# New Development of Teaching Concepts in Multimedia Learning for Electrical Power Systems Introducing Sonification

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**Abstract** - **In the following paper a review of previous and current progress in the field of e-Learning at the Institute of Electrical Power Systems of the University of Technology Graz/Austria is given. An introduction to already realised and implemented improvements – programming of a stand-alone e-Learning-course generator, optimisation of the successfully established ABC-layout and design for e-Learning courses – as well as yet started innovations in progress – simplification of the usability of course-management, enhancement of the multimedia and didactic spectrum by implementation of sonification methods – is given.**
**Sonification is the perceptualization of information and data by means of sound, and it is a versatile complement to standard visual presentation and analysis methods. A research project at the Institute of Electronic Music and Acoustics in Graz, SonEnvir, explores its uses in a number of scientific domains. In electrical power systems, the time behaviour of complex oscillating systems is studied, so auditory display and analysis with its superior time resolution is especially appropriate here, and can enhance understanding of the phenomena under study significantly.**

## I. INTRODUCTION

The improvement and representation of complex correlations within the special field of electrical engineering for learning purpose has always been a main focus of the Institute of Electrical Power Systems (IFEA) of the University of Technology Graz (TU Graz). First steps in the eighties go back to several programs for load flow- and short-circuit calculations as well as for inductive and ohmic interference. Due to the increasing availability of computer-based visualization the possibilities for graphic description and presentation of research and learning matter expanded alike (e.g.: a simulation program for a hydroelectric power station system). The usage of CD-ROMs as a data medium for offline learning content gained in importance whereas online learning options over the internet  were of no importance or did not exist yet.

Motivated by the initiative "New Media in teaching at universities and polytechnics in Austria" (NML) [1] of the Austrian Federal Ministry for Education, Science and Culture (bm:bwk) in spring 2000 the TU Graz started the project "MultiMediaLearning" (MML) [2] when founding a panel of experts, three task forces and implementing the e-Learning platform "eLearning Suite" (eLS by Hyperwave) also called "TUGwbt" (TU Graz web based training). Aim of this ongoing project is to improve the quality of teaching, the institutional and individual management of studies and the technical administration of the e-Learning system itself.

IFEA has been one of the first partners of MML and still holds a leading position within that e-Learning project. Since spring 2001 IFEA undertakes its own e-Learning strategy. For this aim a brand new course-system ("ABC-course system") with a specially designed layout ("ABC-layout") for electronic scripts has been developed and evaluated by independent psychologists. The uniform structure and the high usability of the system allow a wide ranged application of the courses as for the lesson in classroom, for online eLS variant, for offline CD-ROM version and for the hardcopy paper script. Furthermore the modular character of multimedia interactive content units programmed in HTML let a teacher or course designer mix, change, update and create new courses very easily [3] [4].

## II. THE IMPLEMENTED IMPROVEMENTS

### A. The "IFEA-Viewer"

The "IFEA-Viewer" is a new developed tool for creating "ABC-courses" much more easily than before. To understand the importance of this step forward a short review about "ABC-courses" is necessary.

The basic raw material of a course always is a well structured quantity of single HTML-pages of defined "ABC-layout". After the course once was completed regarding the content the course got uploaded to the eLS by using the "JavaVirtualFolders"-System[1] (JVF). The course then was online. To generate an offline CD-ROM version the online course and all its HMI-files had to be downloaded again. By using the "wbt2cd"-tool [4] the offline version was generated indispensably requiring the HMI-files. The usage of the JVF needs a basic understanding of meta-data system which cannot be assumed ad hoc. Due to the structure of the eLS data base

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[1] The "JavaVirtualFolders" is an interface especially for up- and downloading to and from the eLS-data base with several additional options to specify meta-data to a course which are saved in separate HMI-files.

the up- and download may take much time or even gets cancelled because of time-out.

The "IFEA-Viewer" solves all these handicaps. It does not only satisfy the demands of the most important JVF-functionalities but even gains an independency from JVF and therefore enables a stand-alone generation of the CD-ROM version. Moreover its handling is of self-explanatory nature and is therefore better qualified to be used by more people.

After selecting a course (plain HTML files in "ABC course design" structure) the program compiles the content into the "IFEA-Viewer"-environment. During this process the user can change some meta-data concerning name of content-files and visibility in the "IFEA-Viewer"-user interface (see "Fig.1."). Another easement and step towards professionalism is the ready-made thumbnail maker within the compilation. For the "IFEA-Viewer"-user interface offers a text-based and a thumbnail-based directory the thumbnails therefore have to be generated which circumstantial had been done manually till now.
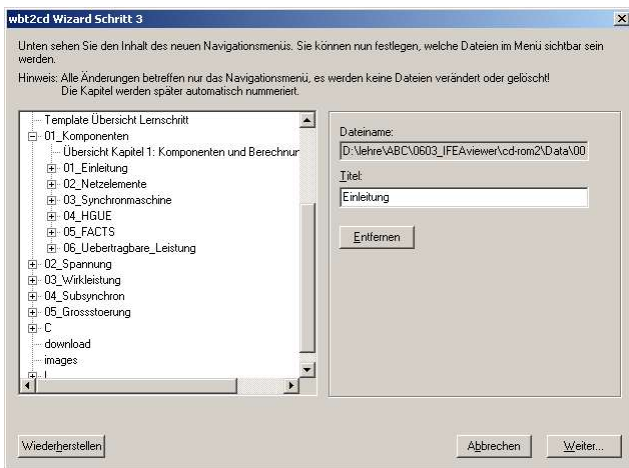


Fig.1. "IFEA-Viewer" course generating interface
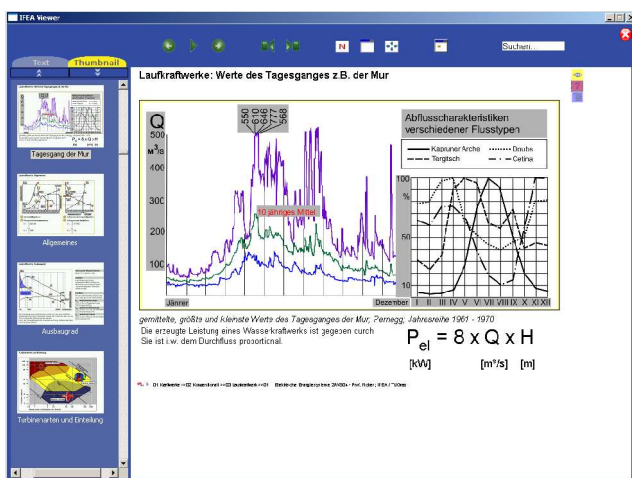step of changing meta-data by user



Fig. 2. "IFEA-Viewer"-user interface in Window Mode
Thumbnail-Directory on the left site, content file in the middle, navigation tools and search tool on the top

The "IFEA-Viewer"-user interface (see "Fig.2.") has a variety of suitable functions besides a search option. The user can choose between four kinds of modes:

- Normal Mode: the application runs within a fixed surrounding filling up the whole screen
- Window Mode: similar to MICROSOFT windows, moveable and minimise able
- Full Screen Mode: the whole application is being enlarged to full screen size
- Presentation Mode: only the content is shown without the environment

Using the "Autoplay"-function the content files slide through by sequence of appearance automatically but with adjustable speed. The directory can be optionally seen as text or thumbnails and holds features like a cookie-effect[2] or the possibility to open and close the whole directory-tree with two buttons.

The program is written in C++ and saves the structure of the directory in an editable XML-file. So it is possibly to change the sequence of the content files used even after the course is completed. This quality of the "IFEA-Viewer" nearly turns it into a kind of what we call "playlist" that allows the user to select the content files he wants and sample them together to a brand new course, which is one of the long-term aims within the IFEA e-Learning project. The "IFEA-Viewer" is programmed for PCs with WINDOWS XP but is going to be extended for LINUX systems and MAC as well.

### B. "The Earth Fault"-CD ROM
### An Example for successful cooperation with Industry

The multimedia CD-ROM „The Earth Fault" is the first CD-ROM whose content is of interest for organisations from industry, economy and other educational institutions but universities. It is created in the established "ABC-course system" in cooperation with the firm a-eberle from Germany[3]. This educational CD-ROM finds the necessary basics to the subject earth fault and is the first of a series of multimedia CD ROMs covering central topics of the electrical power systems array.

The first module discusses physical and electrophysical basics that are of importance in case of an earth fault. The second module exercises complete calculation-examples of earth faults and therefore deepens the comprehension of the subject. An interactive Earth Fault Calculation Tool even allows the user to calculate exemplary earth fault scenarios by its own ("Fig.3."). Further modules display the practical aspects of the theory by pointing out various protection systems. Not only for the sake of completeness but to feature the judicial basics as well an additional module details the most important prescriptions and standards in this context.

Fig.3. Earth Fault Calculation Tool realized in the "ABC-layout"

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[2] The application opens at the content file where it has been closed the last time.

[3] A-eberle is a market leader in the field of all measuring, regulating controlling and recording tasks revolving around the transformer and the choke coil.

Erdschluss-Berechnung
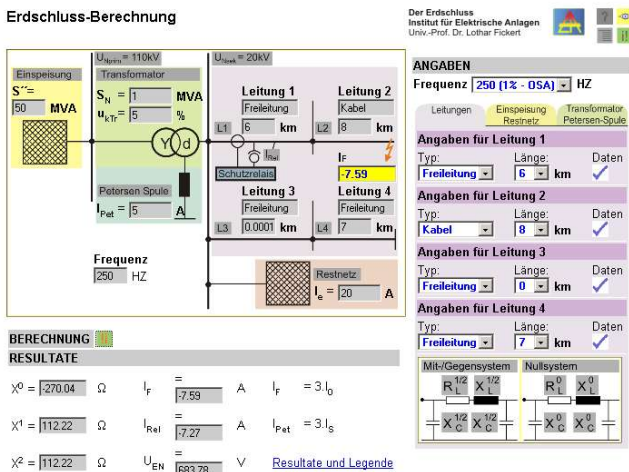
## III. INTRODUCING SONIFICATION AND "SONENVIR"

Current definitions of Sonification define it as the perceptualization of data and/or information by means of (non-speech) sound (l~~ink wikipedia~~ see e.g. http://en.wikipedia.org/wiki/Sonification). Information can be made available to the human senses (perceptualized) in different sensory modalities, and each of these have different sets of strengths and limitations. The main organization for this field, the International Community for Auditory Display (ICAD, see www.icad.org) has been organizing conferences on this field of research for 14 years, and a general position paper written by the ICAD board for the NFS [5] is a good overview of the field and its central concerns.

For understanding the behaviour of complex oscillating systems in time, as in electrical power systems, visual displays are limited by the low temporal resolution of the eye, and by the limited ability to attend to multiple streams of information simultaneously. Here, many phenomena can be rendered very directly by Sonification:

E.g. transients as they occur in faults will carry information in the character of their irregularity, and possible resonant modes; basic audification (playing the time signal as if it were an audio recording, optionally time-scaled) will reveal such information in a very 'analog' way. By filtering out the known constant 50Hz signal, any deviations like transients or sudden changes on overtone content can be detected by attendance personnel almost immediately.

For data of a less direct physical quality, data properties and their evolution can be displayed in a more indirect manner, namely as observable properties of a synthesized soundscape. This technique is called Parameter Mapping, and this is the method of choice for displaying more indirect measurements such as load flow over longer time sequences. Here, the higher time resolution can allow for a making audible the 'character' of fluctuation behaviour, which would be invisible in graphical display methods.

Of course, there are many more aspects and possible application strategies for Sonification; we find that especially for pedagogy of time-domain phenomena, Sonification can become a valuable addition to current approaches.

In this context the "SonEnvir"-project fits in very well. "Son~~Enivr~~Envir" is the first scientific interdisciplinary research project of all four universities of Graz[45]. It is managed by IEM and supported by the Styrian government. Besides network~~ing~~ and clustering purposes between the four universities, the project predominantly aims ~~to~~ at connect~~ing~~ sound experts and scientists from diverse fields of research contributing very different basic data for sonification. ~~To program a~~The main goal of the project is the development of a software environment for sonification ~~software~~ —that can be used by scientists autonomously. Another important aspect of the project is the development of ~~and develop~~ sonification applications ~~of sonification with~~of direct practical ~~use~~ value ~~age within~~for the~~se~~ different fields of research ~~are the main goals of "SonEnvir".~~

At the time of writing, the SonEnvir project is extending these notions of interdisciplinary collaboration by holding a 3-day international workshop on sonification: ~~usties in Graz / Austria (IEM)~~ From March 16-18, 2006, this workshop at IEM Graz will bring together international experts in the area of sonification with distinguished scientists from sonification application domains. Researchers from such diverse areas as quantum physics, neurology, social sciences, assistive technologies and nonlinear signal processing will have the opportunity to make firsthand experiences with sonification for research questions from their fields; sonification experts will receive valuable feedback on their sonification design approaches.

The domain scientists are encouraged to submit data sets from their current research problems and a short description to the workshop organizers prior to the workshop. By preparing initial sonification designs for these data sets, we expect to generate interesting material for experimentation and discussion during this workshop.

## IV. IFEA AND IEM: THE SOUND OF ELECTRICITY

Because of the „SonEnvir"-project and other joint research activities of the two universities, partners from IFEA and IEM met in January 2006 and began experimenting with sonifying electrical engineering data.

The cooperation started with the objective target to find a new and potentially more effective description for existing data-series of different disturbances of an electric grid by analysing them with sonification. Therefore recorded data (in COMTRADE-data format) of a single phase earth fault within an earth fault compensated net have been used (see „Fig.4."). The sonified notation directly and definitely allowed indicating both the voltage increase during an earth fault with its increased emerging harmonics and the transient oscillations during the extinction of the earth fault.

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[4] UNI Graz: Karl-Franzens University of Graz
TU Graz: University of Technology Graz
KUG: University of Mu~~sic~~sic and Dramatic Arts Graz
Medical University of Graz
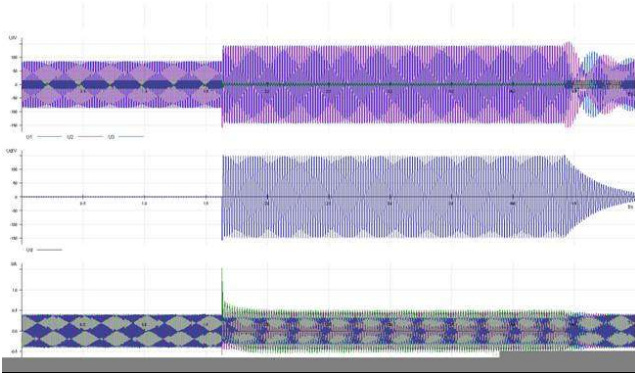[5] ~~http://iem.at/projekte/acoustic/technic/sonenvir/index_html~~
http://sonenvir.at

Fig. 4. Single phase earth fault within an earth fault compensated grid: presentation of COMTRADE-data through SIGRA

By using sonification an insight into even very complicated processes within an electrical power system can be provided without special previous or detailed knowledge of the matter. The Sonification specialists could easily identify by ear phenomena that have been measured, such as changes in harmonic spectrum, and (using special signal conditioning) fluctuating phases between voltage and current in the 'ringing' after the protection circuit switches off.

In the meantime the cooperation has been deepened and data of different measurement ranges (e.g. load flow, flicker, decentralised energy supply, power quality) have been made available for exploratory analysis by means of sonification. So far, our experiments have been quite promising; however, actual scientific advancement and therewith possible application areas in the future resulting from this cooperation are yet to be determined.

## V CONCLUSION

As a medium term aim of e-Learning at IFEA the development and intensification of the trail once blazed is to be designated. The consolidation of e-Learning as an essential element for teaching and communicational purpose within the university life not only at institutional level but also as a matter of education policy as well as a deeper cooperation with international organisations of electrical engineering on the basis of multimedia workings can be seen as the main long term aim of IFEA in this context.

The collaboration within the Estonian LEONARDO[6]-pilot-project "EEEW – Electrical Engineering in Easy Way" whose application is now being evaluated states an important step. The aim of this project is to develop an international multilingual and multimedia off- and online platform on basis of e-learning structure with its contents belonging to subjects from the area of electrical power systems and electrical engineering that chiefly will be applied for secondary and tertiary education as well as for further education or retraining in the means of lifelong learning.

[6] LEONARDO: Leonardo da Vinci-programme; Community Vocational Training Action Programme of the EU (second phase: 2000 - 2006)

The permanent improvement of the "ABC-course system" according to new requirements is another primary aim of IFEA. The compilation of already existing and future content and learning objects on base of a data base is of highest interest just as the realisation of the above-named "play-list" for easier and better systematically generation or compilation of new "ABC-courses".

The latest element in the pool of didactical methods, using sonification of data-series from the field of electrical power supply, establishes new and very effective possibilities for the presentation of scientific results, facts and technical processes. Its wide-spread implementation for teaching and learning purposes must be seen as a step towards essential demand of education and therefore shall enjoy highest priority.

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