

The e-Xperimenteren+ Project: Pool of Remote Experiments and Software Environment

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Abstract—The e-Xperimenteren+ project is an innovative project in the field of remote experimenting for educational purposes for Dutch universities. Important goals of the project are

- A pool of about 12 remote physics experiments
- An online environment featuring amongst others reservations and automatic storage of logs and data.
- A set of tools and manuals facilitating easy integration of new experiments into the pool.

A unique feature of the software environment of this project is the concept of ‘experiment bundles’ analogous to the system of credits used for mobile phone prepaid subscriptions. It allows for very flexible and powerful control of who can make reservations at what times for which experiments, while at the same time keeping the administration required to a minimum.

Index Terms—Remote experiments, physics experiments, expandable pool, reservation system, automatic logging, experiment bundles, LabVIEW remote panels.

I. MOTIVATION

Remote experimentation is a trend that has become visible during the last years, both in scientific research and in commercial organizations [2]. In education it can therefore be useful for students to become acquainted with this new method of experimenting.

But there are other reasons why online experiments can be a valuable addition to current educational programs. One can e.g. think of an increase in the availability of experiments. Examples are the possibility to perform an experiment remotely in a lecture room (where normally no laboratory equipment is present), from home, and outside the normal opening hours of the lab. Other examples are the possibility to offer access to experiments that are normally too dangerous for bachelor students (e.g. experiments with radioactive radiation) or experiments that are too vulnerable.

Finally, online experimenting can lead to financial benefits, by sharing expensive equipment between institutions.

Of course, not all experiments are suitable to be performed through a remote interface. The educational purpose of an experiment is crucial here. If the purpose of

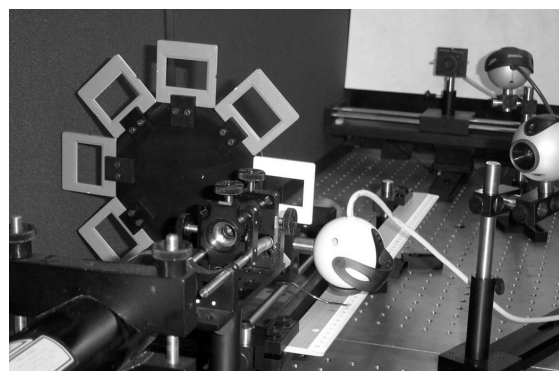


Figure 1. Setup of one of the remote experiments.

an experiment is hands-on experience in building an experiment, the experiment is certainly not suitable to perform remotely. However, some experiments will have other primary purposes, for example learning concepts. These experiments can be suitable as remote experiments.

Often, it is asked why not to use simulations instead of real experiments. Of course simulations can also be very useful in educational settings, but they miss the direct connection to the real world that is so essential for physicists. Recognizing that the experiment is ‘real’ can also be an extra motivation for the student performing the experiment.

For some experiments it is not possible to use simulations for other reasons: For one of our experiments for example it will be possible to send in a sample that can be analyzed with X-ray fluorescence and absorption. Another example is a set of weather stations, where location and time of the measurements are important.

II. RESULTS

The e-Xperimenteren+ project aims at three main results:

- A. An initial pool of online experiments.
- B. A software environment for reservations, logs etc.
- C. A set of tools and manuals that ease the addition of new experiments to the pool.

A. The initial pool of online experiments

Purpose is to build about twelve experiments that can be controlled remotely through the internet:

X-ray fluorescence and absorption: in this experiment X-ray radiation is targeted on different samples. The energy spectrum of the fluorescence photons can be measured with the help of a movable detector and a multi channel analyzer. By comparing the measured spectra with the spectra of known samples it is possible to analyze the contents of the sample.

Laser Doppler Anemometry: Laser Doppler Anemometry is a modern method to determine flow speeds by measuring the speed of small particles within the flow. Two laser beams overlap in a small region. The intensity of the light that is reflected by the particles in that region is measured and by using a Fast Fourier Transform the speed can be determined. LDA can be described either classically by means of interference or relativistic by using Doppler shifts.

Fresnel Diffraction: In this experiment diffraction patterns of several objects can be examined. The setup consists of a laser, a carousel with different objects and a movable detector. Measured patterns can be compared to simulations.

Michelson Interferometer: In this experiment it is possible to measure the thickness and refractive index of a glass plate. A laser beam is split and after taking different optical paths the interference pattern is measured by a CCD camera. By rotating the glass plate in one of the optical arms the interference pattern will vary.

'The Sphere': A glass ball contains a salt solution and a movable electrical dipole. Electric signals on the dipole can simulate amongst others EKG measurements. Different electrodes on the sphere enable diverse measurements. The experiment is usable for a wide range of topics, including medical physics, electronic technique and fundamental electrostatics.

Level Control: The fluid level in a water tank can be controlled by a pump (the water flows back into a buffer tank). Different control problems (like oscillation of the level) are included in this experiment.

Hot wire anemometry: A Hot-Wire Anemometer is a gas velocity sensor. It is interesting due to its simplicity regarding the hardware and its difficulties as a nonlinear system. This experiment focuses on the use of digital PC hardware for measurement and control and dynamical systems and the use of linearization.

Speed of light and the Doppler effect: Microwaves are reflected on a reflector that moves at a constant speed. The interference of the outgoing and reflected waves is recorded. By determining the interference frequency, the frequency of the microwaves and the speed of the detector, the speed of light can be calculated.

Measuring e/m : A glass ball is filled with a gas under a very low pressure. Electrons are accelerated with a controllable acceleration voltage on an electron gun. The gas emits photons when struck by the electrons so the path of the electron beam becomes visible. A uniform magnetic field can be introduced by regulating the current through two Helmholtz coils. The magnetic field causes the electrons to follow a circular path. By measuring the radius of this circle and using the values of other parameters it is possible to determine e/m .

Weather stations: On each of the four participating institutions a weather station will be placed. It will be possible to compare the data from the weather stations, both current data and data from the past.

B. The software environment

The software environment consists of a number of modules. Part of it is based on software from the project Co-lab [4].

Reservations and access: each experiment has an agenda that keeps track of reservations in the future and is also used for registration of past experiments. Students can, if they have sufficient rights for an experiment, make and cancel reservations.

Reservation rights: we use a system that resembles the system used for credits for prepaid mobile phones: by entering a code, a student can acquire rights to make reservations for one or more experiments. In a so called 'experiment bundle' the maximum number of reservations, maximum time for each reservation, validity period etc. is determined. It is possible to associate exclusive time windows with experiment bundles, so only students using a specific bundle can make a reservation during these periods of time.

Storage of measured data: when an experiment is performed. The student can save data. (For some experiments the data will be saved automatically.) When the student logs in to the system at a later moment, he will have access again to the saved data.

Automatic logging and experiment log: during an experiment, some actions are registered automatically to a log. Examples are starting or stopping a measurement or changing a setting. The student is always able to add entries to the experiment log, for example comments explaining why a certain action is performed. In this way an electronic experiment log is assembled. Actions that are logged are specific to each experiment.

Monitoring agent: the status of all experiments is monitored regularly. The status information can include a description of an error, which is sent to the person maintaining the experiment whenever this error occurs. Also, if the experiment becomes unreachable for some reason an email is sent.

To minimize administrative tasks, students have to create their own account using their email address. The only thing a teacher has to do is distribute the codes of an experiment bundle to the students. When the students enter the code in their accounts, the rights of the experiment bundle are added to their accounts.

For complete control it is possible to have different experiment bundles for each student, however, for less efforts in creating and distributing the codes of the experiment bundles, it is also possible to let students share one bundle that contains more reservation credits.

The software controlling the experiments is written in National Instrument's LabVIEW, using the remote panel technology of LabVIEW. A set of LabVIEW components is written for the link to the software environment.

The software environment is web based, using PHP (a scripting language) and MySQL (a database). There are different roles for students, instructors, operators

(maintaining the experiments) and some administrative roles (e.g. experiment bundle creators).

C. Tools and manuals for extension of the initial pool

Purpose of these tools is to ease the process of adding a new experiment to the existing pool of experiments. When a new or existing partner wants to add a new experiment, a number of standard components (LabVIEW VI's) and a manual are available.

The LabVIEW components include components for easy use of (multiple) webcams and components for linking to the reservation system and the system that stores the logs and measured data.

Apart from this there will be manuals and best practices with information on how to set up a new remote experiment. Experiences from the project will be disseminated through these documents.

III. PARTICIPANTS

The project e-Xperimenteren+ [1] is financed by the Digitale Universiteit (DU) [3]. The project was started after a successful pilot-project. The Digitale Universiteit is a consortium of ten universities in the Netherlands. Participating universities of the e-Xperimenteren+ project are the Universiteit van Amsterdam, the Vrije Universiteit Amsterdam, the University of Twente and the University of Professional Education Fontys. We hope that more institutes will participate in the future.

REFERENCES

[1] Project e-Xperimenteren+: <http://www.du.nl/remotelabs/> (under construction)

[2] See e.g. <http://www.collaboratory.nl/>

[3] DU (Digitale Universiteit) <http://www.du.nl/>

[4] Co-lab: <http://www.co-lab.nl/>

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