Teleworkbench: A Remotely-Accessible Robotic Laboratory for Education*

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Abstract

This paper presents a teleoperated robotic-laboratory named Teleworkbench and its benefit for educational purpose. It also presents briefly three issues that we need to take into consideration to make such a laboratory more effective.

Introduction

Robots, as some researchers and educators believe, are beneficial in education; they can help motivating students in learning science and technology. However, robots are not cheap and moreover robots which support high programmability and expandability, are so expensive that they are not always affordable for wide use. One example of such robots is minirobot Khepera from (K-Team). Moreover, providing a robot to every student is economically not feasible. Thus, we need an innovative way to open access to robots as wide as possible. One possible way to achieve this goal is by exploiting the advantage of the Internet. By using the Internet, students located anywhere can interact with robots. Moreover, during idle period in which none *plays* with robots, the resources, e.g. robots, robot modules, fields, etc, can be used by other students.

We have designed a teleoperated platform for performing experiments with robots named as *Teleworkbench* (Tanoto, Witkowski, & Rückert 2005). The original idea of the system is for managing and analyzing experiments using one or many minirobots. Thus, by using this system we aim for more efficient resource utilization, in this case robots and their extension modules. Also at the same time providing wider access to robots regardless of users location. There are some unique features of this system, they are: enable downloading a user-defined program to each robot, the support for tracking more than thirty robots simultaneously, live video of the experiment, and the visualization of occurring events in experiments. With these features, we deem that this system is also suitable for supporting education using mobile robots.

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To date, there are several similar attempts to use the Internet for education using mobile robots. Two examples are the work of Messom and Craig (Messom & Craig 2002) and the web-based telerobotic system for research and education at Essex by Yu et al. (Yu *et al.* 2001). Despite promising results in this area, we see, based on our analysis on the current system, that there are several issues for improving such a laboratory. Thus, it is our intention to shortly present these issues in this paper.

This paper has the following structure: the first section shows our idea on using the Teleworkbench as a tool for education. In the second section, we describe shortly the aformentioned system. Afterwards, we present briefly some issues in employing such system in education. Last, we summarize this paper in the last section.

Teleworkbench Overview

The *Teleworkbench System* (see Figure 1) comprises one field (partitionable into four fields), several cameras monitoring the fields, a wireless communication system, and some computers connected to a local area network with tasks such as image processing, databasing, message redirecting, and web-hosting. Experiments will be executed on the field with resources required as defined by the users during the experiment setup. During an experiment, the web cam above the field will be activated and will send the video information to *Video Server*. This server processes the captured video data for robot tracking purpose and provides position and orientation information of the robots. To allow the tracking, every robot has a color mark on top. Concurrently, this server encodes the video and streams it to remote users via a *Video Streaming Server*, to provide a live-video of the experiment.

During experiment, robots can communicate wirelessly with each other or ask the *Teleworkbench Server* using the Bluetooth module. Every message sent by the robot will be recorded in a log file, which can be used later for analysis. After the experiment is over, users can analyze the experiment by using an MPEG-4-based video generated by the *Post-Experiment Tool* module. This video contains the recorded video of the experiment and some computer-generated objects representing important events and information occurring during the experiment.

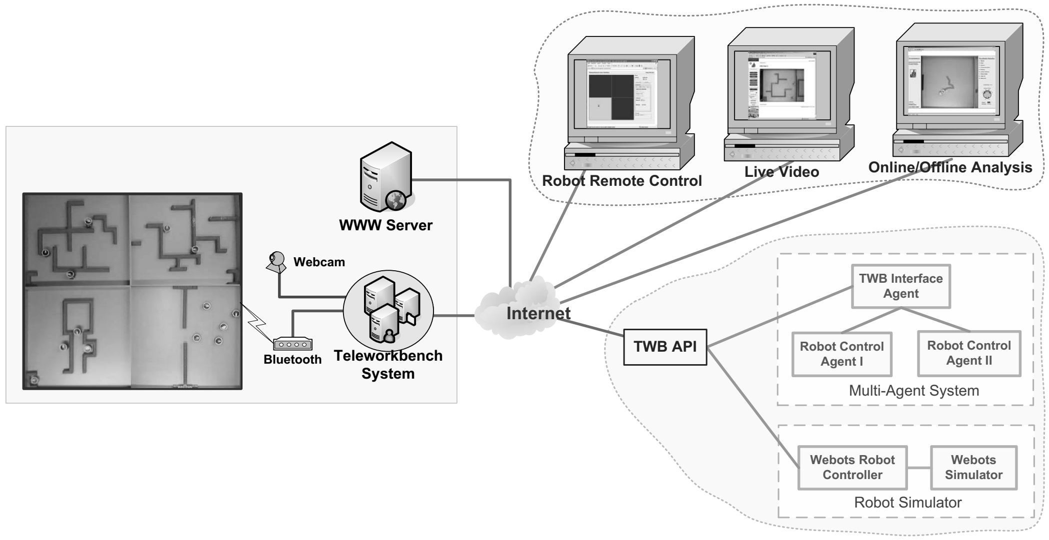

Figure 1: Teleworkbench system with some possible application scenarios for educational purpose.

Issues in Teleoperated Robotic Laboratory

As previously mentioned, we noticed some issues for making the teleoperated robotic laboratory more beneficial. First is interoperability with robotic simulators. While experiment with real robots is ideal and can bring more satisfaction to students, but it consumes time and resources. Moreover, it is hard to debug. Thus, we see the necessity of using a robotic simulator. Even though we know that codes that run perfectly in the simulator will not always run in real robots, but a seamless integration of robot simulator and the remote laboratory might reduce the development time and effort. Furthermore, by proportionally allocating the load between simulator and real robots, we can have higher efficiency and utilization of robots.

Second is the need of analysis tool to assess the behaviour of the robots during experiments. When a program runs on a robot, it is difficult to see what is actually going on inside the robot because we can only see the behaviour from an outsider's perspective. As a result, we might wonder why a program runs perfectly at times but not at some other time. Thus, we somehow need a tool to see the process inside the robots during runtime. So far, we have partially achieve this objective through our post-experiment analysis tool using video that is based on MPEG-4 standard (Tanoto *et al.* 2006).

The third is sufficient feedback and interactivity. Without enough feedback, students will find it difficult to interact with robots, and without good interaction, they will easily get bored. Moreover, if the experiment requires situation assessment from them, e.g. telerobotics with supervised control, it must be very hard to do it properly. Thus, we need to transfer the remote environment where the real experiment runs to the students as much as possible. One way to achieve this is by using video. Even though transfering video data is bandwidth consuming, but as fast internet connection is more common, we deem it feasible to implement in remotely-accessible robotic laboratory.

Summary

We have presented some aspects that might have important roles in the success of remotely-accessible robotic laboratory in education area. Despite the decreasing tendency in robots price, yet they might not be feasible for most students in developing or even in developed countries. Thus, there is still an area in which such a laboratory is likely to be more feasible. Furthermore, by taking into consideration the presented aspects during the design of such a laboratory, we can increase its efficiency and utilization.

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