A Multimedia Visual Feedback in the Web-controlled Laboratory

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***Abstract*— The paper presents development work related to create WWW based remote control laboratory for teaching Applied Photonics. In order to minimize the cost at the end-user domain, simple WWW browser with fundamental plug-in (Java applets, HTML Pages and LabWindows applets) to support the remote control and video transmission functionality of the remote control is proposed. As for telepresence and monitoring of device actions, a simple type zooming web-camera is connected to the hosting multimedia PC via the USB port. The web-camera assists in visual feedback of the system and presents the feeling of telepresence for the end-user (student). USB web-cameras are normally efficient and the presence of another video server is not necessary in this case, thanks to LabWindows.**

I. Introduction

The platform technology for web-controlled laboratories could take different forms [1,3]. The common feature among all structures is to facilitate a powerful Internet hosting machine (multimedia PC) that resides on the experimental site. Multimedia PC servers two purpose: the first is to perform data acquisition, signal conditioning and control interrogated from the photonics experiment setup, and the second is to do the Internet computation and protocol procedures [2,4-7]. The backbone of computation languages could be any of the conventional programming techniques, such as Java, or adopting graphical programming methods like that of CVI/LabWindows applets. This proposal was attributed to the fact that the most of the recent efforts employ expensive interfacing devices for video transmission options and adopt server machines to accommodate the various multimedia and hypermedia components of the system. The proposed approach utilized in this development is based on using of Java methods and the PC parallel port is substituted by LabWindows data acquisition system.

The basic Internet interfacing techniques for web-controlled laboratory can be configured as shown in Fig. 1. In such scenario there will be one main Internet host machine (multimedia PC) to accommodate all procedural steps and to provide immediate responses towards commands activated by the end-user through the particular web-pages designed for this specific application. The Internet host machine should be capable to provide efficiently secured data streaming and to hide the underlying scripting methods beyond any unintended external intrusions. So much that, the adoption of either the Internet Server from JavaServer could be reliably implemented to accomplish this task. Eventually, the utilization of either the Active Server Pages or Java Server Pages are dominating among other scripting languages due to their versatile features in doing the desirable computation on the server side and then in response reflecting back the results to the user upon his request.

As a result, all data transaction and communication protocols are very much protected and the user can only observe the final execution outcomes [4,8-10].

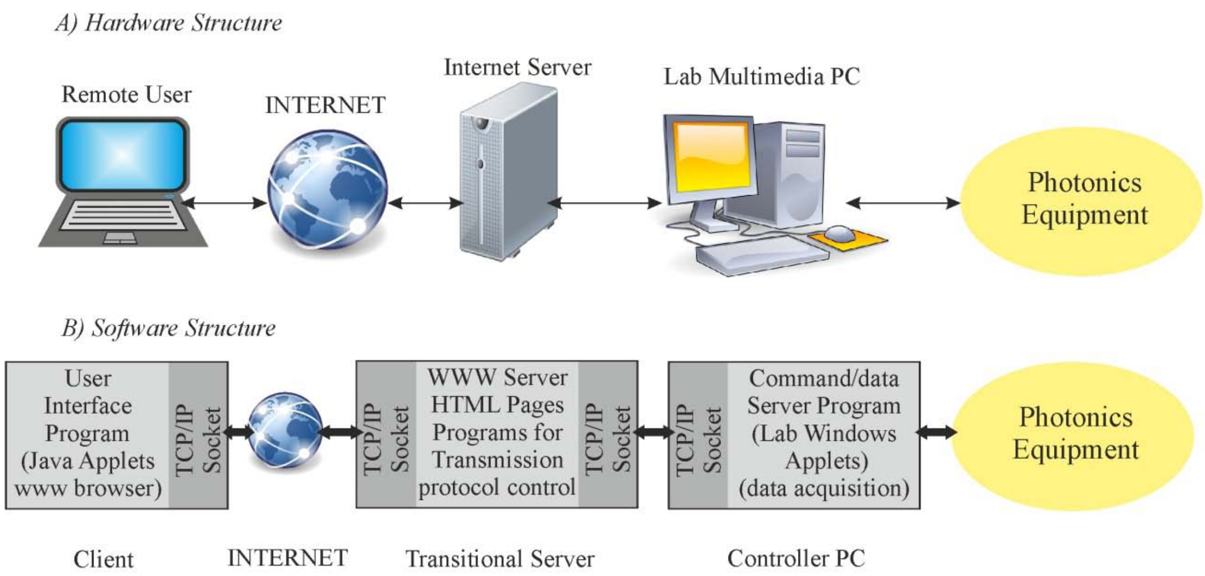


Figure 1. Web-controlled laboratory architecture.

ISSN 1844 – 9689

As for real signal interrogation, remote control and to perform further processing Java Server Pages methods are more prominent due to its rich library functions to perform direct interfacing to the standard computer ports and peripherals. However, to serve multiple input/output functions with external photonics instruments to the same server, there would be a requirement of connectivity expansion. Accordingly, LabWindows data acquisition system and programming techniques were employed in this design in addition to Java Server Pages to accomplish the before mentioned objectives.

As for telepresence and monitoring of device actions, a simple type zooming web-camera can be connected to the hosting multimedia PC via the USB port [4,10]. The web-camera assists in visual feedback of the system and presents the feeling of telepresence for the end-user (student). USB web-cameras are normally efficient and the presence of another video server is not necessary in this case, thanks to LabWindows.

The paper is organized as follows. Chapter II explains some important details of the architecture multimedia laboratory system. Chapter III is devoted to detail description of the web-controlled fiber optic refractometer. Experiments and Results are in Chapter IV. Conclusions are covered in Chapter V.

II. System Architecture Design

Fiber optics sensors of various constructions are valuable devices for wide industrial applications [6-10]. Using fiber optics technology and micro-optics is possible to design innovative fiber optic index of refraction transducer that has unique properties. Basically it consists of input - output pair of simple multimode fibers that interrogate a small lens. The cone of light injected into the lens from the input fiber is internally reflected from inside surface of the lens and focused back into the output fiber. When the outer surface of the lens is in contact with a liquid, the attenuation of the light reaching the output fiber depends strongly on the refractive index of the liquid. Depending on the construction and design of such a transducer, this transducer may have a wide dynamic range. Its relative sensitivity, i.e. the ratio of fractional change of the optical intensity for a given change in index of refraction, is substantial, (of the order of 5 to 10) over a wide range of index, e.g. n = 1.3 to 1.6. For convenience, usually employed lenses have diameter from 5 to 1 mm. In principle, it should be possible to go to even smaller diameters, e.g. 250 to 300 microns - so that relatively small catheter type transducers are feasible. Since the basic design is quite simple it also is possible to produce extremely rugged transducer elements that are suitable for field/industrial applications.

This fiber optic small, probe type structure transducer elements, can be easily inserted into the top of liquid containers or through a simple fitting can be simple to insert in a flow line. It is essential to combine these very practical and versatile transducers capable of detecting small changes of index of refraction with "smart" data acquisition and signal processing technology to develop versatile and practical instruments.

Refractometers frequently are used for medical, pharmaceutical, industrial fluid, chemical, petrochemical, plastic, food, and beverage industry applications. For example, they are used for measuring the concentrations of aqueous solutions: as the concentration or density of a solute increase, the refractive index increases proportionately. Included in such measurements is the percentage of sugar in fruits, soft drinks, canned syrups and other solutions. They also are used to determine the salinity of aquariums and of solutions used in food processing, the freezing point of coolants and deicing fluids, the charge status of acid batteries, the serum protein and urine specific gravity, etc.

A. *Fiber optic refractometer equipment*

The block scheme of the laboratory fiber optic refractometer equipment is shown on Fig. 2. Considering both hardware and software the architecture is conceived such as to enable to develop of basic and differential type of fiber optic refractometers. The front panel of the equipment is connected to fiber optic transducer modules (P1 and P2).

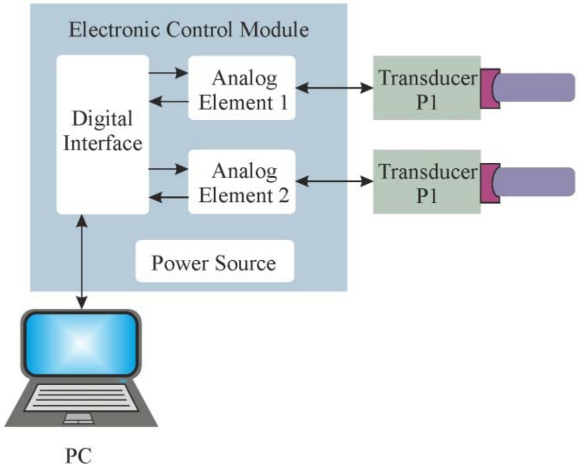


Figure 2. Block scheme of the laboratory fiber optic refractometer equipment.

The analog element contains a driving circuit for the LD based transducer, which produces appropriate current for specific type of transducer, respectively. There is a circuit for back measurement of driving current for LD based transducer, for more accurate driving/detection rate in the analog element. A detection circuit of photodiode for LD sensor module is responsible for amplifying and adjusting of measured currents within range of ADC (Analog Digital Converter). Thermistor detection circuit adjusts a voltage from thermistor to ADC range (0-10V).

The described instrument is designed as a laboratory instrument controlled by computer (multimedia PC) which is powered from the standard supply network ~230V/50Hz.

The interface sensor-computer is developed with the help of the I/O interface chip. The interface chip is responsible for communication of control module with computer via parallel PC interface.

B. *Web-based multimedia laboratory system*

The architecture of photonics multimedia web-based laboratory system is on Fig. 3. The core of the system is experimental setup to realize chosen laboratory (photonics) equipment - Fiber Optic Refractometer. Experimental setup is controlled trough three data acquisition systems: a) Mechanical b) Electronics and c)

Measurement, to provide a desired laboratory function of the photonics equipment and measurement of its parameters. The used simple web-camera assists for multimedia visual feedback in the telelaboratory.

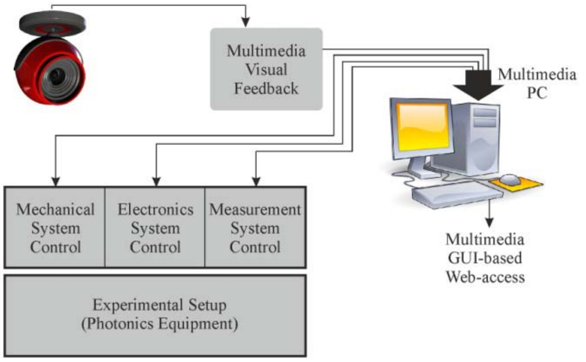


Figure 3. Web-based multimedia laboratory system.

III. WEB-CONTROLLED FIBER OPTIC REFRACTOMETER

This equipment was developed with the appropriate Measured Liquid Magazine, Sensor Module Positioner, Control Servomotors, Heating Element, Sensor Cleaning Element, Visual Camera Feedback, Control and Communication Software (Fig. 5) to create an interactive web controlled Fiber Optic Refractometer instrument. Sensor Module Positioner controls using servomotor the on (measured) and off (non-measured) position of the sensor head. Measured Liquid Magazine is based on the revolver system controlled by servomotor and provides the change of measured liquid (5 different liquids are possible one liquid is used for Sensor Cleaning Element if necessary – oil, petrochemical product measurements, etc.). Heating Element provide controlled heating of the measured liquid. Visual Camera Feedback was added to the system to provide students with the feeling to be virtually present at the measurement place and also as visual feedback for verify correct function of the mechanical parts of the instrument.

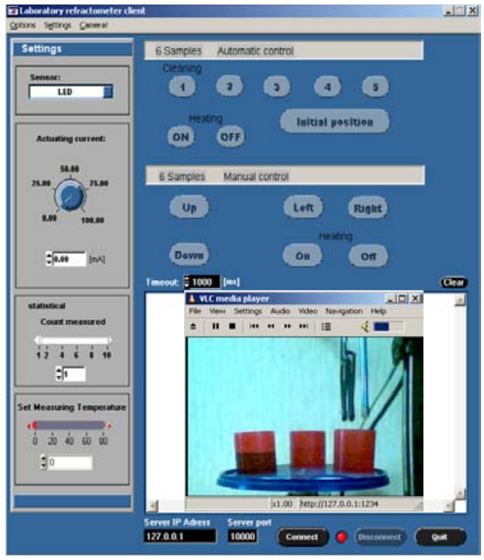


Figure 4. Main control window for the Laboratory Refractometer Client.

The program package for operation with laboratory refractometer is written in design environment of the LabWindows/CVI version 7.0.0. The program allows performing of refractive index measurements with basic or differential architecture. In the main control window (Fig. 4) we can see the value of the measured refractive index, temperature of the measured liquid and the value of the actual driving current for each measurement. Within a window menu it is possible to change the method of measurement, type of sensor and communication port number. Besides mentioned features it is also feasible to modify driving current (0-100 mA), measure characteristic curve of optical power for connected sensors, get a relation of optical output from LD sensor module to temperature, respectively. These features can be very useful when they are used for experiments with new or unknown sensors.

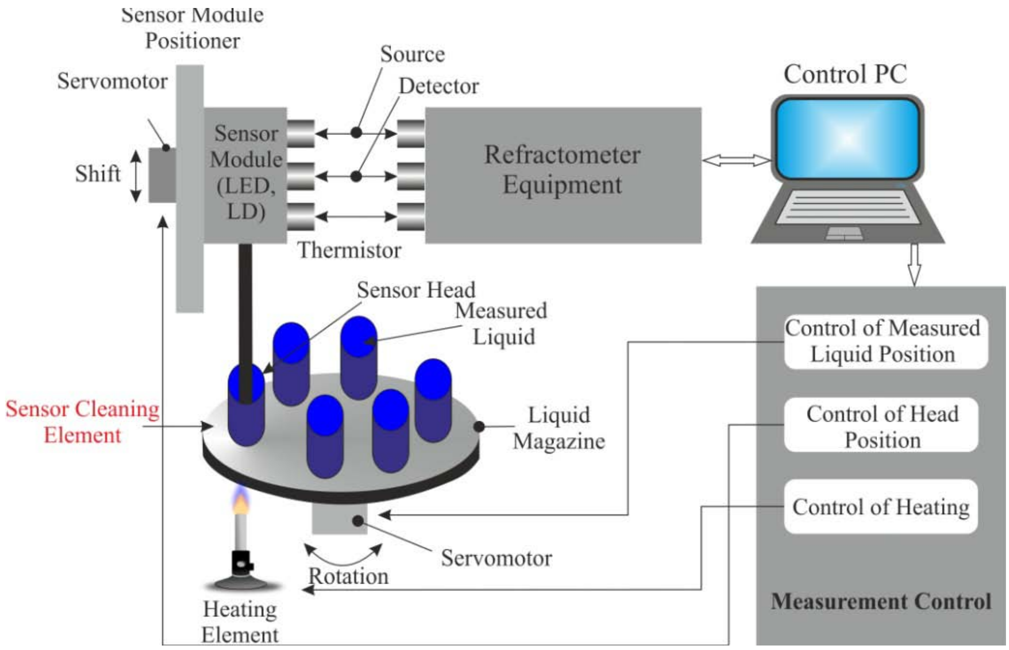


Figure 5. Web-controlled laboratory architecture.

The complete system was set together with the two (Laboratory Refractometer Client Server Fig.4, and Refractometer Server Fig.6) servers based on LabWindows. Operation of needs approval and authorized permission to be granted in advance through the local internet service provider. Therefore, and in step to avoid such complications the system was operated and tested using the internet network available on University campus.

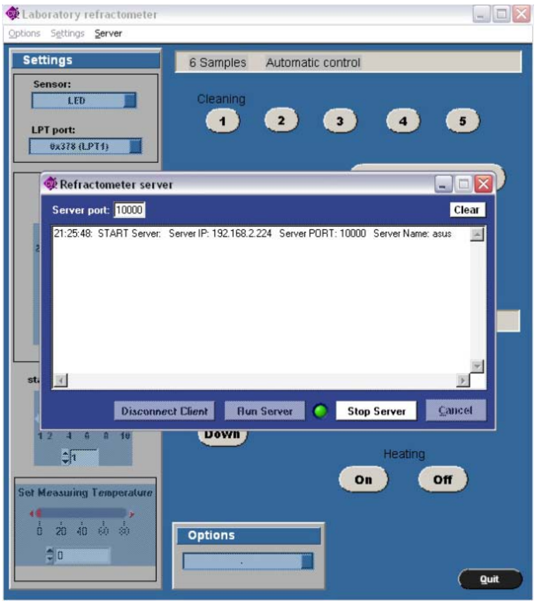


Figure 6. Main control window for the Refractometer Server.

This scenario of course resembles exactly the same situation as of having an off-campus internet connection to the address of our machine. The web browser was then loaded by writing the accurate path for the application server in the URL location as shown in Fig. 6. Accordingly, the system interface will be displayed showing the main items that can be accessed and controlled by the user.

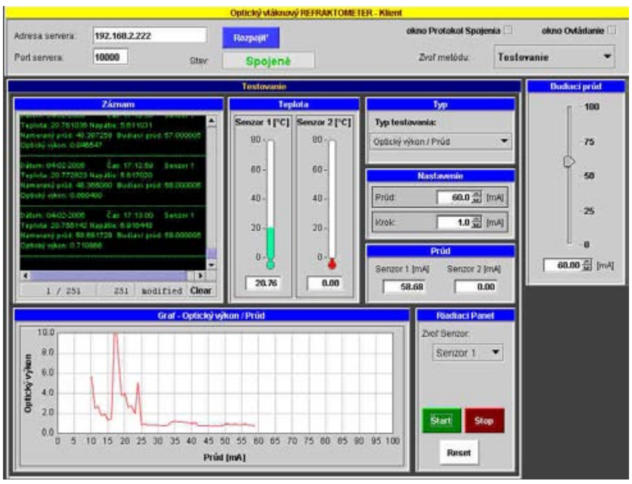


Figure 7. Main control window for the Measurement of the laboratory refractometer.

Then by pressing the Run Server button, transmission packets will be sent forth and back to validate permission and to set the system ready for further commands. Pressing the Start button (Fig.7) will operate the system and eventually the equipment will be switched on via laboratory refractometer equipment.

The camera was put in close proximity to the equpment to get a clear vision of the scene. Almost a real-time image streaming was achieved, which is quite sufficient for such a non-critical application and the same holds true for other systems of the same nature.

IV. EXPERIMENTS AND RESULTS

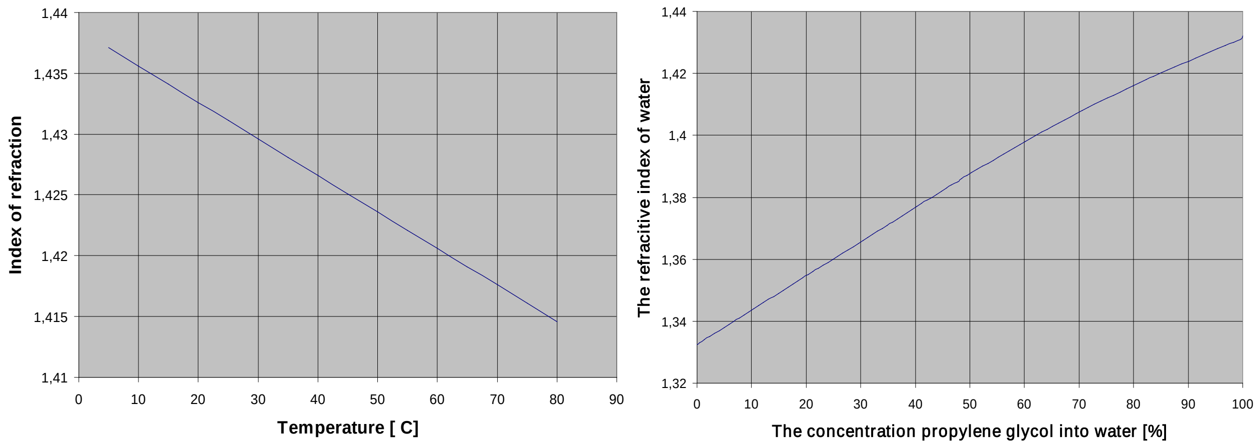
Performance of the developed fiber optic refractometers was evaluated by various test measurements; this is here demonstrated by results of two classical experiments [9]:

- Dependency of the refractive index of propylene glycol on temperature (Fig.8a),
- Dependency of the refractive index of water propylene glycol solution on propylene glycol concentration (Fig.8b).

The data on the index refraction of propylene glycol/water mixture are good to use since it is simple to clean the sensor after dipping in the various solutions, since it is necessary that the sensor face be clean and dry to get a good reading in air and also before dipping in water to get a calibration/comparison reading. Even though the index varies with wavelength we take the water reading at 20°C to correspond to an index of 1.3330, and refer all other readings to this value. The dn/dt for water in the range 15 to 30°C is 0.0001 per degree °C, while that for 100% propylene glycol is 0.0003. Thus for glycol/water solutions one could assume a linear dependence of dn/dt, that is, for example assume dn/dt = 0.0002 for a 50% solution. In all instruments with automatic temperature compensation, it is assumed that they are to be used with water solutions, and it is assumed that dn/dt = 0.0001. We may use also propylene glycol, either 100%, taking its index to be 1.4312, or 100% plus a few mixtures. As field tests we used some calibration oils of known index of refraction. They make it difficult to clean the sensor face however. We recommend keeping the containers of the mixtures sealed when not in use since they tend to drift in index, though this is not much of a problem. We frequently make up relatively large sample, e.g., 100 to 200 cc, and then use one half for our measurements for while and after a week or two, take a reading in the other half that has been kept well sealed. That way we can determine if there has been any shift in the index of our measurement sample. The results of measured index of refraction are depicted on Table I, and are in very good success as compared with results obtained by classical methods.

TABLE I.
RESULT OF PETROCHEMICAL PRODUCTS MEASUREMENTS

Petrochemical products	Refractive index	Temperature (°C)
Water	1.3333	21
Synthetic alcohol	1.3620	21
Propylen glycol	1.4268	21
Mobil VS-200	1.4399	21
Mobil motor 5W-50	1.4678	21
Oil drive	1.4757	21
Madit drive	1.4828	21



a) b)

Figure 8. The refractive index of a) the propyle glycol vs. temperature (°C) and b) the water vs. propyle glycol concentration.

V. Conclusion

Development work related to create web-controlled laboratory modules (equipments) in the Applied Photonics distance education courseware was presented. The system modules structure enables its accommodation to solve remote access trough WWW to various photonics equipments for a relative large pool of students. The system was experimentally tested with module: Fiber Optics Refractometer Instrument.

The system is accessible at the web site: http://dendrit.tuke.sk/~matta/new/ (Fig.9).

Future work includes adding more modules to the system and designing more web-based equipments to enhance teaching and learning of subject Applied Photonics.

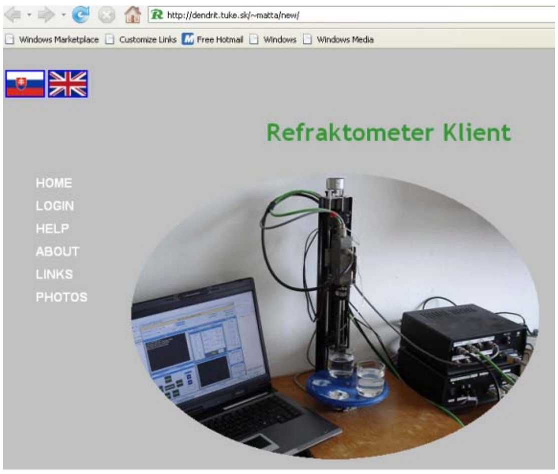


Figure 9. Web-site multimedia laboratory system.

Acknowledgment

We support research activities in Slovakia / Project is co-financed from EU funds. This paper was developed within the Project "Centrum excelentnosti integrovaného výskumu a využitia progresívnych materiálov a technológií v oblasti automobilovej elektroniky", ITMS 26220120055.

This Research was carried out as part of the TAMOP-4.2.1.B-10/2/KONV-2010-0001 project with support by the European Union, co-financed by the European Social Fund.

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