iSES Remote Lab SDK – Lite version

easy remote experiments with Arduino Uno

Manual

Introduction

Software kit **iSES Remote Lab SDK – Lite version** is a collection of simple examples, which can be used for construction of fully functional remote experiment with Arduino Uno by putting these components together. The first example contains video transfer from a common web camera, time dependent graph of one analog input (e.g. a potentiometer as a position sensor, temperature sensor, light sensor, ...), control of one digital output (e.g. relay). Other examples demonstrate recording of one analog channel and data export into a *csv* data file format for e.g. MS Excel, or into a *txt* data file. These experiments are written using HTML5 and JavaScript. All the components can be simply modified and added, so it is possible to create remote experiment with one channel digital and/or graphical output, with data export and control of one channel – for example digital output with relay, and also with online live video stream.

Remote experiment can be installed on PC with operating system Windows 7, 8, 10 (both 32 bit and 64 bit versions), with internet browser (latest version recommended) - e.g. Edge, Internet Explorer, Firefox, Chrome, Opera – only JavaScript is required to be enabled. To process the measured data it is suitable some other software like MS Excel or OpenOffice. If you wish to install programs into Arduino, you will need to install Arduino-IDE (if you already have installed Arduino, it is not needed).

Remote experiment is an application between a server and client. It requires thus two computers: the *experiment* runs on the *server* and the visitor – *client* – needs to use a PC, smart phone, tablet or any other *device with modern internet browser*. On the **server side** there has to be running the *MesureServerLite* for remote measurement, *ImageServer* for live video stream and any WEB server (we use *nginx*, available from http://www.nginx.org). On the **client side**, the visitor needs only a modern browser and URL of the experiment (e.g. 193.213.36.17 or http://kdt-20.karlov.mff.cuni.cz), where user finds all the elements for the control of the experiment. The control of the experiment from the webpage is easy and user-friendly. We can observe the experimental setup, measure, record and export data and copy the experimental values into e.g. MS Excel for further data processing.

In our case the experiment is installed on one computer only, and there must be running three server applications (MeasureServer, ImageServer, and WebServer). We can visit the experiment locally by entering localhost address http://127.0.0.1 . If we want to control the experiment from outside, we have to enter the real physical IP address (e.g. 195.113.123.456) or the assigned domain (e.g. http://kdt-19.karlov.mff.cuni.cz) that you need to find out.

Installation of remote experiment hardware

Arduino Uno is used as measuring hardware (it is possible to use other Arduino models). We use *A0* as input PIN and *D3* as output PIN. Input sensors are connected to +5V, GND and the input *A0*. Output sensors are connected to +5V, GND and output *D3*. Arduino Uno is connected through USB port to the computer.

Installation of remote experiment software

On the web pages www.ises.info download **VirtualLab_Arduino_Lite_EN.zip**. Extract the archive and copy the folder *VirtualLab_Arduino_Lite_EN* (including subfolders) anywhere into your PC, e.g. *C:\VirtualLab_Arduino_Lite_EN*. Open the folder, where you can find subfolders *Arduino_firmware*, *Bin* and *Pages*. We need to

1. install software into Arduino-Uno,
2. install server applications into PC.

1. Installation of *software* into Arduino-Uno

In the folder *VirtualLab_Arduino_Lite_EN* there is a subfolder *Arduino_firmware*, which has to be installed into Arduino-Uno using basic software for Arduino or other hardware clones of Arduino. You need to know number of COM port where Arduino is installed, and hardware of Arduino (Uno, Due, Mega, etc.). For advanced users this is sufficient information. Detailed instructions follow in the next paragraphs.

Of course we present step by step solution for beginners. First, install firmware for Arduino Remote laboratory. The best solution is to install whole development firmware for Arduino including drivers and libraries.

You can download it from the webpage https://www.arduino.cc/en/Main/Software by choosing „Download the Arduino Software Arduino 1.6.7" (latest version) and run the installation file *Arduino-1.6.7-Windows.exe*. Agree with terms and conditions and install all parts. In the *Documents* folder there was created folder *Arduino*. Into this folder you need to import all libraries. Instructions, how to install libraries, can be found at the webpage http://www.arduino.cc/en/Guide/Libraries. Import of libraries can be done from Arduino 1.6.7 program menu (*Project -> Add library …*) or by copying the whole folder *libraries* (located at *C:\VirtualLab_Arduino_Lite_EN\arduino_firmware\libraries*) into the *Documents/Arduino*. The location of the documents folder depends on your OS.

So in the *Arduino* folder you have subfolder *libraries*.

In the folder *C:\VirtualLab_Arduino_Lite_EN\arduino_firmware\Arduino_demo* locate the file *Arduino_demo.ino*. This file has to be copied into Arduino. While opening this file, the programming environment opens. In the *Tools section* choose serial COM port number, where the Arduino is connected (Arduino has to be connected into USB port). Choose there the Arduino type (Uno, Due, Mega, etc.) and then you can run the program into Arduino by clicking on the blue arrow icon in the top menu.

In case of problems, further information can be found on http://arduino.cc (later the support will be added on our website http://www.ises.info). Alternatively request Arduino with preinstalled software. You can also contact us via e-mail: Frantisek.Lustig@mff.cuni.cz. If the firmware is installed, continue to next step.

2. Installation of software for the server

If you copied the folder, the step is complete. For the *local testing* the *server* and *client* might coincide – it is the best way to test the functionality of the experiment. Later, when everything is ready, you can publish it on the Internet for other users.

First run of a remote experiment on the local computer

When the firmware is installed in Arduino and the installation folder is in place (in our case *C:\VirtualLab_Arduino_Lite_EN*), you can connect some input sensor (e.g. a potentiometer, temperature sensor, optical sensor, etc.) to the PIN *A0*, some output sensor (e.g. relay) to the PIN *D3*. Arduino can be powered through the USB port, external power is not required. Connect the Arduino to the computer with Windows OS through USB. You can also connect the WEB camera.

1. **Run all software components required for remote experiment** (*MeasureServerLite.exe, Nginx.exe,* and perhaps *ImageServer2.exe* for web cam).

MeasureServerLite.exe:

Run the executable, in our case located at

C:\VirtualLab_Arduino_Lite_EN\bin\MeasureServerLite.exe.

The program MeasureServerLite.exe needs the number of a virtual COM port, on which your Arduino Uno works. The port can be obtained from *Device Manager* in Windows (you may use Win+X). Write the number into MeasureServerLite. After you do that, don't be surprised by error *Unable to open port*, which says that written COM port is not same as COM port, where your Arduino Uno is connected. Click on the label *Arduino*, click on the button *Configure selected*. In the *Config* panel, click the button *Cfg* and then in the *Port selection* box enter the found COM port number for Arduino (e.g. 5). Click OK and once more. If you have a firewall on your computer, check all exceptions to be enabled for all the server application!

Nginx.exe

Note: If you use custom web server, you might have to set up some configuration to run the experiment – e.g. set up the web folder directory and allow public access. Other possibility is to shut down a running web server (by default) and run the recommended *nginx*.

Run the executable, in our case located at

C:\VirtualLab_Arduino_Lite_EN\pages\nginx\nginx.exe

The application has no standard window, as it runs in background – you can verify it in the Task Manager, where you will find it twice (property of *nginx*).

Note: Don't run the *nginx* more than once, or the remote experiment won't work properly. The web server *nginx* can be terminated by

C:\VirtualLab_Arduino_Lite_EN\pages\nginx\stop.bat

ImageServer2.exe

If you have connected and installed the web camera, run the executable, in our case located at

C:\VirtualLab_Arduino_Lite_EN\bin\Image server2.exe

When the window shows, choose your web camera from list in the top. Other parameters don't need to be changed, as they are set to default values. Now you should see the image from the web camera. Again, if you have a firewall, check the server application to be enabled. The support will be added later on our website http://www.ises.info. You can also contact us on via e-mail: Frantisek.Lustig@mff.cuni.cz.

2. Run any modern internet browser – e.g. Edge, Chrome, Firefox, etc.

Write local host address into the address bar, by default the local URL is http://127.0.0.1. If the *nginx* is running, you should see the page http://127.0.0.1/index.html. You can see sample experiments page *Arduino Remote Experiments*, such as WebCam, Analog input, Digital output, Data Record, Data Export. For our demonstration choose *Analog input*. Some of the experiments contain video transfer from the web camera.

Note: Of course you can see the source code and try to modify it!

All sample experiments are written simply without any styling – to illustrate that the source code is easy and clean!

3. All is done – we have setup sample remote experiments with Arduino Uno on the local address 127.0.0.1, everything on **one** computer. Now you can publish it.

Let's try to connect to the hardware remotely from the Internet. The real experiment is running on one PC and it will be controlled from a different remote PC, smart phone or tablet!

Delivered sample experiments from collection *Arduino Remote Experiments* are written for local testing on address 127.0.0.1. However, the real remote experiment will run on IP address of your computer / server. First you need to obtain your IP – go to the Start menu -> Command Prompt (or press Win+R and type *cmd*) and write command *ipconfig /all*, then press Enter. Here you will find the physical IP address in a format e.g. 195.113.73.33 or text format e.g. kdt-26.karlov.mff.cuni.cz. For example, let's assume you get 195.113.73.33 (you will get of course different address!).

Run the server applications *MeasureServerLite.exe*, *Nginx.exe*, and *ImageServer2.exe*, if you have a web camera. The client will now be on another computer – a notebook, tablet, or a smart phone, etc. Run the web browser at the client computer and enter the server address – in our example 195.113.73.33.

Note: If the experiments' control elements seem to be inactive, make sure that the client web browser has JavaScript enabled. If the browser can't find your experiment page make sure the server is accessible from the Internet – check the settings of the web server and the settings of your site.

Ready!!!

If you have done everything properly, your experiment communicates between your PC (the server), and client (visitor) from the Internet. You can control it with any PC, smart phone or mobile devices connected to the Internet.

Try out the **data recording** and **data export**. You can find it in the collection, the downloaded data can be exported to MS Excel in the *csv* format or in web page in the *txt* format, from where you can copy the values via Ctrl+A (select all), Ctrl+C (copy to clipboard) and Ctrl+V (paste them anywhere you want).

Conclusion

Dear users,

You get freely distributable, fully functional software kit **iSES Remote Lab SDK – Lite version** dedicated to remote experiments with Arduino Uno. The Lite version is limited to only one input and one output and few examples. We kindly ask you to include our footer in your webpages in the next (copyright) section.

Thank you!

Copyright

The look of the footer to be included into your webpages:

Powered by iSES Remote Lab SDK

Source code of the footer:

```
<!-- COPYRIGHT -->
<script src="http://ises.info/licence/licence.js"
type="text/javascript" language="JavaScript"></script>
<noscript>
<iframe src="http://ises.info/licence/licence.html"
width="100%" height="70" frameborder="0"
scrolling="no"></iframe>
</noscript>
<!-- COPYRIGHT -->
```

Thank you for including this footer in your web pages.

Full version for Arduino Uno

Dear users,

We can offer you the full version of **iSES Remote Lab SDK** for Arduino Uno, which consists of 15 inputs, 15 outputs (there can be even more…). We have developed following, more complicated examples:

- Simultaneous 15 analog inputs for diferrent devices
- Analog output for all PWM
- Analog output using 12-bit D/A converter
- Slider
- XY graph
- Long-time data record (e.g. monitoring of the weather, radiation background) with choice of time interval
- Pulse generator: sine, rectangle, saw
- We can create other universal examples according to your specifications.

Full version for other devices

Dear users,

The software kit **iSES Remote Lab SDK** is dedicated to other platforms and variety of hardware, too:

- All clones of Arduino
- hardware ISES (http://www.ises.info/old-site/index.php - only in Czech),
- standard measuring devices with a COM or USB port, e.g. universal multimeter UT-61E, environmental multimeter DT-2232, laboratory source PSP 1405, and many other ...
- universal linear and rotating stepper motors, 2D or 3D positioning device
- Final school kits, such as Phywe Franck-Hertz experiment accessible at http://147.251.192.82/index.html (the experiment is located at PedF MUNI in Brno).
- **iSES Remote Lab SDK** is being developed for CMA CoachLab, Vernier, etc.
- **iSES Remote Lab SDK** can cooperate with any of your hardware

More information is at http://www.ises.info/index.php/en/systemises/sdkisesstudio.

Don't forget to visit our advanced remote experiments situated at the Charles University in Prague, Faculty of Mathematics and Physics. Actually, we have 18 fully functional remote experiments. They are built on the platform **ISES** and software **iSES Remote Lab SDK**. You can visit them for free, without any password at http://www.ises.info/index.php/en/laboratory.

You can get inspired here, we can reproduce them for you and create them on demand. We can build them for any standard measuring devices.

Cooperation offer

Dear colleagues,

we will be glad to ***cooperate*** with you in grants dedicated to remote labs on behalf of the Charles University, or the Small and Medium Enterprise ISES. We can arrange **workshops** in Prague or at your place where we will ***teach*** you, hand over the requested hardware and software, or even produce complete remote experiments on your demand. We also ***seek collaborators and manufacturers*** who will help us to upgrade the *iSES Remote Lab SDK*, and ***dealers*** of hardware and software *iSES Remote Lab SDK*. For more information you can contact us via e-mail: Frantisek.Lustig@mff.cuni.cz .

Your ISES Team

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