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Automation of a lidar system using Labview software for unattended measurements and use in a meteorology virtual course

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ABSTRACT:

We show here preliminary results of the automation of the lidar system present at IPEN/CNEN-SP. The main software employed was Labview software that can be used to build a virtual interface to control the instrument using block programs based on JAVA/Perl. A good aspect of this software is its ability to put the virtual on the internet, allowing remote sensing (access) of the instrument. Also we show the implementation of Labview's virtual interfaces to the modules present at the lidar system and the development of the controlling software for each one. With the intention of using this tool as a virtual course on meteorology we adapted a middleware for this task, namely MOODLE, which is an acronym for "Modular Object-Directed Dynamic Learning Environment".

Keywords: Lidar, Labview, E-Learning.

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1. Introduction

The Laser Environmental Application Laboratory (LEAL) is located at the Center for Laser and Applications (CLA) of Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP) and has been monitoring the air quality since 2001 with an elastic backscattering aerosol LIDAR, first of its kind in Brazil [1]. Aiming to have a climatogical aspect to its research studies the LEAL has a need to run for long periods of time and therefore the experiment might be very time consuming and obliging the attendance by trained personnel in the laboratory site. Besides, recently a fast internet network has been created in the State of São Paulo

(Brazil) which connects many academic institutions, research centers and weblabs – a weblab is by definition a laboratory which can be controlled via internet [2]. Given this opportunity LEAL was upgraded to a hybrid system which can be manually and remotely controlled.

In this paper we show the steps taken to have most of the lidar LEAL system automated and therefore capable of being controlled and monitored through the web. The main software used was Labview for controlling the devices, pre-processing the data and webpublishing. While the system control is not an entirely new concept [3,4] the fact that is to be put in a fast collaborative network largely enhances its potential for applications specially as a learning tool.

We shall give a description of the LEAL weblab system architecture and the details of the main instruments which have been adapted to be controlled via internet as well.

2. System description

The system developed at CLA is an aerosol back scattering lidar system, operational since 2001 and is being used for monitoring and categorizing the pollution in the São Paulo Metropolitan Area. From the point of view of setting up a weblab the lidar system consists of three main modules: a) Light source which consists of a 20 Hz pulsed solid state laser running at the second and third harmonics (532 nm and 355 nm) with energies up to 100/40 mJ (532/355 nm). b) Receiver which is a 30 cm diameter Newtonian telescope to collect the signal generated in the atmosphere by the laser and c) Photomultiplier tube transforms the optical signal into electrical and digitizes it in a 12-bit Transient Recorder which is computer controlled and interfaced by a fast data transfer card. From these 3 modules the last one can be fully automated through the internet since it is interfaced by a TCP/IP card which connects to a PC computer and controlled with Labview with all the programs already developed at the manufacturer (Licel GmbH).

3. Weblab design

The LEAL weblab design is schematically described in Fig. 1 which involves three main subsystems: the web interface, the lidar control system and webserver and data analysis system software. The combined use of these three systems will allow users to control of the remote lidar equipment. The lidar subsystem contains the Labview software programs developed under the Windows XP platform which are described as VI's (Virtual Interfaces) as follows:

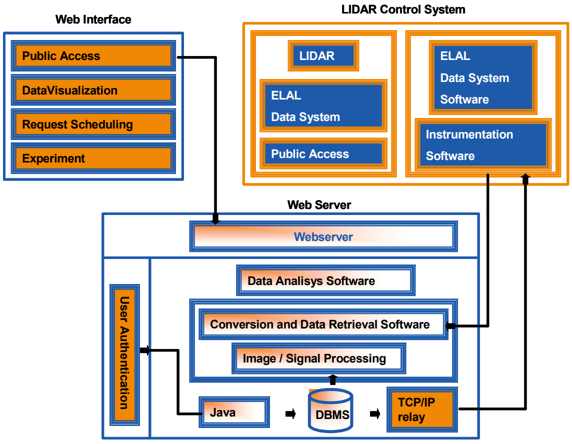

Fig. 1. Weblab architecture.

3.1. Laser control VI

Controls the laser via the RS232 port and receives as input ASCII commands provided by the laser manufacturer (Quantel/BigSky Laser). The user has the option control to turn the laser on/off and selecting its output power (Fig. 2). Embedded to this VI is another VI which has a webcam (connected to the USB port) to monitor visually when the laser is running or not. One has to bear in mind though that a switch has to be added to this two VI's as the simultaneous and continuously running of both could seriously impair the application speed and consume the memory access by all other processes running in parallel in the entire computer.

QS- Delay 410 µs

Delay QS 410

Temperatura (ºC) 0

Pulsos emitidos pela Lâmpada 0

Total de Pulsos 0

Tensão aplicada na Lâmpada (V) 0

Frequência de pulsos (Hz) 0

Fig. 2. Laser control front panel VI layout.

3.2. Transient digitizer VI (package)

This package of VI's was provided by the hardware manufacturer to control the transient recorder/digitizer which is connected by a standard ethernet interface and uses the TCP/IP protocol in which the controller can have a static IP address or a dynamically assigned address (DHCP). The package has built-in access to control the photomultiplier voltage and a trigger module which can synchronize the transient digitizer to an external laser flash or Q-switch trigger.

3.3. Mini-meteo station and ceiling door control VI

The LEAL system operates in a room which has a sliding door on the ceiling which should be shut in case of precipitation. This was previously done manually. For that purpose a moisture sensor was adapted to measure the air relative humidity (RH), temperature and dew point. This sensor has an electronics box which sets a RH threshold (previously selected by the user) with which it will (when precipitation is imminent) act on the sliding door motor to close it and through a microswitch to shut down the laser as well. The meteo station is interfaced by the serial port of the PC and controlled via a Labview VI (Fig. 3).

3.d. Data visualization and web publishing VI

In order to follow the status of the measurement and verify data alignment a VI was developed in which the raw data generated in the TR is converted from binary to ASCII and then the signal as follows:

$$S = \left(S_{raw} - BG\right)\cdot\left(bin_{\#}\cdot resol\right)^2, \qquad (1)$$

where S_{raw} is the ASCII converted data (analog or photoncounting), BG is the background radiation, $bin_{\#}$ is the bin number and *resol* is the resolution, typically 15 or 30 meters. The visualization front panel contains information on the time/date of measurement, the altitude of the different aerosol layers/clouds in the atmosphere, and the signal intensity which is somehow proportional to the amount of scattering hence the aerosol load in the atmosphere, as seen in Fig. 4.

The entire set of VI's should be connected via TCP/IP protocol and get the front panels using the built-in web server in Labview. This allows all the VI's to be controlled on the internet from a remote computer or even among the different terminals in a laboratory environment.

4. Conclusions

We presented here the steps taken to implement a web based lidar laboratory in a high speed internet environment. It has also been shown how the different instruments present at the laboratory were interfaced to a PC via the Labview software. The good aspect of this implementation is that it will:

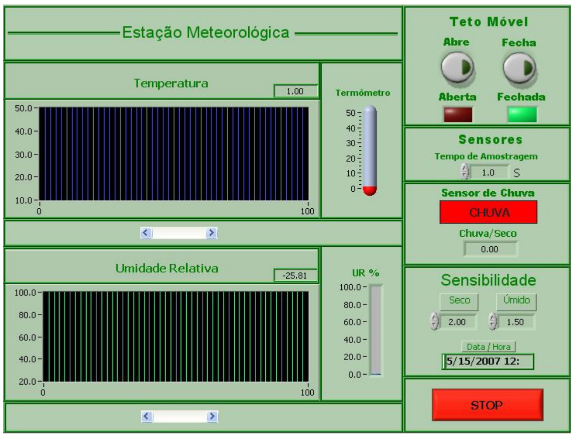

Fig. 3. Mini meteo station front panel VI layout.

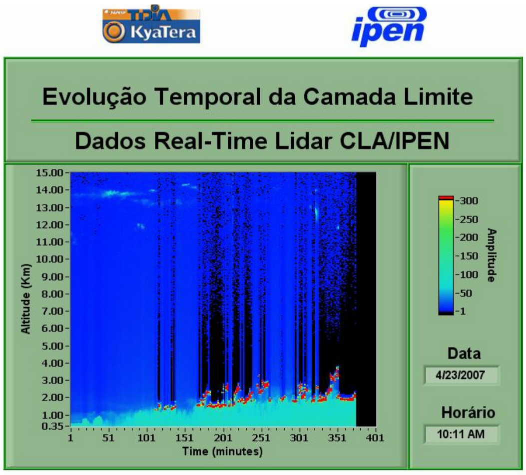

Fig. 4. Pre-processed data visualization front panel VI layout.

1. Extend the time of acquisition since unattended operation should be possible.
2. Allow distance learning for part time and remote students.
3. Prepare students before having access to the actual laboratory since working with the class of lasers involved (CLASS IV) might be risky.
4. Share expensive laboratory equipment with other universities and departments.

The system besides the operational aspect can with its web controlling feature become a teaching tool for students [5] in the engineering, atmospheric sciences and physics field [6] as it will allow students to learn aspects of atmospheric dynamics and understand atmospheric light scattering in the applications shown.

In the future we intend to implement a web-based course for undergraduate meteorology and atmospheric science students. Also we will make a hybrid system which should evaluate its tasks on the type of gateway being in use, conventional internet or Internet 2 based on the latency time the applications are being taken. Besides we should be plan a joint campaign with other university campuses belonging to the KYATERA network.

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