WEB- BASED MULTIMEDIA COURSEWARE: APPLIED PHOTONICS

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Abstract: *Distance education and non-traditional classrooms have the capability to reach more students using specialised instruction, self-paced learning and virtual laboratories (and/or virtual instruments). While a good learning experience can be obtained from such a purely simulation systems, in many situations, it is commonly recognised that effective and complete learning, especially in engineering and science, requires a mixture of theoretical and practical sessions. This paper presents development work to design multimedia courseware: Applied Photonics. This courseware is based on: 1) multimedia document about the basic theory of Applied Photonics; 2) simulation and measurement supporting multimedia programme package able solving selected CAD and CAE problems in Applied Photonics. As special application of practical session web-based interactive fiber optic instrument is described in details.*

Key words: *multimedia courseware design, distance education photonics, fiber optic refractometer, remote measurement through WWW*

1. INTRODUCTION

Rapid development in computer technology and telecommunication, the use of Internet has been expanding exponentially. The common convergence product of this technologies: Multimedia Signal Processing is now extensively used for commercial, personal, and tele-education purposes [1,2]. Multimedia and Internet convergence opens of new avenues of methodologies for enhancing the experience of learning as will as expanding educational opportunities for a larger pool of students. Specifically, distance education and non-traditional classrooms have the capability to reach more students using specialised instruction, self-paced learning and virtual laboratories (and/or virtual instruments). Traditionally the integration of Multimedia and Internet with education can be based on the following:

a) Developing a courseware and course web site to centrally house various online functions and facilitate course management (especially feedback),
b) Creating a Virtual laboratory to replace physical experiments with multimedia animation or simulation (CAD and CAE multimedia package).

While a good learning experience can be obtained from such a purely simulation systems, in many situations, it is commonly recognised that effective and complete learning, especially in engineering and science, requires a mixture of theoretical (and/or simulation). and practical sessions. To address this very important issue we embedded to our multimedia distance education courseware: Applied Photonics, web-based laboratories that have capability to enable for students to set up parameters to run experiments from a remote location. This capability also is essential from the point of view to effective use of very expensive instruments and limited students time resources.

2. MULTIMEDIA COURSEWARE: APPLIED PHOTONICS

The explosive growth of the photonics market leads to wide up the need for CAD and CAE analysis tools applicable for designees, engineers and university students [3,4,12,13]. The recent advantage of hardware, software and digital signal processing allow for application of new discipline called multimedia signal processing [5,6] to be embedded to these tools. This discipline is motivated to the convergence of traditionally separated technologies, namely, digital signal processing, digital image processing, computer vision, computer graphics and document processing [6]. The most innovative way to application this new discipline is the systematic approach to multimedia graphical user interface (GUI) design [7] and efficient interpretation of used multimedia material [7,8]. Multimedia graphical user interfaces (GUI) are traditionally created by intuition [2]. They are usually designed and developed without exact analysis of multimedia information presentation. The objective of co-operative teleworking among students and teachers (with simultaneously possible using of databases and others multimedia CAD and CAE tools) is the provision of some degree of "telepresence" for geographically distributed persons and teaching, simulation, measurement and design materials in a quality comparable to that of a real-world lecture (conference, co-operation) [7,8]. In the modern multimedia courseware four multimedia GUI have to be designed:

- **System supervisor GUI** – operator GUI, responsible for the system.
- **Teacher (tutor, supervisor) GUI** – responsible for the course content.
- **Student GUI** – user (student, designer, engineer) GUI.
- **Browser GUI** – GUI for any person interesting about the course.

The developed Applied Photonics courseware represents an interactive multimedia course based on use of multimedia document and visual simulations CAD and CAE programme package for teleeducation purposes. The course structure and some of its interactive features are noticed in Fig. 1.

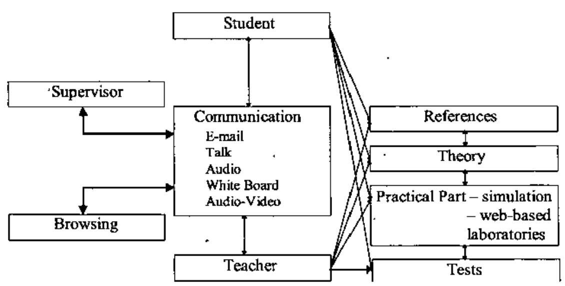

Fig. 1 Course structure.

Student and teacher have access to an interactive multimedia document stored in a server. Teacher as a master has the possibility of changing this document if necessary. There are possibilities of interactive multimedia communications between student and teacher using various tools (E-mail, White Board, Audio-Video). Teacher has the possibility to supervise of student work and able to monitor his/her progress and interactively change-tailor the course content.

The basic organisation of the courseware consist from four parts:

- **Theoretical part** - this is an interactive multimedia document about the theory of Applied Photonics.
- **Practical part** - this is an interactive multimedia based simulation and measurement supporting multimedia programme package able to solve CAD and CAE problems in the area of Applied Photonics.
- **Part references** - this is a multimedia document about published documents related to Applied Photonics.
- **Part tests** – the tests embedded to the courseware are entitled to evaluated the knowledge, routines and working skills obtained by students through the learning process.

Measurement practising in Applied Photonics for a large number of students is an economic problem. One approach to solve this problem is to create web-based laboratory equipments which are available to students through using standard Internet Protocol procedures on WWW. This approach was choosed in the course for practising measurements in the chapter: Fiber Optic Sensors, particularly in application of fiber optics refractometer.

3. FEEDBACK IN THE PHOTONICS COURSEWARE

The architecture of feedback used in the courseware: Applied Photonics is depicted in the Fig.2.

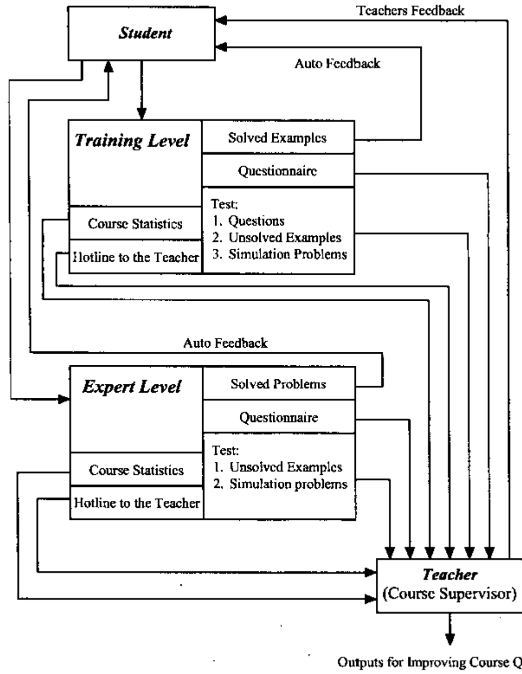

Fig. 2 Feedback in the "*Photonics*" Multimedia Teleeducation Courseware.

It consists from five feedback loops, which are realised on the both level of the course (training and expert level). The simplest way of the feedback is the study and practicing solved examples embedded to the courseware. The quality of the courseware and the student progress in the course may be evaluated using predefined Questionnaire and the course statistics available to the teacher (course supervisor). Course statistics deals with registration and multimedia document utilization (users data, data and time using (working) of the courseware, results of evaluations etc.). Course Questionnaire deals with questions about course structure, optimal material selection, multimedia document quality etc. Tests embedded to the courseware are entitled to evaluate the knowledge, routines and working skills obtained by students trough the learning process. The test is structured trough the courseware content and may consist from the questions, unsolved examples and simulation problems. If there is any problem with the student progress in the course the student is able activate a hot line to the teacher, but only in consultation hours. At the present level of development of the courseware and available technology it may be only a E-mail contact with the remote teacher. Outputs from the feedback is structured, saved and statistically processed to be used for improving the courseware quality in next development step.

4. WEB-BASED FIBER OPTIC REFRACTOMETER DESIGN

Almost all currently available classical refractometers employ a prismatic element on which the liquid sample is placed. These instruments yield an output that is based on measuring the critical angle of reflection of a light beam at the liquid-prism interface. In more modern, digital type instruments, the angle of reflection is measured automatically using a linear photodetector array [3,4]. Since the index of refraction is strongly dependent on temperature and also, to a lesser degree, on wavelength, these effects must be corrected for in designing and/or using such instruments.

As with any other refractometer, any instrument that employs this fiber optic based transducer must be capable of correcting for the intrinsic temperature dependence of a liquid's index of refraction [4]. In addition, however, for an intensity type fiber optic sensor, other corrections and precautions must be taken especially if, a precision of 1 part in 10.000 is to be attained. It will be necessary to employ low noise electronic circuitry and/or correct for photodetector dark current, especially at higher indices, where the output light intensity is strongly attenuated. It also will be necessary to correct for light source and photodetector temperature sensitivities and for any stray light that might affect the photodetector. In one sense, in terms of capabilities of today's microprocessor controlled "smart" sensor technology, it should be straightforward to design instruments that automatically "massage" the raw transducer data to correct them for each of these effects [9,10].

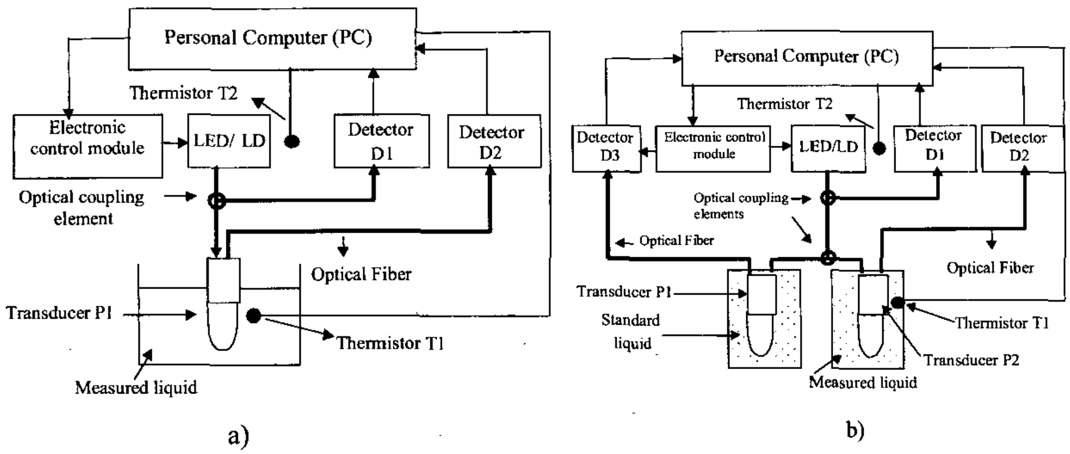

Fig. 3 Block diagram outlining the design of a a) basic and b) differential type fiber optic refractometer.

Referring to the block diagram in Figure 3a, the basic system, as presently conceived, consists of the following elements: a light emitting diode (LED) or semiconductor laser diode (LD) light source and its electronic driver/pulser; a monitor photodetector to determine the output light level of the use light source, a second photodetector to record the return light from the transducer; and a microprocessor to automatically control the system and process the data from the various elements.

It computes the ratio of the intensity of the transducer output for an unknown liquid and that recorded earlier for a standard liquid, e.g., water. The microprocessor then determines an index value, either by a comparison and interpolation process between this ratio and those in a calibration data lookup table, or by computation using a transducer response equation. In addition, the temperature of the liquid sample and of the source/detector module is measured simultaneously with the index, to correct for their temperature dependence. The liquid sample temperature is determined using a thermistor, as indicated in Fig. 3a, or using a fiber optic temperature sensor in applications requiring an all dielectric transducer, e.g., for use in explosive or high voltage environments [11]. A second system, as outlined in Figure 3b, was also considered in detail. Basically, it employs a differential technique and would allow measurements/comparisons of index to a very high precision. Instead of taking comparative readings of index of a known and an unknown liquid at separate time, as would be done with the system outlined in Figure 3a, both readings would be taken simultaneously, using two index of refraction transducers, one in the unknown and the other in a standard liquid sample.

For the course laboratory equipment type fiber optic refractometer able to emulate block diagrams described in Fig. 3a and Fig. 3b was choosed. This equipment was furnitured with the appropriate Measured Liquid Magazine, Sensor Module Positioner, Control Servomotors, Heating Element, Visual Camera Feedback, Control and Communication Software (Fig. 5) to create an interactive 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 provide the change of measured liquid (6 different liquids are possible). Heating Element provide controlled heating of the measured liquid. Visual Camera Feedback [14] was added to the system to provide student 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. Developed multimedia software is able to control the various parts of the instrument, support control remote measurements using standard Internet Protocol procedures through WWW. The control of the refractometer is realised under standard Windows procedures (Fig. 4).

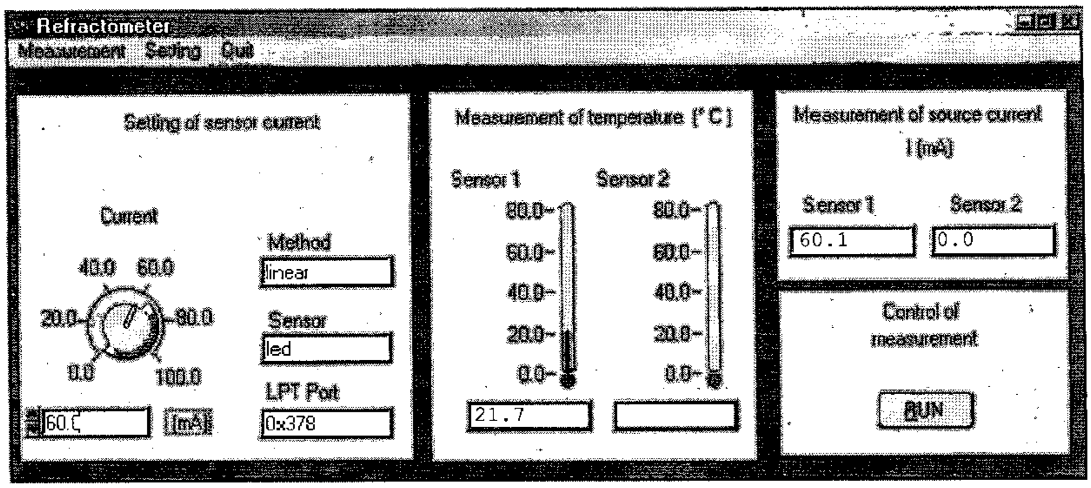

Fig. 4 Main control window of the fiber optic refractometer.

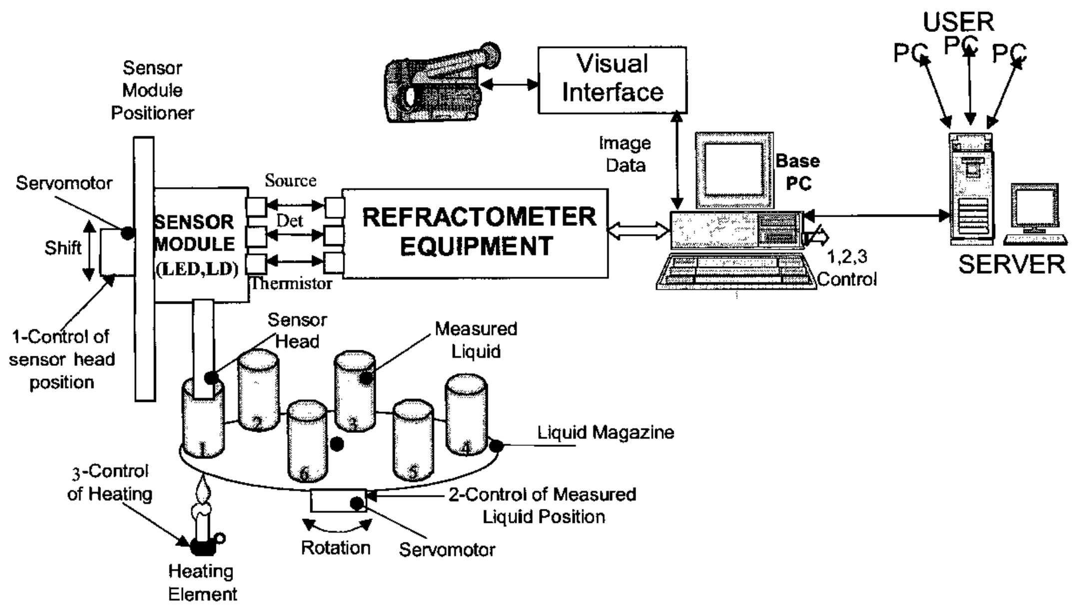

Fig. 5 Block scheme of the interactive web-based fiber optic refractometer instrument.

5. EXPERIMENTS AND RESULTS

Performance of the developed web based laboratory fiber optic refractometer equipment was evaluated by various testing measurements, this is here demonstrated by results of two basic laboratory experiments and measurements of index of refraction of various petrochemical products:

A) Basic laboratory experiments

- dependence of the refractive index of propylene glycol on temperature,
- dependence of the refractive index of water propylene glycol solution on propylene glycol concentration.

B) Measurements of petrochemical products of the developed equipment

As field tests we use some petrochemical products of known index of refraction.

6. CONCLUSIONS

Development work related to create a web-based multimedia courseware: Applied Photonics has been presented. The courseware is based on the traditional multimedia learning document and simulation CAD and CAE programme package, with using practical sessions: web-based laboratories. In more detail we describe development and results of web-based fiber optic refractometer.

The developed multimedia courseware was tested in teaching MSc. students. Since the number of student taking the course is of the range of 60 the aviable laboratory time slot is limited, and the few aviable expensive instruments are more effectively used to obtain real hands-on experience for the individual students.

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