

Teleworkbench: A Remotely-Accessible Robotic Laboratory for Education

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1 Introduction

We have designed a teleoperated platform for managing multirobotic experiment. We call this system *Teleworkbench* [6]. The aim of this system is to provide a tool for managing and analyzing experiments involving one or many minirobots. Thus, by using this system we aim for more efficient resource utilization, in this case robots, and at the same time for providing more access to robots regardless of users location. There are some unique features of this system: the ability to download a user-defined program for each robot, the support for tracking more than 30 robots simultaneously, live video of the experiment, and the visualization of occurring events in experiments.

To date, there are several similar attempts to broaden access of mobile robots for education purpose. One example is the work of Messom and Craig [3]. They designed a web based workbench for doing experiments with PID controller of real mobile robots. To prevent heavy bandwidth, this system sends only the position information of the robots instead of image or video data. On the client side, this information is rebuilt to resemble the original environment. Another example is the web-based telerobotic system for research and education at Essex by Yu et al [7], which aims for enabling remote users to control and/or program their mobile robot to explore their laboratory. To do so, the system sends continuous 24-bit JPEG images to users as a feedback. To program a robot, a user have to submit a text-based script, based on the Colbert language, containing commands for the robot. After the program uploaded, a Colbert evaluator is run to analyse the script.

However, based on the analysis on our current system, we hypothesize that there are several aspects needed for making the remotely-accessible robotic laboratory more beneficial for users in general and students in particular. First is interoperability with robotic simulator. While experiment with real robots is an ideal and can bring more satisfaction to users, however it takes 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 simulator will not always run in real robots, but to have a seamless integration between the simulator and the remote laboratory might reduce the development time and effort during the experiment. Furthermore, by allocating proportionally the load between simulator and real robots, we can have higher efficiency and utilization of robots. To this respect, we are studying the feasibility on integrating some robotic simulators to our Teleworkbench; some of them are Pyro [1], Microsoft Robotic Studio [4], and Webots [2].

Second is the need of analysis tool to assess the behaviour of the robots during experiments. When the program running on the robot, it is difficult to see what is actually going on inside the robot because we can only see the behaviour from outsider perspective. However, in this way, we might wonder why a program runs perfectly at times but not at some other time. Thus, we need somehow a tool to see inside of the robots during runtime. So far, we have partially achieve this requirement. We have developed a post-experiment analysis tool using video based on MPEG-4 standard [5].

Third is enough feedback and interactivity. Without enough feedback, users 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 users, 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 users as much as possible. One way

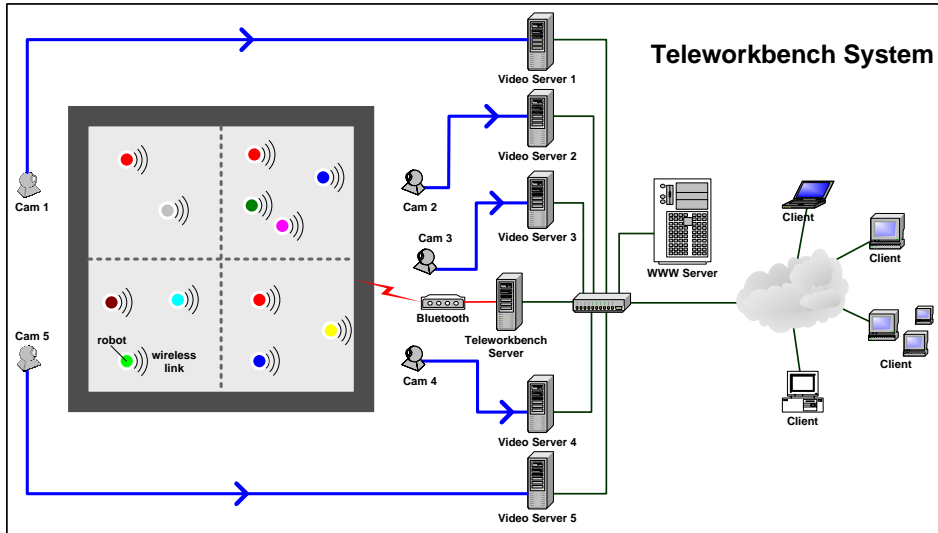


Figure 1: Teleworkbench’s diagram showing its components and they are interconnected to each other.

to achieve this is by using video. Even though transferring video data is bandwidth consuming, but as fast internet connect is more commonplace, we see it feasible to be implemented in remotely-accessible robotic laboratory.

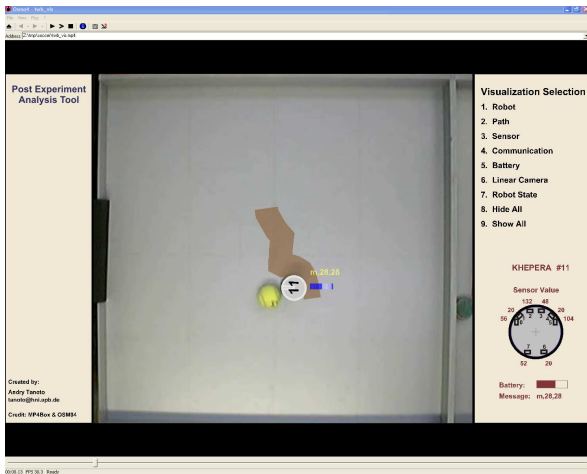
2 Teleworkbench System Description

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. The experiments will be executed on the field which has the resources required as defined by the users during the experiment setup. During the experiment, the web cam above the field will be activated and send the video information to the *Video Server*. This server will process the captured video data to track any robot on the field and calculate the position and orientation of the robots. To allow the extraction of robot position, every robot has a color mark on top. The detected robots along with their position will be recorded in a log file called *Position Log File*. Concurrently, this server will encode the video and stream it to remote users through a *Video Streaming Server*, to provide a live video of the experiment.

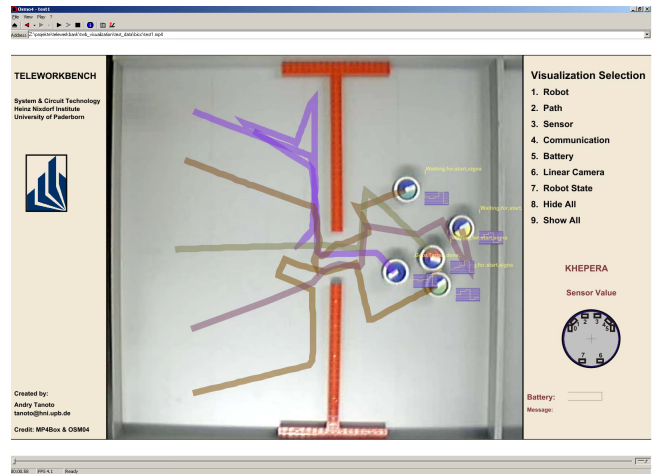
During experiment, robots can communicate wirelessly with each other or ask the *Teleworkbench Server* using the Bluetooth module. In some experiments, robots might need to send some internal information for analysis purpose. Every messages sent by the robot will be recorded in a log file called *Communication Log File*. If required by the users, it is also possible to involve some intelligent agents running on separate computers connected to the *Teleworkbench Server*. These agents then can communicate or even control the robots during the experiment. After the experiment is over, the *Teleworkbench Server* calls the *Post-Experiment Tool* module to generate an MPEG-4-based video (see Figure 2) that has a role as an analysis tool of the experiment. This video contains the recorded video of the experiment and some computer generated objects representing important events and information occurring during the experiment.

3 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, still will it be not feasible for most people in developing countries or even for some educational institutions 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.



(a) The tool shows that the robot kicks the ball before it gets aligned with the ball and the goal. Apparently, the robot soccer algorithm used does not check it first. It simply does so after it says to the robot to do a certain maneuver.



(b) The tool shows the movement as well as the internal states of the robot group trying to go through the gate without explicit communication among each other.

Figure 2: Examples of MPEG-4-based video as an analysis tool.

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