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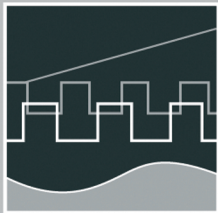
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Session 6 - Environmental Systems: Management and Optimisation

**Session 7 - New Methods and Technologies for Medicine and
Biology**

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision


Session 10 - Mobile Communications

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Andrea Schneider
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Fax: +49 3677 69-1743
e-mail: kongressorganisation@tu-ilmenau.de
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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

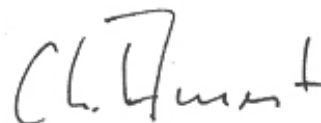
All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.

I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau



Professor Christoph Ament
Head of Organisation

Table of Contents

CONTENTS

	Page
6 Environmental Systems: Management and Optimisation	
T. Bernard, H. Linke, O. Krol A Concept for the long term Optimization of regional Water Supply Systems as a Module of a Decision Support System	3
S. Röhl, S. Hopfgarten, P. Li A groundwater model for the area Darkhan in Kharaa river Th. Bernard, H. Linke, O. Krol basin	11
A. Khatanbaatar Altantuul The need designing integrated urban water management in cities of Mongolia	17
T. Rauschenbach, T. Pfützenreuter, Z. Tong Model based water allocation decision support system for Beijing	23
T. Pfützenreuter, T. Rauschenbach Surface Water Modelling with the Simulation Library ILM-River	29
D. Karimanzira, M. Jacobi Modelling yearly residential water demand using neural networks	35
Th. Westerhoff, B. Scharaw Model based management of the drinking water supply system of city Darkhan in Mongolia	41
N. Buyankhishig, N. Batsukh Pumping well optimi ation in the Shivee-Ovoo coal mine Mongolia	47
S. Holzmüller-Laue, B. Göde, K. Rimane, N. Stoll Data Management for Automated Life Science Applications	51
N. B. Chang, A. Gonzalez A Decision Support System for Sensor Deployment in Water Distribution Systems for Improving the Infrastructure Safety	57
P. Hamolka, I. Vrublevsky, V. Parkoun, V. Sokol New Film Temperature And Moisture Microsensors for Environmental Control Systems	63
N. Buyankhishig, M. Masumoto, M. Aley Parameter estimation of an unconfined aquifer of the Tuul River basin Mongolia	67

M. Jacobi, D. Karimanzira 73
Demand Forecasting of Water Usage based on Kalman Filtering

7 New Methods and Technologies for Medicine and Biology

J. Meier, R. Bock, L. G. Nyúl, G. Michelson 81
Eye Fundus Image Processing System for Automated Glaucoma Classification

L. Hellrung, M. Trost 85
Automatic focus depending on an image processing algorithm for a non mydriatic fundus camera

M. Hamsch, C. H. Igney, M. Vauhkonen 91
A Magnetic Induction Tomography System for Stroke Classification and Diagnosis

T. Neumuth, A. Pretschner, O. Burgert 97
Surgical Workflow Monitoring with Generic Data Interfaces

M. Pfaff, D. Woetzel, D. Driesch, S. Toepfer, R. Huber, D. Pohlers, 103
D. Koczan, H.-J. Thiesen, R. Guthke, R. W. Kinne
Gene Expression Based Classification of Rheumatoid Arthritis and Osteoarthritis Patients using Fuzzy Cluster and Rule Based Method

S. Toepfer, S. Zellmer, D. Driesch, D. Woetzel, R. Guthke, R. Gebhardt, M. Pfaff 107
A 2-Compartment Model of Glutamine and Ammonia Metabolism in Liver Tissue

J. C. Ferreira, A. A. Fernandes, A. D. Santos 113
Modelling and Rapid Prototyping an Innovative Ankle-Foot Orthosis to Correct Children Gait Pathology

H. T. Shandiz, E. Zahedi 119
Noninvasive Method in Diabetic Detection by Analyzing PPG Signals

S. V. Drobot, I. S. Asayenok, E. N. Zacepin, T. F. Sergiyenko, A. I. Svirnovskiy 123
Effects of Mm-Wave Electromagnetic Radiation on Sensitivity of Human Lymphocytes to Ionizing Radiation and Chemical Agents in Vitro

8 Embedded System Design and Application

B. Däne 131
Modeling and Realization of DMA Based Serial Communication for a Multi Processor System

M. Müller, A. Pacholik, W. Fengler Tool Support for Formal System Verification	137
A. Pretschner, J. Alder, Ch. Meissner A Contribution to the Design of Embedded Control Systems	143
R. Ubar, G. Jervan, J. Raik, M. Jenihhin, P. Ellervee Dependability Evaluation in Fault Tolerant Systems with High-Level Decision Diagrams	147
A. Jutmann On LFSR Polynomial Calculation for Test Time Reduction	153
M. Rosenberger, M. J. Schaub, S. C. N. Töpfer, G. Linß Investigation of Efficient Strain Measurement at Smallest Areas Applying the Time to Digital (TDC) Principle	159
9 Image Processing, Image Analysis and Computer Vision	
J. Meyer, R. Espiritu, J. Earthman Virtual Bone Density Measurement for Dental Implants	167
F. Erfurth, W.-D. Schmidt, B. Nyuyki, A. Scheibe, P. Saluz, D. Faßler Spectral Imaging Technology for Microarray Scanners	173
T. Langner, D. Kollhoff Farbbasierte Druckbildinspektion an Rundkörpern	179
C. Lucht, F. Gaßmann, R. Jahn Inline-Fehlerdetektion auf freigeformten, texturierten Oberflächen im Produktionsprozess	185
H.-W. Lahmann, M. Stöckmann Optical Inspection of Cutting Tools by means of 2D- and 3D-Imaging Processing	191
A. Melitzki, G. Stanke, F. Weckend Bestimmung von Raumpositionen durch Kombination von 2D-Bildverarbeitung und Mehrfachlinienlasertriangulation - am Beispiel von PKW-Stabilisatoren	197
F. Boochs, Ch. Raab, R. Schütze, J. Traiser, H. Wirth 3D contour detection by means of a multi camera system	203

M. Brandner Vision-Based Surface Inspection of Aeronautic Parts using Active Stereo	209
H. Lettenbauer, D. Weiss X-ray image acquisition, processing and evaluation for CT-based dimensional metrology	215
K. Sickel, V. Daum, J. Hornegger Shortest Path Search with Constraints on Surface Models of In-the-ear Hearing Aids	221
S. Husung, G. Höhne, C. Weber Efficient Use of Stereoscopic Projection for the Interactive Visualisation of Technical Products and Processes	227
N. Schuster Measurement with subpixel-accuracy: Requirements and reality	233
P. Brückner, S. C. N. Töpfer, M. Correns, J. Schnee Position- and colour-accurate probing of edges in colour images with subpixel resolution	239
E. Sparrer, T. Machleidt, R. Nestler, K.-H. Franke, M. Niebelschütz Deconvolution of atomic force microscopy data in a special measurement mode – methods and practice	245
T. Machleidt, D. Kapusi, T. Langner, K.-H. Franke Application of nonlinear equalization for characterizing AFM tip shape	251
D. Kapusi, T. Machleidt, R. Jahn, K.-H. Franke Measuring large areas by white light interferometry at the nanopositioning and nanomeasuring machine (NPMM)	257
R. Burdick, T. Lorenz, K. Bobey Characteristics of High Power LEDs and one example application in with-light-interferometry	263
T. Koch, K.-H. Franke Aspekte der strukturbasierten Fusion multimodaler Satellitendaten und der Segmentierung fusionierter Bilder	269
T. Riedel, C. Thiel, C. Schmallius A reliable and transferable classification approach towards operational land cover mapping combining optical and SAR data	275
B. Waske, V. Heinzl, M. Braun, G. Menz Classification of SAR and Multispectral Imagery using Support Vector Machines	281

V. Heinzl, J. Franke, G. Menz Assessment of differences in multisensoral remote sensing imageries caused by discrepancies in the relative spectral response functions	287
I. Aksit, K. Bünger, A. Fassbender, D. Frekers, Chr. Götze, J. Kemenas An ultra-fast on-line microscopic optical quality assurance concept for small structures in an environment of man production	293
D. Hofmann, G. Linss Application of Innovative Image Sensors for Quality Control	297
A. Jablonski, K. Kohrt, M. Böhm Automatic quality grading of raw leather hides	303
M. Rosenberger, M. Schellhorn, P. Brückner, G. Linß Uncompressed digital image data transfer for measurement techniques using a two wire signal line	309
R. Blaschek, B. Meffert Feature point matching for stereo image processing using nonlinear filters	315
A. Mitsiukhin, V. Pachynin, E. Petrovskaya Hartley Discrete Transform Image Coding	321
S. Hellbach, B. Lau, J. P. Eggert, E. Körner, H.-M. Groß Multi-Cue Motion Segmentation	327
R. R. Alavi, K. Brieß Image Processing Algorithms for Using a Moon Camera as Secondary Sensor for a Satellite Attitude Control System	333
S. Bauer, T. Döring, F. Meysel, R. Reulke Traffic Surveillance using Video Image Detection Systems	341
M. A-Megeed Salem, B. Meffert Wavelet-based Image Segmentation for Traffic Monitoring Systems	347
E. Einhorn, C. Schröter, H.-J. Böhme, H.-M. Groß A Hybrid Kalman Filter Based Algorithm for Real-time Visual Obstacle Detection	353
U. Knauer, R. Stein, B. Meffert Detection of opened honeybee brood cells at an early stage	359

10 Mobile Communications

K. Ghanem, N. Zamin-Khan, M. A. A. Kalil, A. Mitschele-Thiel Dynamic Reconfiguration for Distributing the Traffic Load in the Mobile Networks	367
N. Z.-Khan, M. A. A. Kalil, K. Ghanem, A. Mitschele-Thiel Generic Autonomic Architecture for Self-Management in Future Heterogeneous Networks	373
N. Z.-Khan, K. Ghanem, St. Leistritz, F. Liers, M. A. A. Kalil, H. Kärst, R. Böringer Network Management of Future Access Networks	379
St. Schmidt, H. Kärst, A. Mitschele-Thiel Towards cost-effective Area-wide Wi-Fi Provisioning	385
A. Yousef, M. A. A. Kalil A New Algorithm for an Efficient Stateful Address Autoconfiguration Protocol in Ad hoc Networks	391
M. A. A. Kalil, N. Zamin-Khan, H. Al-Mahdi, A. Mitschele-Thiel Evaluation and Improvement of Queueing Management Schemes in Multihop Ad hoc Networks	397
M. Ritzmann Scientific visualisation on mobile devices with limited resources	403
R. Brecht, A. Kraus, H. Krömker Entwicklung von Produktionsrichtlinien von Sport-Live-Berichterstattung für Mobile TV Übertragungen	409
N. A. Tam RCS-M: A Rate Control Scheme to Transport Multimedia Traffic over Satellite Links	421
Ch. Kellner, A. Mitschele-Thiel, A. Diab Performance Evaluation of MIFA, HMIP and HAWAII	427
A. Diab, A. Mitschele-Thiel MIFAv6: A Fast and Smooth Mobility Protocol for IPv6	433
A. Diab, A. Mitschele-Thiel CAMP: A New Tool to Analyse Mobility Management Protocols	439

11 Education in Computer Science and Automation

S. Bräunig, H.-U. Seidel Learning Signal and Pattern Recognition with Virtual Instruments	447
St. Lambeck Use of Rapid-Control-Prototyping Methods for the control of a nonlinear MIMO-System	453
R. Pittschellis Automatisierungstechnische Ausbildung an Gymnasien	459
A. Diab, H.-D. Wuttke, K. Henke, A. Mitschele-Thiel, M. Ruhwedel MAeLE: A Metadata-Driven Adaptive e-Learning Environment	465
V. Zöppig, O. Radler, M. Beier, T. Ströhla Modular smart systems for motion control teaching	471
N. Pranke, K. Froitzheim The Media Internet Streaming Toolbox	477
A. Fleischer, R. Andreev, Y. Pavlov, V. Terzieva An Approach to Personalized Learning: A Technique of Estimation of Learners Preferences	485
N. Tsyrelchuk, E. Ruchaevskaia Innovational pedagogical technologies and the Information educational medium in the training of the specialists	491
Ch. Noack, S. Schwintek, Ch. Ament Design of a modular mechanical demonstration system for control engineering lectures	497

A. Fleischer / R. Andreev / Y. Pavlov / V. Terzieva

An Approach to Personalized Learning: A Technique of Estimation of Learner's Preferences

INTRODUCTION

The term “e-learning” presents “technology enhanced learning”. It describes the use of computer-based technologies to support and enhance learning practice. The focus of e-learning engineering is on the design and implementation of e-learning environment. There are two approaches to the development of an e-learning environment that take into consideration two of its aspects. According to the first aspect, e-learning environment is a server that provides learners with learning objects and services. The approach concerning this aspect bases on service-orientated design and implementation models in the development of e-learning environment. Such environment consists of two fundamental types of servers:

- Servers that provide learning content (content providers);
- Servers for provision of learning services - the learning services support various learning styles, which correspond to the existing pedagogical methods.

The second approach considers e-learning environment as environment that supports educators in process of producing of learning resources that are composition of learning objects and services. It ensures the development of *production-oriented (productive) e-learning environments*.

Personalized learning concerns learner-centered adaptation of learning resources. In the web-based e-learning environment the process of personalization of learning objects requires *model of an individual learner* that represents its profile [6]. This model is an element of adaptive e-learning environments that carry out various adaptation methods. Some of them use semantic-based reasoning for achieving automatic adaptation of e-learning environment [1]. Others utilize to the fullest extent reasoning that bases on matching learning material described by metadata with learners' characteristics. A service-based strategy for implementation of an adaptation method of reasoning that uses heuristic rules for deriving recommendations using learner profile information model is presented in [7]. The adaptive servers providing learners with educational

services are personalized, as well. An approach to personalization of adaptive learning services provision is given in [8]. A model of personalization of an adaptive e-learning environment that provides learning objects and services together is presented in [2]. The adaptation of learning resources to individual learners in a productive e-learning environment bases on transformation of generalized learning resources into specific ones. This is an adaptation technique, which bases on *generalization/specification* method of reasoning and determines the e-learning environment as “adaptable”[13].

A MODEL-BASED FRAMEWORK FOR PERSONALIZED LEARNING IN PRODUCTION-ORIENTED E-LEARNING ENVIRONMENT

A model-based framework for supporting of personalized learning in a production-oriented e-learning environment is presented on Figure 1. It integrates various entities that take part in learner-adapted production of this environment. The architecture of this framework consists of the following components: success, learner, product, process and evaluation models. The overriding top-priority success model defines the optimization criterion of the productive e-learning environment and makes some of the other components the primary driver for framework integration [4]. In our case, the success model of productive e-learning environment work is to “Achieve usability of products of e-learning environment”. It requires learner-centered adaptation of learning resources that are products of teacher work and are represented by work product models. According to the success model, the key goal of the productive e-learning environment is to deliver “fit for characteristics and attributes of a learner” learning resources. This requirement to the production-oriented environment qualifies the learner model as primary driver of learning resources production.

The development of personalized learning resources depends on the learner profile, which has multi-layers structure. The bottom layer represents the learner’s preferences, which determine *how* a man learns with pleasure [5]. The upper layer describes learner background that relates to learner’s experience. The top two layers present the attributes of a learner: learner requirements and goals. In the presented framework, the way of transformation of work product models conforms to the model of the teaching process. The top level of the upper loop involves the generalized conceptual model of the initial work product. The lower loop involves elaboration of the conceptual products models until these are reified to the point that can be transformed to a learning resource suitable for a learner.

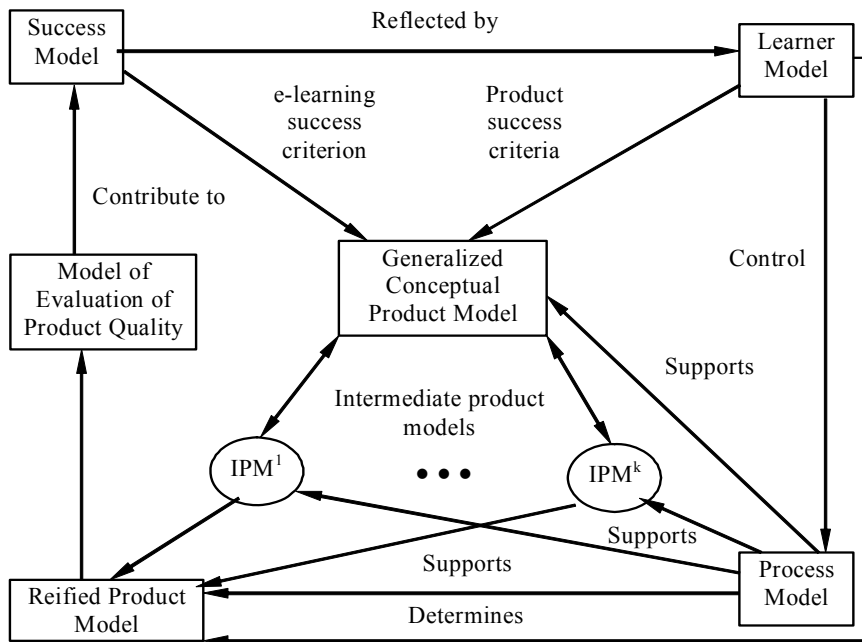


Fig. 1 Framework for personalization of productive e-learning environment

MATHEMATICAL FORMULATIONS AND METHODS

The preferences of learners are estimated on the basis of a mathematical approach that refers to the utility theory [3]. In this case, the learner is considered as a decision-maker (DM). The explicitly expressed preferences of the DM can serve for evaluation of learning resources (object). The main objective of this evaluation is to keep the correlation between the expressed preferences and the DM's utility function. Standard description of the utility function is presented by formula (1). There are a variety of possible final results ($x \in \mathbf{X}$) that are consequence of a DM activity. A utility function $U(\cdot)$ assesses each of these results. The DM judgment is measured quantitatively by the

following formula:

$$U(p) = \sum_i P_i U(x_i), \quad p \text{ is probability distribution } \sum_i P_i = 1 \quad (1)$$

We denote with P_i ($i = 1 \div n$) subjective or objective probabilities, which reflect the uncertainty of the final results. Strong mathematical formulation of the utility function is the next: Let \mathbf{X} be the set of alternatives and \mathbf{P} be a subset of the set of probability distributions over \mathbf{X} . The DM's preferences over \mathbf{P} are described by the binary "preference" relation (\succ) including those over \mathbf{X} ($\mathbf{X} \subseteq \mathbf{P}$). A utility function is any function $U(\cdot)$ for which is fulfilled: $((p \succ q), (p, q) \in \mathbf{P}^2) \Leftrightarrow (\int U(\cdot) dp > \int U(\cdot) dq)$. Thus, the mathematical expectation of the utility $U(\cdot)$ is a quantitative measure concerning the DM preferences about the probability distributions over \mathbf{X} . In practice the set \mathbf{P} is a set of finite probability distribution. We suppose that the singleton distributions belong to \mathbf{P} , ($\mathbf{X} \subseteq \mathbf{P}$). There are

quite different evaluation methods of the utility functions [9, 12] that based prevailing on the "lottery" approach. A "lottery" is every discrete probability distribution over \mathbf{X} . We mark the lottery "x with probability α and y with probability $(1-\alpha)$ " as $\langle x, y, \alpha \rangle$. There are different systems of axioms (like *Von Neumann and Morgenstern's axioms*) that give satisfaction conditions of utility existence.

We start with the assumption that any convex combination of elements of \mathbf{P} belongs to \mathbf{P} : $(q, p) \in \mathbf{P}^2 \Rightarrow (\alpha q + (1-\alpha)p) \in \mathbf{P}$, for $\forall \alpha \in [0, 1]$ [10, 11]. This condition and $(\mathbf{X} \subseteq \mathbf{P})$ determine the utility function over \mathbf{X} (when this function exists) with the accuracy of an affine transformation. The most used utility assessment approach is comparisons of the kind: $(z \sim \langle x, y, \alpha \rangle)$, where $(x \succ z \succ y)$, $\alpha \in [0, 1]$, $(x, y, z) \in \mathbf{X}^3$. Every comparison of this kind defines a "learning point" $t = (x, y, z, \alpha)$. With probability $D_1(x, y, z, \alpha)$ the DM assigns the "learning point" to the set A_u or with $D_2(x, y, z, \alpha)$ to B_u :

$$A_u = \{(x, y, z, \alpha) / (\alpha U(x) + (1-\alpha)U(y)) > U(z)\}, B_u = \{(x, y, z, \alpha) / (\alpha U(x) + (1-\alpha)U(y)) \leq U(z)\}.$$

The DM answers ($\succ \Leftrightarrow 1$; $\prec \Leftrightarrow -1$; $\sim \Leftrightarrow 0$) are with probability and subjective uncertainty.

The main recurrent stochastic procedure in the proposed approach has the form:

$$c_i^{n+1} = c_i^n + \gamma_n \left[D'(t^{n+1}) - \overline{(c^n, \Psi(t^{n+1}))} + \xi^{n+1} \right] \Psi_i(t^{n+1}), \sum_n \gamma_n = +\infty, \sum_n \gamma_n^2 < +\infty, \forall \gamma_n \geq 0. \quad (2)$$

Here $(c^n, \Psi(t))$ denotes scalar product and $D' + \xi$ are the teacher's answers ($\succ \Leftrightarrow 1$; $\prec \Leftrightarrow -1$; $\sim \Leftrightarrow 0$) where ξ is noise (uncertainty) in the teacher answers with mathematical expectation equal to zero [10, 11]. The scalar product has the form:

$$(c^n, \Psi(t)) = \alpha(c^n, \Phi(x)) + (1-\alpha)(c^n, \Phi(y)) - (c^n, \Phi(z)) = \alpha g^n(x) + (1-\alpha)g^n(y) - g^n(z) = G^n(x, y, z, \alpha). \quad (3)$$

The coefficients c_i^n take part in the decomposition of $g^n(x)$ by a chosen family of functions $(\Phi_i(x))$: $g^n(x) = \sum_{i=1}^N c_i^n \Phi_i(x)$. The line above $\bar{T} = \overline{(c^n, \Psi(t))}$ means that $\bar{T} = 1$, if

$T > 1$, $\bar{T} = -1$ if $T < (-1)$ and $\bar{T} = T$ if $-1 < T < 1$. It is known that under the procedure (2)

conditions specified above the next integral converges to the (min):

$$J_D(G^n(x, y, z, \alpha)) = M \left(\int_{D'(t)}^{G^n(t)} (\bar{y} - D'(t)) dy \right) = \int \left(\int_{D'(t)}^{G^n(t)} (\bar{y} - D'(t)) dy \right) dF \xrightarrow{\text{p.p.}} \inf_{s(t)} \int \left(\int_{D'(t)}^{s(t)} (\bar{y} - D'(t)) dy \right) dF. \quad (4)$$

Here p.p. denotes "almost sure" and $s(t)$ denotes $s(t) = \alpha s(x) + (1-\alpha)s(y) - s(z)$. After some calculations the following make the convergence clear:

$$\inf_{s(t)} \int \int_{D'(t)}^{s(t)} (\bar{y} - D'(t)) dy dF \geq \lim_n \left(\frac{1}{2} \int \overline{(G^n(t) - D'(t))^2} dF \right) \geq 0 \quad (5)$$

Taking in to account the convergence and the structure of the function $G^n(x, y, z, \alpha)$ (3) it

is assumed that $g^n(x)$ is approximation of the empirical utility if (n) is sufficiently great.

A USAGE OF THE TECHNIQUE OF LEARNER'S PREFERENCES ESTIMATION

There are shown examples of usage of this technique in the estimation of learner's preferences with regard to the content attributes of learning resources. Its mathematical description is implemented by means of a decision support system developed in the environment of Visual Studio (Visual Basic 6.0). The final calculations and graphics are performed in MATLAB environment.

We apply the developed evaluation tool for representation of learner's preferences to content exposition of learning resources through a function. It concerns the choice of proportion of theoretical presentation to the example-based presentation of knowledge. Figure 2 presents the preference of a learner for content exposition – % theoretical presentation of the whole content presentation.

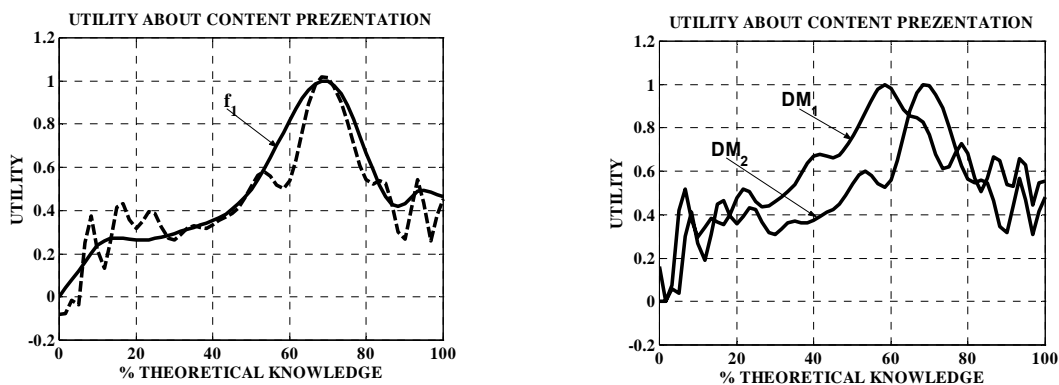


Fig. 2. Learner's preferences to form of content presentation

The seesaw line of the left graphic in the figure recognizes correctly more than 95% of the learner's answers. The stochastic uncertainty makes to see the utility function as a seesaw line. The first evaluation is based on 64 questions (learning points) – utility function $f_1(x)$. It is sufficient only for the first raw approximation. This assessment is fast, since the examination takes about 20 minutes. The utility function $f_1(x)$ clearly reveals the tendency of learner's preference. The right graphic shows estimation of the preferences of two learners (DM_1 and DM_2). It is noticeable that learners have different preferences for the percentage of theoretical knowledge presentation given in learning resources (DM_1 chooses lower level of theoretical presentation than DM_2). Consequently, learners will need altered learning resources, adapted to their preference. Presented graphics are with stochastic uncertainty.

CONCLUSIONS

The presented framework for learner-centered *adaptable e-learning environment* has the followings characteristics: the personalized learning is ensured by a learner model-driven, product-focused process of producing learning resources; learner reference model has layered structure; the learner model controls the production of learning resources; learner-centered adaptation is teaching process capability, this framework supports the optimization of teaching process.

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Authors:

Dipl.-Inf. Alexander Fleischer
Technical University Ilmenau, Faculty of Informatics and Automation
PSF 98694 Ilmenau, Germany
Phone: + 49 3677 69 1435
E-mail: alexander.fleischer@tu-ilmenau.de

Assoc. Professor Rumen Andreev PhD
Assoc. Researcher Valentina Terzieva
Institute of Computer and Communication Systems, BAS
Acad. G. Bonchev str. Bl. 2
1113 Sofia, Bulgaria
Phone: +358 2 872 01 32
E-mail: {rumen, valia}@isdip.bas.bg

Assoc. Researcher Yuri Pavlov PhD
Central Laboratory of Biomedical Engineering, Bulgarian Academy of Sciences,
Acad. G. Bonchev str. Bl. 105
1113 Sofia, Bulgaria
Phone: +359 02 979 36 48
E-mail: yupavlov@clbme.bas.bg