

## E-LEARNING ON MULTIMEDIA

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### ABSTRACT

*This paper presents e-learning course on multimedia prepared within European Commission Leonardo da Vinci Programme "Invocom: Internet-based vocational training of communication students, engineers, and technicians". The "Invocom" project is already finished, but the prepared courses are still available. Basic aims, target groups and prepared interactive lessons of Multimedia Course are described. Described is also application of the ActiveX technology for the interactive exercises. The project proves that low-cost efficient distant learning tools may be prepared even for highly resource-demanding lessons on image, video and audio processing and compression.*

### 1. INTRODUCTION

Rapid increase number of Internet access points all over the Europe leads to many projects on new technologies for education and working. E-learning and teleworking are interesting options for all people, but especially disabled. The Internet-accessible learning materials are also an interesting option for students of stationary courses as additional material helping them to study.

Institute of Electronics and Telecommunications (IET) at Poznań University of Technology (PUT) has started e-learning efforts few years ago. Authors of this paper are members of the Multimedia Telecommunications Group (MTG) at IET PUT. Activity of Multimedia Telecommunication Group is focused on research on image, video and audio processing and teaching on image and video engineering, multimedia systems, analog and digital television, signal and system theory [2]. This paper describes the e-learning tools newly developed by the team deeply involved both in research and teaching.

### 2. THE INVOCOM PROJECT

The Multimedia Course presented in this paper is a part of materials prepared in cooperation with partners from Finland (Tampere Univ. Technology), France (ENSTB Brest, INT Evry), Portugal (Inst. Soldadura e Qualidade) and Poland (Activis) within an international project entitled "Internet-based Vocational Training of Communication Students, Engineers and Technicians" that was sponsored by European Commission under Leonardo da Vinci Programme [1, 3]. The aim of the project was to prepare a high-quality

package of interactive software tools for distance learning and continuous education of communication technology. The courses include software tools supporting simulation experiments that have been prepared according to the experience with laboratory courses given since many years for students and technicians.

The primary target groups are students of electronics, telecommunications, etc. (both BSc and MSc). Students who work and study (part-time students) have their educational opportunities and quality of studies relatively worse than their full-time colleagues. Internet-based vocational training would be, therefore, an element of creating equal opportunities for both groups of students. The second target group are engineers and technicians from IT industry. The studies of ICT experiments prepared in the project enable them to realize their profession in a more competent and competitive way. Besides, more general target groups may be identified, due to global and extra-territorial character of the Internet: these are students, engineers and technicians, all over the world.

The project resulted in several distant learning courses on telecommunications. Among the courses, there is Multimedia Course described in this paper. The courses have been prepared in two language versions: English and Polish.

### 3. MULTIMEDIA COURSE

#### 3.1 Introduction

The goal of the course is to give insight into terminology, problems and tasks of multimedia signal processing as well as to describe the methods, techniques and standards related to this branch. The course consists of 12 basic units called lessons. Each lesson comprises introductory theoretical material followed by interactive exercises, self evaluation tests and glossary.

The course prerequisites include backgrounds in digital signal processing and system theory; but users without such background will be still able to find this course useful, since interactive exercises with real test images, audio and video clips explain basic issues related to fundamental multimedia signal processing techniques.

The course is intended for low-cost applications, therefore the display page layout is optimized for both 1024×768 and 800×600 resolutions. In the second case, the Full Screen mode should be used. The course navigation is fully inline

with Invocom rules, so the user has no problems switching from other Invocom courses.

The interactive exercises in this course mostly use ActiveX controls, so a browser which supports ActiveX technology should be used. For the users without ActiveX support, there are special links passing pages with interactive exercises, so the course can still be helpful in self-study on multimedia.

Some additional remarks concerning both image/video and audio settings have been prepared for the users, helping in proper tuning of their PCs.

### 3.2 Intellectual property rights

The problem of intellectual property rights is crucial in all applications using samples of audio and video. So is in the case of Multimedia Course. All image and video test data used in interactive exercises (as well as some sound excerpts) came from test data exchanged by science community without any notes on copyrights. A characteristic exception is the famous *Lena* image - also a widely used standard test image - which is a part of digitized Playboy centrefold. The full story is given for example at [5]. All texts and most of illustrations on theory pages have been created by the course authors.

### 3.3 Prepared lessons

The Multimedia Coursse consists of twelve lessons entitled:

1. Digital image representation
2. Basic image processing operations
3. Filters for image processing
4. Image quality assessment
5. Spectral properties of images
6. Lossless image compression and JPEG-LS
7. Image transform coding and JPEG
8. Image wavelet coding and JPEG2000
9. Digital video representation and motion compensation
10. Video compression according to MPEG, H.263 and H.264/AVC
11. Sound and hearing
12. Digital audio representation and compression in MPEG

First lessons deal with very basic issues related to digital imagery. Lesson 1 deals for example with sample bit depth, sample value histograms, colour sample representation and colour spaces. Lesson 2 provides basic information on very basic image processing operations that may be considered as image histogram transformations. Next, Lesson 3 deals with basic issues related to digital image filtering. Issues related to digital images assessment are presented in lesson 4. The last lesson presenting basics is Lesson 5: Spectral properties of images.

Next, there is a group of lessons for image compression techniques. Both lossless techniques (i.e. predictive and entropy coding in Lesson 6) and lossy techniques (DCT in Lesson 7 and wavelet/subband coding in Lesson 8) are introduced.

After acquiring knowledge concerning static images, the user is able to start Lessons 9 and 10, where the basics of modern video compression standards are described. Last but not least – audio processing basics are presented in Lesson 11. Lesson 12 deals with efficient storage and transmission of digitized acoustic information, with special focus on MPEG standard techniques.

Each lessons starts with a page presenting the goals and prerequisites. Next, there are several pages of the introductory materials to give the definitions as well as to describe the methods, techniques and standards.

After the theoretical background, several interactive exercises are presented. These exercises start from a simple “select from the list and observe results” mode in first lessons; to the more flexible forms for more advanced topics. Using this philosophy, we are sure that the basic problems are presented in a “fool-proof” way.

In many interactive exercises, the user is asked to answer some questions or to solve some small problems, for example: “Find the most appropriate filter for ...” (Lesson 3: Filters for image processing) or “Observe how the practical results are related to the theory. What is the consequence of the object's size change?” (Lesson 5: Spectral properties of images). Some of these questions will be asked again on the test page, helping the user verifying newly acquired knowledge.

At the end of each lesson the summary and future references are given.

Each lesson is expected to need about 45 – 60 minutes to pass. The course has been tested by the students of Introduction to Multimedia stationary course at Poznań University of Technology. The experience is that they were able to pass the exercises during the assumed 45-60 minutes.

### 3.4 Technology

The assumption to the project was that the courses will not need any special software or hardware. The Multimedia Course is compliant to popular Windows operational system and the hardware requirements are minimum. The experiments proved that the course works even on old Celeron 300MHz processors.

The multimedia course use ActiveX controls [6] for still and moving images as well as for audio. It means that all processing is performed on the user terminal that does not need any special software. The course is accessible as a web page. The requirement is that the web browser supports ActiveX controls as, e.g., Microsoft Internet Explorer 5.0 does.

The controls have been developed by MTG in C++ language; partially basing on previous experiences with software prepared for stationary courses. The controls (there are different controls – for static images and for video) include all input data as well as procedures for generating some additional “starting points” (for example – low-pass filtered images). Now, the size of control for still images is 1.62 MB and the size of that for video is 3.97 MB. Adding additional images/video to control would increase its size.

The controls may be automatically downloaded and installed after the first visit on a page with any interactive exercise (both for static images as for video). After that, the controls are not downloaded again unless a new version is released. A special page explaining details of installation process - in case of any troubles - has been prepared.

The interface between user and the controls is built using forms and dynamic HTML extensions (namely Java-script) [7]. Such interface is intuitive and typical for web services.

The control is embedded in the web page by the use of HTML <object> tag as shown below:

```
<OBJECT id="control1" codeBase="MTG.ocx"
height="256" width="256"
Classid="CLSID:F4C817BA-3E0D-4108-A0B9-
6A31CC7A68E8">
</OBJECT>
```

Figure 1 – HTML code for ActiveX control

In Fig.1, MTG.ocx is the name of control file placed on the same location as web pages which use it; CLSID is the unique ID of this control class. The control1 is used as the unique ID of a given instance of control. Since usually there is more than one instance of control on each page (used for different tasks), this ID is useful for passing data for a given control.

Every control displays one static image of size 256 × 256 or CIF/QCIF video (i.e. 352 × 288 max.), which is optimal in case of two control outputs presentation on standard monitor resolution.

Figure 2 shows a Java-script example for a page with two controls. First, it displays an original image in the control1 area. Then the input value (given by user in some form with ID form1) is read and used as threshold for offset() function, realizing some simple image point operation. Finally, using special command format, internal buffer no.1 is filled with thresholded image data and displayed in the control2 area.

```
function SelectImage(i)
{
    control1.SetPic(i,0);
    control1.SetView(0);
    document.form1.val.value=thresh;
    control2.Command("buff[1] = offset
(buff[0]," + thresh + ")");
    control2.SetView(1);
}
```

Figure 2 – Java-script function example

More details about ActiveX in Multimedia Course may be found at [3].

For the audio we use different concept. All data are prepared as the set of independent, small audio files. The user is able to choose some parameters from a set of predefined values and then hear the produced sound. There is no need of previous installation.

### 3.5 Interactive exercises examples

Figure 3 shows an example of interactive exercise, concerning digital filtering. The filter mask size and coefficients values are set by user.

At the top the reader can find a short description of presented image processing problem. Below, on the left, icons of images used in the exercise are presented. The bigger images in the center and on the right are output areas of two controls.

The first control is used for presenting original image, the second – processed one. The user selects an image by clicking the image on the left. Next he/she defines filter size and realization and opens the filter coefficients matrix.

In the newly opened window, the user is able to set filter parameters, and then – after clicking the “Process!” button – the result is shown on the right. The filter coefficients may be changed after that, new result will be presented on the right again.

Figure 4 shows an example of audio exercise, namely AAC coding. The user clicks on the small picture on the left, which represents one of the five available test sound. Then he/she chooses the desired bitrate after AAC compression (or original sound), appropriate file is downloaded and played.

## 4. CONCLUSIONS

In this paper we have presented the Multimedia Course available at Poznań University of Technology. Some details about ActiveX technology used in the interactive experiments have been described. The course in its interactive form has been well tested by the students in several countries. The project proves that low-cost efficient distant learning tools may be prepared even for highly resource demanding lessons on image, video and audio processing and compression.

## REFERENCES

- [1] <http://www.invocom.et.put.poznan.pl/>
- [2] <http://www.multimedia.edu.pl/>
- [3] M. Bartkowiak, Z. Korus, R. Świerczyński, *Invocom Multimedia: Internet-based Vocational Training*: Proceedings of International Conference on Signals and Electronics Systems ICSES 2004, Poznań (2004), pp. 577-580
- [4] [http://www.multimedia.edu.pl/invocom/MultimediaEN/mm\\_rights.htm](http://www.multimedia.edu.pl/invocom/MultimediaEN/mm_rights.htm)
- [5] <http://www.cs.cmu.edu/~chuck/lennapg/>
- [6] S. Lalani, K. Jamsa, R. Chandak, *Activex Programmer's Library*, Course Technology, 1997
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Interactive exercise: Create your own filters

1. Set the filter matrix size (number of rows and columns in the mask).  
 2. Choose the filter implementation form (one 2-D filter or two 1-D filters).  
 3. Click the first button to open example matrix in new document.  
 4. Type in the filter coefficients in the new document (only integer values are scaling factor!).  
 5. Without closing the new window come back to this window and press "Process!".  
 6. Observe results.  
 7. If you want to change some coefficients, press "Show current coefficients".  
 8. If a filter with other dimensions and/or realization form is needed - repeat it!

Rows:  Columns:

one 2-D matrix  two 1-D vectors

Original image      Filtered image

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Figure 3 – An example of interactive exercise on static images processing

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Interactive exercise: Comparison of MPEG AAC coding at various bit rates

The purpose of this exercise is to demonstrate the efficiency of MPEG-4 Advanced Audio Coding technique. Selected examples are encoded to a range of bit rates using the fully implemented AAC coder (using TNS, prediction and PNS tools).

1. Select an audio excerpt on the left  
 2. Select the bit rate using the buttons below  
 3. Wait for the sound to play  
 4. Listen to the original programme and compare subjectively the decoded programme with the original. Can you identify and name the audible artifacts?  
 5. Repeat the experiment for other excerpts and bit rates. Observe, how the impairments increase as the bit rate decreases  
 6. What is the minimum bit rate for this coding technique that offers high quality audio? At what bit rate the quality decreases rapidly?

Selected sound: ?  
 Selected bit rate: ?

Original | 128 kb/s | 96 kb/s | 64 kb/s | 48 kb/s | 32 kb/s

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Figure 4 - An example of interactive exercise on audio processing