Remote-Controlled Real-Time Experiments for Foundation Physics Learning in PolyU

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1. Introduction

Practical sessions in laboratories play an essential role of science education, from which students grasp abstract concepts through direct observations and data analyses. Experimental methodologies and techniques can be acquired by students through repeated trials in hands-on experiments, instead of being conveyed through lecturing or video demonstrations in the classroom environment.

In practice, the provision of such training opportunities can be limited by the availability of physical space, as well as the huge capital costs involved in establishing such facilities [1]. The launch of the new 4-year undergraduate curriculum among universities in Hong Kong in 2012 imposed chronic challenges to service teaching of science subjects: the large subscription of such subjects by students of various disciplines placed strains on laboratory spaces and time slots available for the students to conduct the experiments.

Here we describe an on-going effort in the Department of Applied Physics, PolyU, in the development of a platform for a selected set of remote-accessible physics experiments, which are equipped with automation for crucial experimental parameter that allows direct user control. Students are able to access the laboratories at anywhere and anytime, as long as they have access to the network. The results on a pilot run of a physics experiment setup (Interference and diffraction of light) are presented. Reflections on the experience and potential future development of the experiment platform are discussed.

2. Remote-controlled Experiment Platform

2.1 Infrastructure

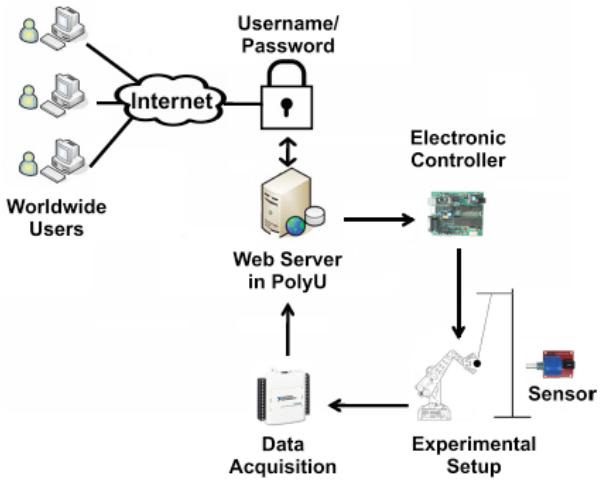


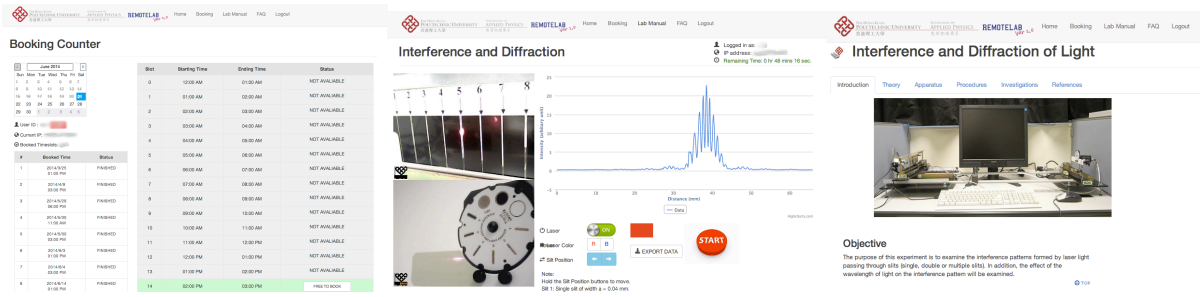
Fig. 1 Schematic of experiment platform

Fig. 1 shows the schematic of the infrastructure for the experiment platform [2]. Remote users login to a password-controlled server, through which they are diverted to a booking system for reserving slots to perform certain experiments. During the experiment session, students can control an automated experiment setup from a remote location via the internet; at the same time, experimental results will be logged and can be downloaded by the user during the session. All of these actions are performed via web-browser pages, without the need of installing any proprietary software.

2.2 User Interface

A number of experiment setups have been built over the past years. As an example the screen shots of the experiment 'Interference and Diffraction' is shown in Fig. 2. Users login the platform and reserve sessions for the particular experiment setup at the booking page, where a record of the utilization history is also displayed (Fig. 2(a)). Once the students arrive at the experiment page, images of crucial experimental parameters are displayed real-time,

and the control buttons allow the students to perform the change of experimental parameters remotely. In Fig. 2(b) for example, the laser spot on the slit sets and the interference/diffraction patterns are simultaneously imaged, such that students need to switch between different slits and fine-tune for optimal effects (brightest pattern) before they start the measurement. Laboratory manuals (Fig. 2(c)) are provided for students' perusal during the experiments and for the preparation of laboratory reports.



(a) (b) (c)

Fig 2. Screen shots of the user interfaces: (a) experiment setup booking page; (b) experiment control page; and (c) laboratory manual page.

2.3 Plilot-run of Interference Experiment

A pilot run of on the interference experiment was conducted in a class of Year 1 students enrolled to a lecture-based (i.e. no laboratory sessions) introductory physics course, at which no prior physics knowledge was assumed for the students. Post-experiment survey indicated that students generally showed positive response by students towards the concept of remote experiment, which provided high flexibility in their learning schedules and was a good supplement to the lecture materials. Post-exam analysis on students' performance in interference-related questions indicated a 60%-increase in the averaged marks of students, as compared with another class of students in the same subject enrolled in the previous semester, which is an encouraging indication for the benefit of conducting remote experiments.

2.4 Future Prospects

The concept of remote laboratory can well be applicable to different science subjects (chemistry, biology) and across different sectors of education (junior or senior secondary levels) [3]. Apart from the benefits of overcoming spatial and time constraints in attending laboratory sessions, remote experiments are ideal for setups that (i) poses hazards to students, (ii) requires long duration for completion, and (iii) expensive for installation by single institution but can enjoy economies of scale through the sharing of facilities. The development of remote-controlled experiments is gathering speed in various countries [4], and it is anticipated that more setups will be available in the future, not only for registered users but could also be used by the general public for science popularization purposes.

Acknowledgement

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