represent the internal measurement system of the robot, the coordinate grid of its internal, cognitive world. The AI/Robotics Laboratory in Orangeburg also has a tiled floor, and it turns out that a tile in the robot cognitive map is the size of two tiles in reality, in linear dimensions (four lab tiles in surface dimensions). In the cognitive map for this experiment we programmed more than 10 points. The most important point is the robot's home base. Some of the other points are points where the robot can sense an obstacle in the real world and the other points have no (for the robot) recognizable features in the real world, they exists only in the robot cognitive map.

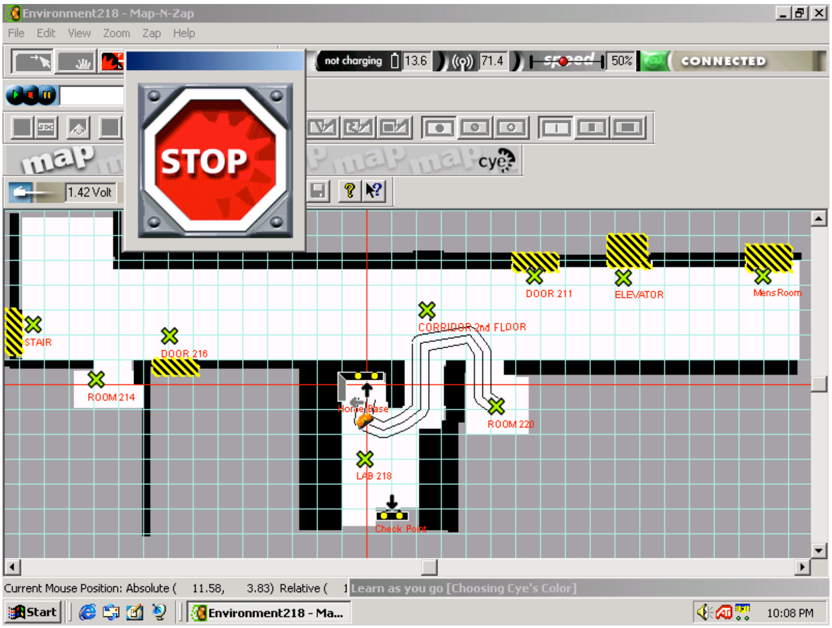

Figure 7. The cognitive world model of the robot used in the experiment

The HomeBase is placed at some “corner”: a solid obstacle (e.g. a wall) is in place in the robot front-side, as well as at its left-side, so the robot can use that fact to locate its home base, since the robot relies only on its obstacle sensors. The other point, at the bottom of the screen is the CheckPoint. Along with the HomeBase, it is a place where a robot cognitive map can be checked against the real world; in our experiment at the CheckPoint we placed on the floor a (computer) box which we do not use. The remaining points are denoted as HotPoints. They are not recognizable by the robot in the real world; they exist only in its cognitive map. However, a human observer could establish relationship between the HotPoints and the points in the intersection of the tiles on the department’s floor.

Once the cognitive map is constructed, it will appear on a robot server webpage, provided an appropriate username and password is entered for this particular robot (Fig. 5). The distant control is carried out by clicking on a point marked in the robot cognitive map. The manifestation of the control is actual robot movement in its real world, on the other side of the Internet connection.

We carried out several successful experiments using the setup shown in Figures 5 and 6. Depending on the Internet connection quality, the control signal processing is sometimes rather slow, in comparison to the experiments with

Internet connections noticed during our class activities when we use the Internet based robot control.

6. The virtual classroom

The students of the CS480 Introduction to Robotics class have the opportunity to follow the class via Internet virtual classroom. It uses Espernet IRC server as chat - room (Fig. 9) where the instructor gives the students instructions where to move the robot to, or gives them instructions about some other actions that should be taken (e.g. taking pictures). The students, using the webbots robot server web site, take the appropriate action, and are able to follow the robot's movement in response to the action they took.

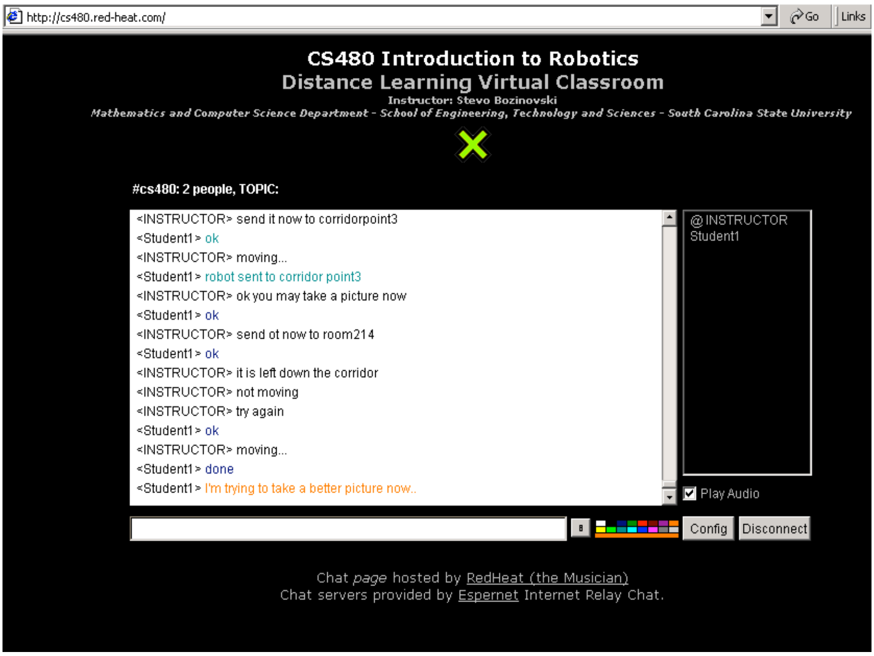

Figure 9: Robotics virtual classroom

7. Conclusion

The paper points out the potentials of use of web based robot control, through the concept of robot server. Such a server is used in regular educational activity, while teaching the CS480 Introduction to Robotics class on the Department of Mathematics and Computer Science on South Carolina State University. The paper reports the experience with a distant control of the robot using an Internet robot server. We believe that, like many other applications of Internet to education and science, this is one of the potentially most promising applications and it will soon become a regular activity in the education and research in robotics.

8. References

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