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REVIEWS - LETTERS - REPORTS

MULTIMEDIA TELEEDUCATION COURSEWARE: ADAFOX —— MODELLING DIGITAL AND ANALOGUE FIBER OPTICAL NETWORKS

Ján Turán * — **Ľuboš Ovseník** * — **Ján Turán, Jr** **

The expanding worldwide move towards optical communications indicates a long term need for system designers proficient in fiber optic design techniques. Consequently, designers must have an array of CAD and CAE analysis tools applicable to the lengthy and often-tedious calculations required for the evaluation of fiber optic communication networks. The proposed multimedia programme package ADAFOX for modelling of digital and analogue fiber optic networks, is a computational aid for fiber optic designers to use in the development of networks that conform to given system performance specifications. The proposed paper gives the results of the development work related to design multimedia CAD and CAE tools for digital and analogue fiber optic networks design and analysis.

K e y w o r d s: multimedia courseware, modelling fiber optical networks, teaching fiber optical networks, digital fiber optical networks, analogue fiber optical networks

1 INTRODUCTION

Multimedia communication is the field referring to the representation, storage, retrieval and dissemination of machine processable information expressed in multiple media, such as: text, image, graphics, speech, audio, video, animation, and handwriting and data files. With high capacity storage devices, powerful and yet economical computer workstation and high speed integrated services digital networks providing a variety of multimedia communication services is becoming not only technical, but also economically feasible [1–12].

Multimedia best suits the human beings complex perception, communicating behaviours as well as the way of acting. Applications in medicine, education, travel, real estate, banking, insurance, administration and publishing are emerging at a fast pace [1–20].

Trends towards multimedia communication are represented on Fig. 1.

The recent developments in information technology, telecommunication, Internet and multimedia open new possibilities for expanding teleeducation opportunities for large pool of students [1–25]. Integration of Multimedia and Internet with education can be based on:

- Developing a Courseware and course web site to centrally house various online functions and facilitate course management (especially feedback) [6,14–22],
- Creating a Virtual laboratory to replace physical experiments with multimedia animation or simulation (CAD and CAE multimedia package) [6, 14, 20, 21],
- Creating a Web-controlled laboratory equipment which is available to students through using standard TCP/IP protocol procedures on WWW [7, 14, 20, 25].

While a good learning experience can be obtained from using 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 [6, 7, 14]. To address this very important issue we embedded to our multimedia distance education courseware, web-controlled laboratories that have capability to enable for students to set up parameters and to run experiments from a remote location [30–37]. This capability also is essential from the point of view to effective use of very expensive photonics instruments and limited students time resources dedicated to laboratory work.

2 MULTIMEDIA COMMUNICATION MODEL AND NETWORK REQUIREMENTS

The multimedia communication model is strongly influenced by manufacturer-dependent solutions for personal computers and workstations, including application software on the one hand, and by the intelligent network concept on the other. A layered model for future multimedia communication comprises five constituents:

- partitioning of complex information objects into distinct information types for the purpose of easier communication, storing and processing,

* Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovakia. E-mail: jan.turan@tuke.sk
** 3D People, GmbH; Kaiser passage, D-72766 Reutlingen, Germany

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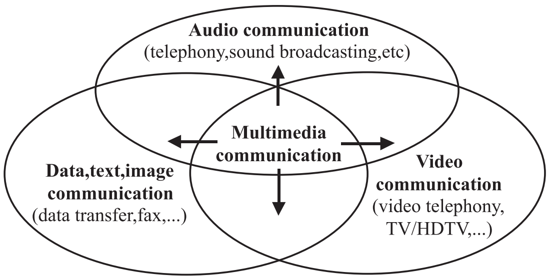

Fig. 1. Trends towards multimedia communication

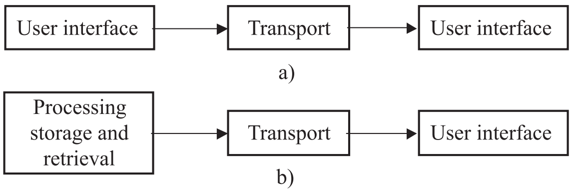

Fig. 2. Elements of multimedia systems: a) person-to-person communications, b) person-to-machine modes

- standardization of service components per information type, possibly with several levels of quality per information type,
- creation of platforms at two levels: a network service platform, and a multimedia communication platform,
- generic applications for multiple use,
- specific applications: electronic shopping, teletraining and remote maintenance, the multimedia communication platform, as well as including general applications.

There are two key modes in which multimedia systems are used (Fig. 2):

- ♦ person-to-person communications, and
- ♦ person-to-machine communications.

Both of these modes have a lot of commonality as well as some differences. For example, in the person-to-person mode, user interface provides the mechanisms for all users to interact with each other and a transport layer (teleconferencing, videophones, and distance learning, shared workspace scenarios). The user interface creates the multimedia signal and allows users to interact with the multimedia signal. The transport layer preserves the quality of the multimedia signals, so that all users receive what they perceive to be high-quality signals at each user location [1–5].

On the other side, in the person-to-machine mode, there is again a user interface for interacting with the machine, along with a transport layer moving the multimedia signal from the storage location to the user, as well as mechanism for storage and retrieval of multimedia signals that are either created by the user, or requested by the user (creation and access on business meeting notes, access broadcast video and document archives from digital library or other repositories). The storage and retrieval involve browsing and searching to find existing multimedia data. Also, storage and archiving in order to move user created multimedia data to the appropriate place for access by others.

A number of key requirements are common to the new multimedia services, like instant availability, real-time information transfer, service always on-line; users should be able to access their services from any terminal (mobile point of delivery). Multimedia applications have several requirements with respect to the service offered to them by the communication system. These requirements depend on the type of the application and on its usage scenario which influences the critically of the demands [1–5].

From a user's point of view, the most important requirements of multimedia communications are:

- fast preparation and presentation of the different types of interest, taking into account the capabilities of available terminals and services,
- dynamic control of multimedia applications with respect to connection interactions and quality of demand combined with user-friendly human/machine interfaces,
- intelligent support of users, taking into consideration there individual capabilities, and standardization.

From network point of view, the most important requirements of multimedia communications are:

- high speed and changing bit rates,
- several virtual connections over the same access,
- synchronization of different information types,
- suitable standardized services and supplementary service supporting multimedia applications.

Service usage conditions can be defined by their use, place independence and degree of urgency. The requirements of applications regarding the communications services can be defined into traffic and functional requirements.

The traffic requirements include transmission bandwidth delay and reliability. They depend on the used type, number and quality of the data streams. The requirements concerning traffic can be satisfied by the use of resource management mechanisms. The functional requirements are multicast transmission and the ability to define coordinated sets of unidirectional streams. A key requirement is that same high quality network services should exist when building integrating networking platforms for voice, data and multimedia services.

3 MULTIMEDIA GRAPHICAL USER INTERFACES

Multimedia graphical user interfaces (GUI) are currently created by intuition [1–20]. They are usually designed and developed without exact analysis of multimedia information presentation.

A modern multimedia teleeducation must be thought of in terms of networked organisation (Fig. 3). The objective of co-operative teleworking among students and

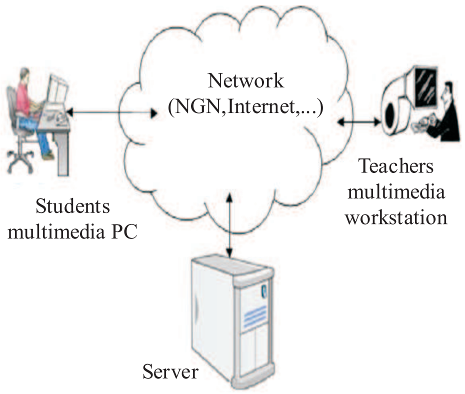

Fig. 3. Co-operative modern teleeducation

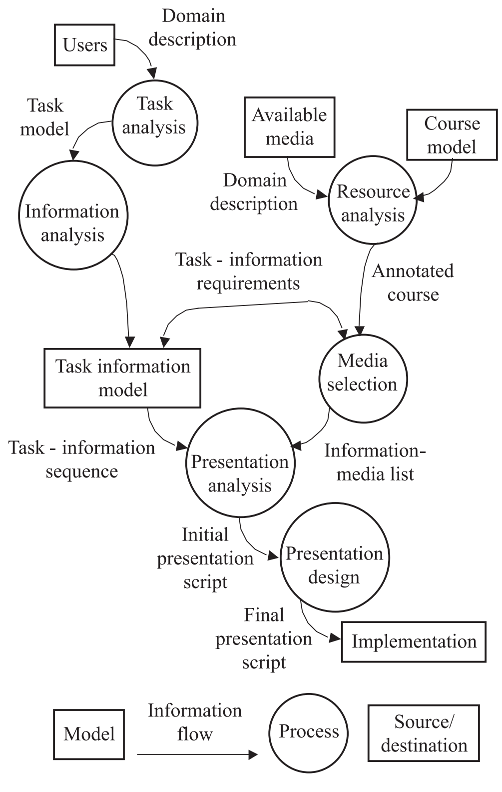

Fig. 4. Systematic method for GUI design

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 and design materials in a quality comparable to that of a real-world lecture (conference, co-operation) [1–6].

Co-operative teleworking enables a group of distant participants to jointly view, discuss, and edit multimedia documents while at the same time using communication and computing resource. This can be considered as an extension of conventional audio/video conferencing access, and collaborative work assistance. A desktop multimedia workstation allows the student to create, retrieve, and manipulate and activate a "hotline" to a teacher (central specialist). Co-operative teleworking represents a case of complex and dynamic communication, which encompasses a number of participants, connections, information types, systems, and functions [1-6].

Multimedia GUI is usually designed by intuition. This way is not suitable to use all the available resources and utilising the multimedia effect in maximally way. So it is important to develop a systematic approach to multimedia GUI design [2, 6].

The systematic method (Fig. 4) for teleeducation graphical user interface design is based on the methods of task components. This is based on the following components: model, information flow, process, source, and destination. This method proved useful as a means of exploring the issues involved in multimedia teleeducation graphical user interface design for the particular teleeducation course about fiber optical communication. Emerging access techniques (such as xDSL over copper network, HFC and PON) have result into a number of demonstrators and field trials in the area of educational telecommunication. The users are connected to the SDH backbone network by means of a copper access network that transports ATM over ADSL [1–5].

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.

4 MULTIMEDIA COURSEWARE DESIGNS

The developed courseware represents an interactive multimedia course based on the use of multimedia document and visual simulations CAD and CAE programme package for teleeducation purposes [30–32]. The course structure and some of its interactive features are noticed on Fig. 5.

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, talk, audio, 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 organisations of the course consist from four parts:

- Theoretical part — this is an interactive multimedia document about the theory of optical communications.
- Practical part — this is an interactive multimedia based simulation programme package able to solve

CAD and CAE problems in the selected area of applications of optical communications.

- Part references — this is a multimedia document about published documents related to optical communications and its applications, *ie* modelling and analyse digital and analogue fiber optical networks.
- Part tests — the tests embedded to the courseware are entitled to evaluate the knowledge, routines and working skills obtained by students trough the learning process.

5 MODELLING OF OPTICAL NETWORKS

Fiber optic technology has been accepted as a viable communication medium since the early 1980's. Yet, as the fiber telecommunication industry continues to mature, no tapering of demand is in sight. Installation of optical fiber communication networks is increasing at a rapid rate, with worldwide optical fiber consumption exceeding several million kilometres per year.

The expanding worldwide move towards optical communication indicates a long-term need for system designers proficient in fiber optic design techniques. Consequently, designers must have an array of CAD and CAE analysis tools applicable to the lengthy and often tedious calculations required for the evaluation of fiber optic communication networks. Unfortunately, although computer-aided design software exists in abundance for various analysis and design chores such as circuit design and optical system design, cheap software specific to fiber optic communication is limited. The program for modelling of analogue and digital fiber optic networks (ADAFOX), is a computational aid for fiber optic designers to use in the development of networks that conform to given system performance specifications. The proposed paper gives the results of the ADAFOX development work related to design multimedia CAD and CAE tools for digital and analogue fiber optic networks design and analysis. The tools are implemented as a software package on PC and tested in experiments in various network design tasks [30–37].

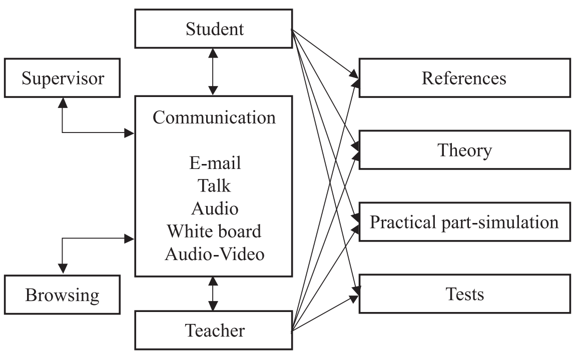

Fig. 5. Course structure

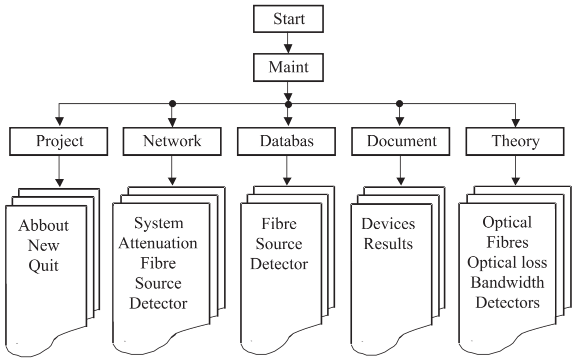

Fig. 6. ADAFOX menu flow

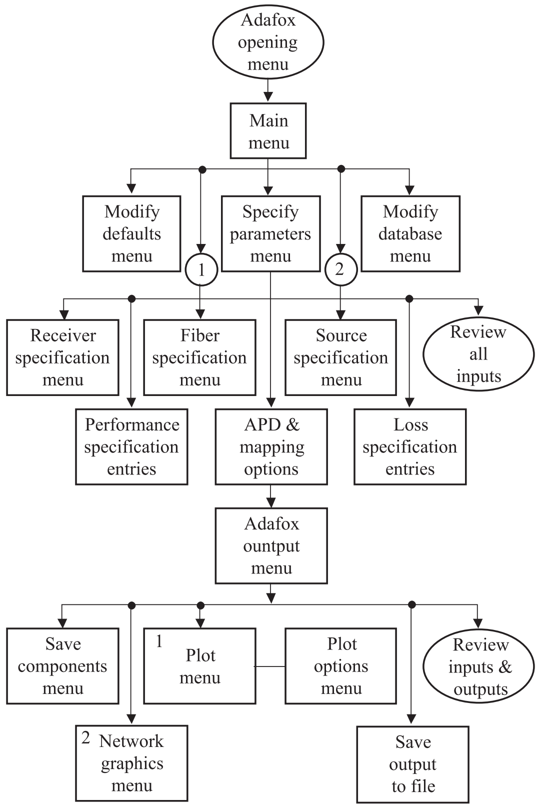

Fig. 7. Opening screen and menus

6 PROGRAM DESCRIPTIONS

The ADAFOX modelling of fiber optic networks programme package is designed for input flexibility, enabling the designer to specify as little or as much specific system design information as desired.

Minimum required entries are the system length in kilometres, data rate in bits-per-seconds, return- to-zero or non-return-to-zero data type, system temperature in Kelvin, and probability of error. In addition to automated design modelling and synthesis, operation of the program without any design specifications will result in program calculation based upon default parameters, all of which may be modified by the user.

The simplified menu flow of the ADAFOX program is shown on Fig.6, and the opening screen and menus

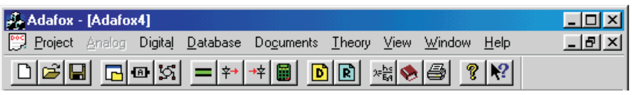

Fig. 8. ADAFOX opening screen and primary menus

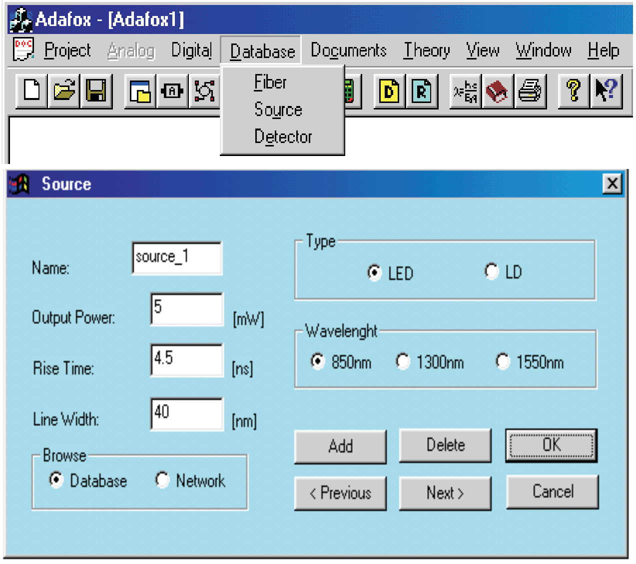

Fig. 9. The “Database Menu” and source specifications menu

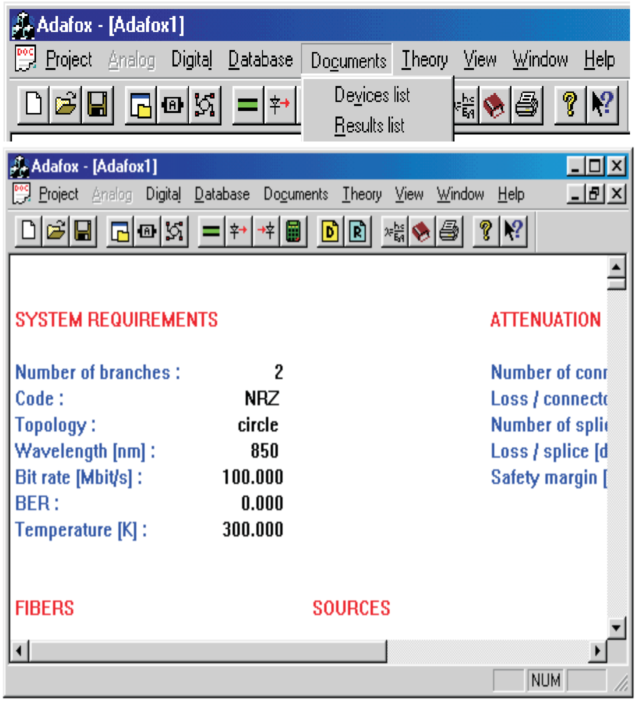

Fig. 10. Example ADAFOX input review screen

in Fig. 7. The opening screen and primary menus are displayed on Fig. 8.

System performance calculations include complete power budget and bandwidth estimation. System losses are tallied, including losses due to fiber, connectors, splice, reflection and source coupling. The other system parameters calculation includes maximum link length, length margin due to power and bandwidth constraints. Though several automatic design options are available to the ADAFOX user, all system parameters may be defined explicitly, with appropriate menu and mouse-driver data entry screens to aid in numerical input. Devices may be custom specified or manually selected from the fiber, source or detector database. The “Database Menu” and a representative source database record screen is shown on Fig. 9. Fiber and detector specifications follow similar format.

Custom device entry screens support complete data editing for all parameters associated with the particular component and provide for device storage to the appropriate database. The ADAFOX device database provides the ability to append new devices, delete unwanted entries, browse through existing entries, and select devices for calculations. An example of the ADAFOX input review screen is displayed on Fig. 10.

7 FEEDBACK IN THE COURSEWARE

Very important part of the teleeducation courseware is the feedback. The architecture of the feedback used in the fiber optic communication courseware is depicted on the Fig. 11. Feedback consists of five feedback loops, which are realized on the both levels, of the course. The simplest way of feedback is the study and practicing solved examples embedded to the course. The quality of the courseware and student progress may be evaluated using: Questionnaire, Course Statistics or Hotline to the Teacher (Supervisor)

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 course 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. At the present level of development of the course and available technology it may be only an E-mail contact with the remote teacher. Outputs from the feedback is structured, saved and statistically processed to be used for improving the course quality in next development steps.

8 CONCLUSIONS

Designed and implemented multimedia teleeducation courseware Fiber Optic Communication with the multimedia CAD and CAE tool ADAFOX is able to serve for designers, engineers and university students to solve problems in the area of fiber optic communication. The course design philosophy, structure and development quality was evaluated in experimental teaching of MSc and PhD students.

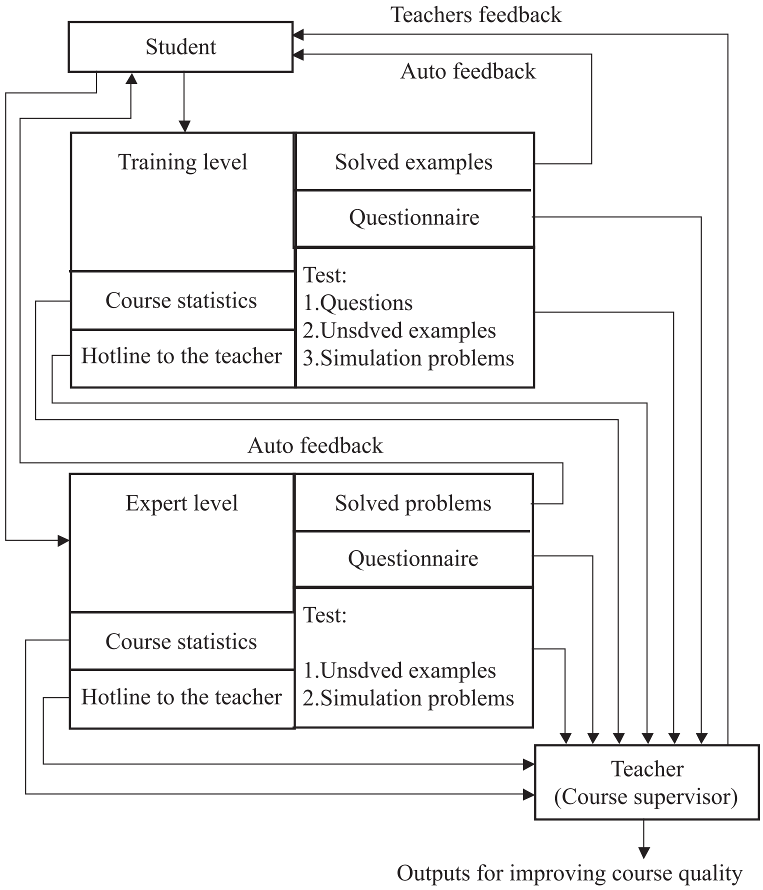

Fig. 11. Feedback in the Multimedia Teleeducation Courseware

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References

[1] RAO, K.R.—BOJKOVIC, Z.—MILOVANOVIC, D. : Multimedia Communication Systems,, Prentice-Hall, New York, 2002.

[2] RAO, K. R.—BOJKOVIC, Z.—MILOVANOVIC, D. : Introduction to Multimedia Communication: Application, Middleware and Networking, John Wiley, New York, 2006.

[3] MANDAL, K. M. : Multimedia Signals and Systems,, Kluwer Academic Publishers, New York, 2003.

[4] BOJKOVIC, Z.—TURÁN, J.—SAMCOVIC, A.—OVSENÍK, Ľ. : Coding, Streaming and Watermarking — Some Principles in Multimedia Signal Processing, Acta Electrotechnica et Informatica **4** No. 3 (2004), 13–20.

[5] BOJKOVIC, Z.—TURÁN, J.— OVSENÍK, Ľ. : Towards to Multimedia Across Wireless, J. Electrical Engineering **56** No. 1-2 (2005), 1–6.

[6] THIRIET, J.M. *et al* : Towards a Pan-European Virtual University in Electrical and Information Engineering, IEEE Trans. **EDU-45** No. 2 (2002), 152–160.

[7] GOMES, V.G. *et al* : Web-based Courseware in Teaching Laboratory-Based Course, Global J. of Eng. Education **4** No. 1 (2002), 65–71.

[8] ZOVKO-CIHLAR, B. : Multimedia in Creation Digital Video Broadcasting, Proc. 4^{th} EURASIP Conference EC-VIP-MC 2003, Zagreb, Croatia, 2003, pp. 53–57.

[9] ENYEDI, B.—KONYHA, L.—SZOMBATHY, C.—FAZEKAS, K. : Real-Time Video Compression with 3D Wavelet Transform and SPIHT, IEEE 4^{th} Int. Conference on Int. Systems Design and Application. ISDA 2004, Budapest, Hungary, August 26-28, 2004, pp. 157–161.

[10] ENYEDI, B.—KONYHA, L.—SZOMBATHY, C.—TRAN MION SON—GSCHWINDT, A.—SZOKOLAI, M.—FAZEKAS, K. : MPEG-4 alapu atvitel megvalositasa a DVB-T technikaban, Híradastechnika **59** No. 7 (2004), 23–27. (in Hungarian)

[11] ENYEDI, B.—KONYHA, L.—FAZEKAS, K. : Fast Video Compression Based on 3D Wavelet Transform and SPIHT, In. 7^{th} COST 276 Workshops, Ankara, Turkey, November 4-5, 2004, pp. 121–124.

[12] ENYEDI, B.—KONYHA, L.—SZOMBATHY, C.—TRAN MION SON—FAZEKAS, K. : Új lehetoségek a digitalis televízíózásban, Híradástechnika **60** (2005), 53–57. (in Hungarian)

[13] KOS, T.—GRGIC, M.—MANDIC, L. : CATV Broadband Technologies, Proc. 4^{th} EURASIP Conference EC-VIP-MC 2003, Zagreb, Croatia, 2003, pp. 829–834.

[14] SALAM, A. O. A.—OZKUL, T. : Multimedia Methods for Web-based Engineering Labs, Proc. 4^{th} EURASIP Conference EC-VIP-MC 2003, Zagreb, Croatia, 2-5 July 2003, pp. 759–764.

[15] VAZIRGIANNIS, M.—KOSTALAS, I.—SELLIS, T. : Specifying and Authoring Multimedia Scenarios, IEEE Multimedia **6** No. 3 (1999), 24–37.

[16] BURNIK, V.—POGAČNIK, M. : Personalised Content and Presentation for Ubiquitous Communication Services, Proc.

COST 276 Workshop: Inf. and Knowledge Management for Int. Media Communications, Brodeaux, France, 2003, pp. 83–88.

[17] KAISER, M.—CUCEJ, Z.: Artificial Intelligence in Modern Telecommunication Systems: Analysis and Implementation, Proc. 4th EURASIP Conference EC-VIP-MC 2003, Zagreb, Croatia, 2003, pp. 805–810.

[18] KOSČIČ, A.—PEDRAZA-JIMENEZ, R.—MOLINA-BULLA, H.— VALVERDE-ALBACETE, F.J.—CID-SUEIRO, J.—NAVIA-VAZGUEZ, A.: Student Modeling Based on Fuzzy Interference Mechanisms, Proc. IEEE EUROCON 2003, Computer as a Tool, Ljubljana, Slovenia, 2003.

[19] FERNANDEZ-OLEA, I.—SAEZ-TORNES, A.—CID-SUEIRO, J.—MARTINEZ-FERNANDEZ, A.: EHAS Course Editor. A Multimedia Tool for E-learning Course Creation, Proc. of COST 276 Workshop, Ankara, Turkey, November 2004, pp. 4–6.

[20] ROMANTAN, M.—VLAICU, A.: Information Management in a Distance Education Environment, Proc. COST 276 Workshop, Prague, Czech Republic, 2003, pp. 40–43.

[21] WENDLING, E.—SKALA, K.: Free-Space Optics Link Towards Remote Clusters, Proc. MIPRO'2003, Opatija, Croatia, 19-23 May 2003, pp. 173–176.

[22] ALTLY, J. L.—BERGAN. M.: The Design of Multimedia Interfaces for Process Control, Proc. 5th IFIP, IFAC, IFORS, IEA Conf. on Man-Machine Systems, 1992, pp. 249–255.

[23] SANCHEZ, P.—ALVAREZ, B.—IBORRA, A.—FERNANDES, J. M.—PASTOR, J. A.: Web-Based Activities Around a Digital Model Railroad Platform, IEEE Trans. on Education **46** No. 2 (2003), 302–306.

[24] PRATO, A.—LOPES, P. F.: How to Plan, Develop and Evaluate Multimedia Applications — A Simple Model, VIPromCom 2002, Zadar, Croatia, 2002, pp. 111–115.

[25] SANCHEZ, P.—DORMIDO, S.—PASTOR, R.—MORILLA, F.: A Java/Matlab-Based Environment for Remote Control System Laboratories: Illustrated with an Inverted Pendulum, IEEE Trans. on Education **47** No. 3 (2004), 321–329.

[26] KOTROPOULOS, C.—PITAS, I.: Intelligence in Modern Communications Systems, Proc COST 254, Int. Comm. Technologies and Appl., Neuchatel, Switzerland, May 5-7, 1999, pp. 1–12.

[27] LOWERY, A. J.—GURNEY, P. C. R.—WANG, X. H.—NGUYEN, L. V. T.—PREMARTANE, M.: Time-Domain Simulation of Photonic Devices, Circuits and Systems, In: Lasers and Integrated Devices Symposium, San Jose, USA, 1996, pp. 256–267.

[28] BERGSTROM, C. S.—PALAIS, J. C.: Digital Fiber Optic Network Synthesis, IEEE LTS, February 1992, pp. 27–33.

[29] BARBOSA, L. O.—GEORGANAS, N. D.: Multimedia Services and Applications Europ., Trans. Telecommun. **2** No. 1 (1991), 5–19.

[30] TURÁN, J.—OVSENÍK, Ľ.: Teleeducational Multimedia Courseware: Teaching and Modelling Digital and Analogue Fiber Optical Networks, 5th International Scientific Conference DSP-MCOM 2001, Košice, Slovakia November 27-29, 2001, pp. 86–89.

[31] TURÁN, J.—OVSENÍK, Ľ.: GUI for Teleeducational Multimedia Courseware: Teachng and Modwelling Digital and Analogue Fiber Optical Networks, MIPRO 2002, 25th International Convention. Opatija, Croatia, 2002, pp. 64–67.

[32] TURÁN, J.—OVSENÍK, Ľ.—TURÁN, J. jr.: Web-Based Multimedia Courseware: Applied Photonics, Proceedings EC-VIP-MC 2003: 4th Eurasip Conference Focused on Video/ Image Processing and Multimedia Communications 2003, Zagreb, Croatia, 2-4 July, 2003, pp. 741–746.

[33] TURÁN, J.—OVSENÍK, Ľ.: Multimedia Courseware: Teaching and Modelling Digital and Analogue Fiber Optical Networks, POSTEL2004 — XXII Symposium on new technologies in postal and telecommunication traffic, Beograd, Serbia, December 7-8, 2004, pp. 185–194.

[34] TURÁN, J.—OVSENÍK, Ľ.—TURÁN, J. jr.—FAZEKAS, K.: Design Web-Controlled Multimedia Laboratory, Proceedings ELMAR-2004, 14th International Symposium Electronics in Marine, Zadar, Croatia, 16-18 June, 2004, pp. 154–159.

[35] TURÁN, J.—OVSENÍK, Ľ.—FILO, P.—TURÁN, J, jr.: WWW-Based Remote Access to Engineering Laboratory, 7th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Services. TELSIKS05, 2005, Sept. 28-30, Niš, Serbia and Montenegro, pp. 39–44.

[36] TURÁN, J.—OVSENÍK, Ľ.—FILO, P.—TURÁN, J. jr.—FAZEKAS, K.: Multimedia Courseware: Applied Photonics, Proc.: 47th International Symposium ELMAR-2005 Focused on Multimedia Systems and Applications, Zadar, Croatia, June 8-10, 2005, pp. 167–170.

[37] OVSENÍK, Ľ.—TURÁN, J.: Web-riadené laboratórium: Optický vláknový refraktometer, Optick komunikace 2005, OK2005: Trojhra v optice, Prague, Czech Republic, October 20.-21, 2005, pp. 111120. (in Slovak)

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Jn Turán (Prof, Ing, RNDr, DrSc), was born in Šahy, Slovakia in 1951. He received an Ing (MSc) degree in physical engineering with honours from the Czech Technical University, Prague, Czech republic in 1974 and a RNDr (MSc) degree in experimental physics with honours from the Charles University, Prague, Czech republic in 1980. He received a CSc (PhD) and DrSc degree in radioelectronics from the Technical University, Košice, Slovakia, in 1983 and 1992 respectively. From 1974 to 1997, he worked as an electrical engineer at the Firm ČKD Polovodiče, Prague. From 1997 to 1997 he was with the Institute of Nuclear Technology and Radioecology, Košice, as a research fellow. Since March 1979, he has been at the Technical University of Košice, as a professor of electronics and telecommunications technology. His research interests include multimedia signal processing and fiber optics communication. Prof. Turán is a senior member of the IEEE, member of Czech and Slovak Radioengineering and Photonics Societies.

Ľuboš Ovseník (Ing, PhD) was born in Považská Bystrica, Slovakia, in 1965. He received his Ing (MSc) degree in 1990 from the Faculty of Electrical Engineering and Informatics of University of Technology in Košice. He received PhD degree in electronics from University of Technology, Košice, Slovakia, in 2002. Since February 1997, he has been at the University of Technology, Košice as Assistant professor for electronics and information technology. His general research interests include optoelectronic, digital signal processing, photonics, fiber optic communications and fiber optic sensors.

Ján Turán, Jr (Ing), was born in Košice, Slovakia in 1977. He received an Ing (MSc) degree in computer engineering from University of Technology, Košice, Slovakia in 2000. Since September 2000 he has been at 3D People, GmbH, Reutlingen, Germany as project manager. His research interest include multimedia signal processing, 3D computer game theory and visualization.