

BUILDING YOUR OWN REAL REMOTE EXPERIMENT COTROLLED BY A MOBILE OR TOUCH ENABLED DEVICE

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Abstract

We present “**iSES Remote Lab SDK**”, a new version of software development kit (SDK) devoted for creation of online real remotely controlled experiments. In comparison with the original version based on Java applets, current interface based on JavaScript and HTML5 allows users to access it from **smartphones** or other **touch enabled devices**. It offers better graphical and design customization capabilities. While mostly used with ISES hardware, the kit also supports other hardware platforms (COM and USB devices, encapsulated third-party experimental setup, multimeters, stepper motors etc.) When deployed, it also provides basic logging features allowing the creator to observe user interactions with the experimental interface in detail. We also present a unique set of elementary modules of the iSES SDK that may be easily combined and used by beginners to create any parameter value input/output, XY or Y(t) graphs, visualizations including a webcam view etc. Experimental data can be easily exported for further processing. Finally, we present a few sample experimental designs available on our sites <<http://www.eedu.eu>> and <<http://www.ises.info>>.

Keywords

Remote experiments, reseach-based education, Physics, HTML5, JavaScript.

1. Remote experiments based on Java applets

Since 2002 the remote laboratories have been developed at the Faculty of Mathematics and Physics. The first generation of remote experiments was based on Java applets. However, since 2012 Java applets began to be restricted due to security issues. Users now have to confirm running Java applets with warning about possible security risk. This basically rendered the technology unusable for client-side web user interfaces in all applications. Moreover, support of Java applets in smartphones and similar devices was mostly lacking.

2. Remote experiments based on JavaScript

Since 2013 we have been moving to JavaScript when creating user interfaces for remote experiments on our faculty. Remote experiments are built with new software kit “**iSES Remote Lab SDK**” (Dvořák, Kuriščák, Lustig 2013). Philosophy of this new kit is the same as in case of Java applet version „ISES WEB Control“ (Dvořák, Lustig, 2003). We want to provide non-programming users a possibility to create custom remote experiments. By using **JavaScript** and **HTML5**, the experiments work also on **mobile and other touch enabled devices**.

Let us summarize how remote experiments work. Remote experiment is a server-client type application. *Server side* of the experiment consists of computer connected to the Internet. A measuring apparatus of real experiment is connected to the computer (e.g. our system ISES [3], [4], or other measuring systems like LabVIEW, devices with RS 232 or newly USB

interface). It can also consist of stepper motors, controllable sources, multimeters etc. Note: If you want to create a remote experiment, where the user is able to control some device, it is not possible to use measuring systems which do not have output channel. Such systems (such as Pasco, Vernier) consist only of input channels and can be used only for experiments of type “sensing”, where quantities are only measured. Systems with analogue or digital control channels, such as ISES, LabVIEW and others, allow building of remote experiments of type “control”.

Server-side computer has to run a *MeasureServer* application that communicates with hardware and provides data to connected users. To serve the actual user interface, a web server has to be also running, usually also on the measuring machine. Our experimental setups are using freely distributable *WebServer Nginx*. To provide webcam-captured live video stream, we developed an *ImageServer* application that can also be running on the measuring computer.

Client device should run an internet browser supporting JavaScript and preferably WebSocket connection (fallback is available). These are considered almost standard features of all modern browsers in most devices.

3. Software kit “iSES Remote Lab SDK” for remote laboratory

iSES Remote Lab SDK consists of approx. 20 freely distributable (under Creative Commons licence) JavaScript objects in commented source code. Objects/elements with graphical interface are called widgets. The widget source code can be modified by experienced *programmers*. However, widgets are highly configurable and provide many thoroughly documented options, which are available by default and which allow even *non-programmers* to build a complex measuring and controlling interface with data and video transfer. Among built-in features, users have access to real-time spline interpolation, simple processing, export of data in various formats, graphical output and other sophisticated functionality. Direct connection to the remote experiment server is realized through WebSocket protocol, which provides very low-latency.

User interface elements are mostly based on JQuery and few other freely available JavaScript libraries that are distributed together with the SDK. By using these standard elements, the user interface visual design is also highly customisable. Web-page developers are able to alter the default design using standard methods (mostly CSS) to fit the webpage in which the interface is embedded.

3.1. Original on-line pedagogical research based on log system

The *MeasureServer* records each user’s activity in a log file with time stamps, which provides important information about measurement sessions of all users. Although there is a problem with anonymous IP addresses, we have some means like unique codes for each student that should be used for login before the session starts in order to surely assign a log record to the user. Through the analysis of the log file we can learn how students behave in a virtual learning environment, e.g. how much time they spent on a certain activity, which steps they did or did not perform, and whether the whole procedure was meaningful, or just playing with control elements, perhaps with some kind of confusion. We present an example of a log record in Tab. 1.

81.25.16.87	17.4.2011	18:37:29	1035 s	ID(4)
0:W(1){88}*Sv1{23}*Sv1{10}*Sr(100){71}*Sl1{1}*Sl0{4}*Sl1{7}*Mv(-12.16){0} *Mv(-445.85){0}*Mv(-477.93){0}*Mv(-1000.00){1}*Mv(1000.00){4} *Ma0{160}*Sf(0){1}*Sf(1){3}*Sf(0){10}*Ma1{46}*Pr(1){9}*Ma1{43}*Sf(1){3}*Ma1{43} *Sf(2){3}*Ma1{44}*Sf(3){3}*Ma1{42}*Sf(4){3}*Ma1{43}*Sf(5){8}*Sl0{5}*Ma1{44} *Ps(1){0}*Pd(1){12}*Pd(1)*D				

Tab. 1: Example of a log record derived from the log file of the remote laboratory on the photoelectric effect.

From the log-record in Tab. 1 we can read that a student selected the measurement of the Volt-Ampere characteristics of a vacuum phototube (mode 0 at the beginning) and had to wait in a queue for 88 seconds till he took control of the experimental setup. He switched the mercury lamp on (Sv1) and after approx. 5 min of playing and getting familiar with the interface he started data recording and systematically measured all the V-A characteristics for six available frequencies of light (Sf0-5). The student always used automatic measurement (Ma1) that takes approx. 40 s. Finally he stopped recording (Ps) and downloaded (Pd) his own data for further processing – determination of the stopping-voltage values and the experimental value of Planck constant. Curly brackets {...} correspond to the time duration since previous action in seconds. Parentheses (...) contain a parameter, e.g. an index of the selected filter.

Furthermore, log records include some basic classification of activities for statistical analysis (S – settings, M – measurement, P – advanced processing of data). We managed to find 4–5 behaviour patterns, e.g. students’ decisions to download and process someone else’s data records when he/she is completely lost or because of traffic jams just before deadline. We also detected some kind of students’ disengagement and perhaps confusion by the user interface, which helps us to develop new and better remote laboratories and to improve user interface as well. Details can be found in (Lustigová, Brom, 2014); (Lustigová et al., 2014).

3.2. Collection of simple remote tasks

For beginners who want to try out custom remote experiments, we prepared the *Collection of simple remote tasks* such as remote analogue record of one quantity (e.g. temperature) in time, remote analogue control of one channel (e.g. switch relay), remote control of digital inputs and outputs, time dependence of two or more quantities, XY dependence of input and output quantities, remote control of linear and stepper motors, remote data transfer from multimeters with COM port, data record, data export, WEB camera stream etc. Examples are written very simply so the source code is clear. These simple tasks can be arbitrarily merged and combined, so even beginners are able to rapidly develop complex interfaces. They can immediately control their own remote experiments via mobile phone or tablet.

3.3. Final notes to “iSES Remote Lab SDK”

Remote experiments built on **iSES Remote Lab SDK** can be used *anywhere, anytime* and *by anyone* and newly we modify them in such way so they are accessible from any **PC platform, tablet or mobile phone**.

Few notes to hardware of measuring apparatus - nowadays we use ISES-PCI and ISES-USB kits. ISES-PCI uses ADDA PCI card installed in desktop PC. The big advantage of solutions based on ADDA card is large number of inputs and outputs (e.g. ISES-PCI with relay card has 8 analogue inputs, 2 analogue outputs, 16 digital inputs/outputs, resp. 16 relay outputs). There is no other kit that would offer such wide possibilities. Moreover, we prepared new simple kit ISES-USB, which has two analogue inputs, one analogue output and five digital inputs/outputs; also mini kit ISES-link with one analogue input and output and five digital

inputs/outputs. Note that all variants provide outputs, because no proper remote experiment can be built without them.

4. Contemporary hardware base for “iSES Remote Lab SDK”

Software kit “iSES Remote Lab SDK” presently supports measuring apparatuses *ISES* (ISES-PCI, ISES-USB, ISES-link), universal measuring apparatuses with *COM* or *USB* communication, especially linear and rotation positioning devices with large XYZ range (10 cm to 1 m). The *commercial equipment “Franck-Hertz experiment”* made by corporation Phywe and few other dedicated devices are supported as well. Support for other equipment is just a matter of new plugins. We are also able to create *plugins for arbitrary equipment on demand*.

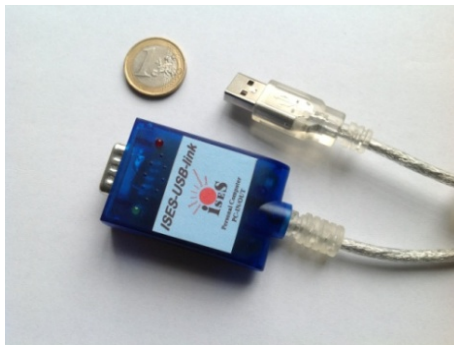


Fig. 1: ISES-link kit

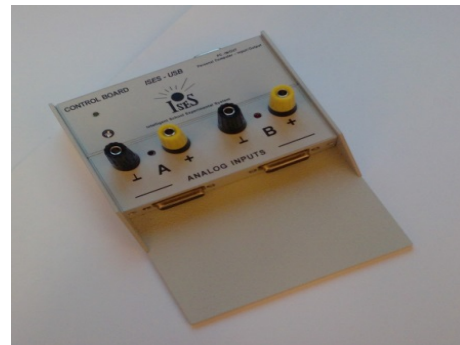


Fig. 2: ISES-USB kit



Fig. 3: ISES-PCI kit



Fig. 4: Phy, Che and Bi ISES modules



Fig. 5: Universal measuring device with COM or USB communication port (e.g. multimeter UT-61E, environmental multimeter DT-223, power supply PSP 12010), that are supported by iSES Remote Lab SDK



Fig. 6: Universal rotation and linear stepper motors, which are supported by iSES Remote Lab SDK

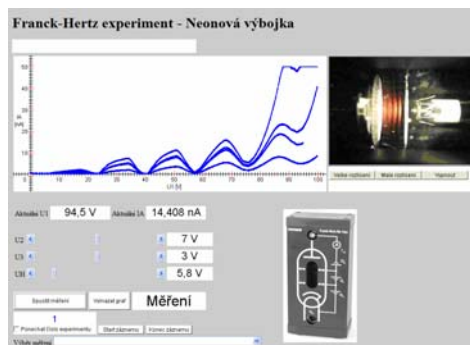


Fig. 7: Commercial laboratory device „Franck-Hertz experiment“ by Phywe (left), which is used in remote experiment developed by iSES Remote Lab SDK (right). http://194.160.213.12/index_js.html on PŘF UKF Nitra, <http://147.251.193.82/index.html> on Ped MUNI in Brno.

5. Showcase of remote experiments

On website <http://www.ises.info/index.php/en/laboratory> and <http://www.eedu.eu>, you can find showcase of experiments based on “iSES Remote Lab SDK”, and also videos demonstrating how to work with them. Many experiments also contain an assignment, measuring instructions and examples of processing.

Up to now we have built 18 remote experiments for secondary school and university level, which we freely offer to you for use in your school projects, education and also free time activities.



Fig. 8: Electromagnetic induction
http://kdt-20.karlov.mff.cuni.cz/ovladani_2.html



Fig. 9: Solar energy conversion
<http://kdt-4.karlov.mff.cuni.cz/>

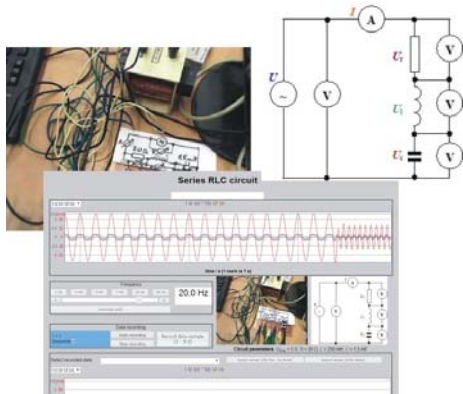


Fig. 10: Series RLC circuit
<http://kdt-30.karlov.mff.cuni.cz>



Fig. 11: Water level control
<http://kdt-34.karlov.mff.cuni.cz/cz/mereni.html>

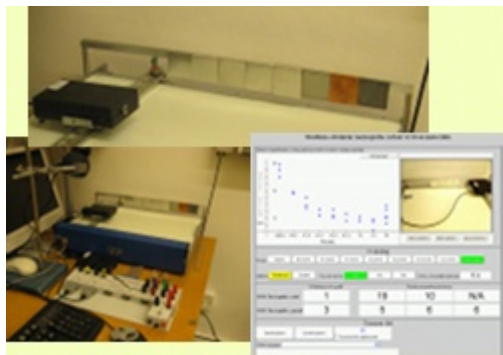


Fig. 12: Study of radioactivity (5 experiments)
http://kdt-38.karlov.mff.cuni.cz/choice_cz.html

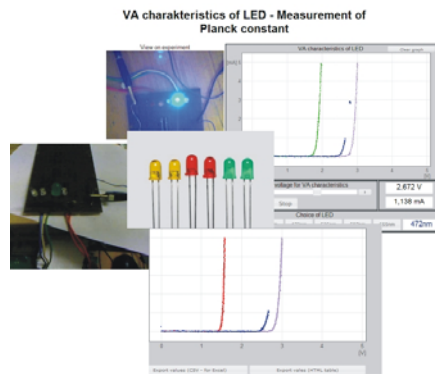


Fig. 13: Measurement of Planck constant
<http://kdt-33.karlov.mff.cuni.cz/>

Other remote experiments:

Rectifier

<http://kdt-19.karlov.mff.cuni.cz>

Map of stations monitoring natural background radiation

<http://kdt-1.karlov.mff.cuni.cz>

Meteorological station in Prague

<http://kdt-16.karlov.mff.cuni.cz/cz/mereni.html>

Heisenberg uncertainty principle

http://kdt-13.karlov.mff.cuni.cz/sterbina_js.html

Natural and driven oscillations

<http://kdt-17.karlov.mff.cuni.cz>

Photoelectric effect

<http://kdt-29.karlov.mff.cuni.cz>

Some remote experiments built with „iSES remote Lab SDK“ are running also on other schools such as:

Mass oscillating on a spring

<http://remote-lab.fyzika.net/experiment/05/experiment-5.php?lng=cs>

at Gymnázium J. Vrchlického, Klatovy

Franck-Hertz experiment (Phywe apparatus)

<http://147.251.193.82/index.html>

at Pedagogical faculty MU Brno.

Other remote experiments built with „iSES remote Lab SDK“ are located at Pedagogical faculty in Trnava and Faculty of Natural Sciences UKF in Nitra (SK).

We are going to restore **Polarisation of light**, **Faraday phenomenon**, **Magnetic field mapping**, **Magnetic field in coil axis** etc. soon.

6. Conclusion – mobile technologies YES or NO?

On fig. 14 we see the remote experiment Electromagnetic induction, visited by tablet and smartphone.



Fig.14: Remote experiment „Electromagnetic induction“, on iPad and on mobile phone.

We expect that new technologies of remote experiments based on JavaScript, which work on mobile devices, will become attractive for young generation. Mobile phones in school are a controversial topic. Their use is banned during class almost everywhere. However, the smartphones replace calculator, stopwatch, camera, GPS etc. Smart applications make possible to work with sound, light; measure speed, acceleration; record sound and video. They become priceless when one needs connection to the Internet – e-mail, cloud storages etc.

To ban personal mobile devices or to actively use them? The movement to use personal mobile devices is called BYOT/BYOD Bring Your Own Technology/Device.

Passive users of smartphones do not feel the rise of the “cloud computing” (originally based on utility and consumption of computer resources, nowadays providing services, programmes accessible from internet browsers). It is not surprising that the same webpages can be downloaded into PCs and mobile devices. In the past webpages for PCs and mobile phones had to be written separately!

Social media become omnipresent with fast rise of smartphones. We are no more bound to classroom with computers. We are in a “school without walls”.

We are able to download music, videos, and books from the Internet. Now we have proved that you can “download” whole real experiment on physics/nature studies!

Learning can be realised through mobile devices. It can be realised outside school, home, somewhere on the way, in restaurant, on party, while travelling etc. This phenomenon called “downtime learning” and was studied by (Dean Groom, 2011).

Above listed technology and learning visions are suitable for remote experiments on mobile phones. Education, e.g. classic laboratories, which are nowadays inside school walls, become “laboratories without walls”, which are accessible from anywhere, anytime, to anyone and they can be completed from any device (e.g. mobile).

Remote experiments are new objects in e-learning and in m-learning. We do not try to prefer m-learning although it is very tempting. Let us use it spontaneously, on untraditional places, but in such way where we educate, explore and construct with classic or distant form of education; not where we only demonstrate new technologies. Let us work individually or in groups.

In conclusion let us remind Dean Groom, who says that improving in environment of unlimited contact with different people and information means to be fond of exploring – to be anytime ready for an action, until you know everything, you have ever wanted...

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