

Developing a System View Approach for the Multimedia Communication Systems Course

RODICA STOIAN, LUCIAN ANDREI PERIȘOARĂ, RADU FLORIAN PAVEL,
ADRIAN VICTOR RĂILEANU

Faculty of Electronics, Telecommunications and Information Technology, “Politehnica” University
of Bucharest, Iuliu Maniu Bvd., no. 1-3, Sector 6, Bucharest

ROMANIA

rodicastoian2004@yahoo.com, lperisoara@yahoo.com, radu@orfeu.pub.ro, adrian@orfeu.pub.ro,
www.orfeu.pub.ro

Abstract: - The Multimedia Communication Systems (MCS) course focuses on multimedia data representation and transmission over communications networks. This paper illustrates some pedagogical techniques used to maximize learning results and facilitate creating a mindset that can drive further innovation for this domain. Besides presenting multimedia standards and communication techniques, these methods focus on setting a system view approach, understanding parameters that influence or control the multimedia systems. They also allow determining the handful of concepts that govern the entire field of multimedia compression, formats and network communications based on the Information Theory and Coding paradigms.

Key-Words: System Approach, Control and Performance Parameters, Active Learning, Multimedia.

1 An Overview of the Multimedia Communication Systems Course

The Multimedia Communication Systems (MCS) course is a graduate level course held since 2001 by the first author to the fourth-year students of the Faculty of Electronics, Telecommunications and Information Technology, “Politehnica” University of Bucharest.

The objective of the course is to provide students with theoretical and practical knowledge (concepts, principles, algorithms and standards) concerning the representation and transmission of multimedia signals over communications networks [1]-[5], covering:

- techniques and algorithms for lossy and lossless compression of multimedia data (e.g. sampling, quantization, DCT, motion estimation and compensation, etc.);
- image, video and audio compression standards (e.g. JPEG, MPEG, MP3, etc.);
- multimedia data transmission over ATM, LAN, mobile networks;
- relations and compatibility between system standards and compression standards;
- error control techniques in multimedia data transmission over networks.

The course is structured to fit a 14 weeks semester (28 hours of lectures, 14 hours of labs). Students (2 or 3 classes of 25 students) also receive a homework project on one of the course topics. The course assumes that students have previously gained

knowledge of mathematics, information theory, digital signal processing, digital communications and networks.

The emphasis is on creating specific connections and illustrating the main concepts that govern the multimedia systems world from a system based approach, the educational process being interactive [7]. Other educational goals of this course are the development of various skills needed in the engineering profession like communication (writing, oral and presentation), argumentation, debating and teamwork. The following sections of this paper describe these pedagogical techniques.

2 System View Approach – Creating the Right Mindset

One of the main challenges in teaching a domain that is vast (and still expanding) is focusing on the “big picture” view and not getting lost in details. The course aims to create the system view mindset for students, allowing them to see beyond the standards, and understand relations within the system or within component subsystems, main parameters that control the system and how they are derived from the system purpose.

In the end students should be able to design a system that meets the desired needs given the control parameters, to extract relevant system parameters from existing systems and to evaluate the system performance parameters.

The fulfillment of the MCS course objectives relies on concepts and formalization of the Information Theory. Transcending this theory, the main idea that emerges is that all laws, techniques and principles in every day life, physics, information theory, multimedia techniques etc. are governed just *by a handful of concepts*. These fundamental concepts have various representations and interpretations, but in the end they can model most interactions in or inter systems (multimedia systems being an example). Examples of such *fundamental concepts* are: energy (with its variant: power), entropy, time, etc.

The MCS course allows such fundamental concepts to emerge from all subsystems and techniques descriptions, illustrating how they are applied in every particular case. For example, compression is based on representing the energy of a signal (e.g. image) in a N -dimensional space chosen conveniently such that N is as small as possible, DCT being an example of such a transformation.

Besides the fundamental concepts, each system and their component subsystems can be described by a set of specific parameters (that are usually derived from the fundamental concepts, but for which the deriving formula is specific to the system or subsystem level). Going through the various standards and systems, the students are taught how to identify these parameters and what is their influence on the current system, the pedagogical techniques used varying from lectures to educational software applications.

The continuous increase in information makes it necessary for engineering students to be able to acquire new knowledge rapidly and process it in situations where changes are normal. Students must learn to study efficiently and exercise their skills to learn how to learn.

3 Training That Makes Sense

One of the main caveats of theoretical lecturing is losing sight of the purpose of the lecture between formulae and details. This is why each system, algorithm or concept, presented in a lecture of the MCS course, receives a summary characterization that includes:

- what it is used for;
- how it is used or controlled;
- relations within the system or subsystems.

Only after such attributes are clarified, the lectures proceed to elaborate on actual implementation details and standard specifications.

3.1 Illustrating Concepts

A picture is worth a thousand words they say, and teaching maybe one of the places where this is most obvious. An essential part in efficient learning is finding the image that best represents the information you want to transmit on a concept or algorithm.

One of the focus areas when developing the material for this course was identifying and defining the illustrations that best capture the essence of the associated concepts. This deep-level approach to the learning process is focused on understanding, on what is significant (concepts) and what is not, relating previous knowledge to new knowledge [8].

With this in mind, the MSC course illustrations focus on systems and algorithms outlining the parameters that control or just influence them.

Another area of interest was related to hands on applications. As it will be detailed in a later section, hands on applications were created with the illustration of concepts in mind.

3.2 Identifying the Relevant Parameters

A simplistic view to a system is to consider it as a black box with inputs and outputs and having a specific transfer function. Going further into details, a set of characteristic parameters can be identified. These parameters describe the system, in the sense that the system transfer function is build as a relation between them (not necessarily linear).

Several types of parameters (and associated system descriptions) are illustrated for a given system during the course or labs:

- *work parameters* or *control parameters* influence the way the system works (how it responds to inputs);
- *metrics* are the relevant measures for the system, allowing quantifying the inputs and outputs of the system;
- *performance parameters* describe the system performance (how to tell when the system performs better or worse, usually using the metrics associated to the system).

These classes of parameters describe a system quantitatively or qualitatively and allow students to have several views on the same system.

For example, in Fig. 1, we have a snapshot from a student project, which illustrates a transmission from the left computer (information source) to the right computer (destination). With the control buttons from the left and right sides, we can modify the sizes of the source and destination buffers (network parameters) while the transmission is in

progress, so the outcome of the user selection is shown in real time as well as the selected values of the control parameters.

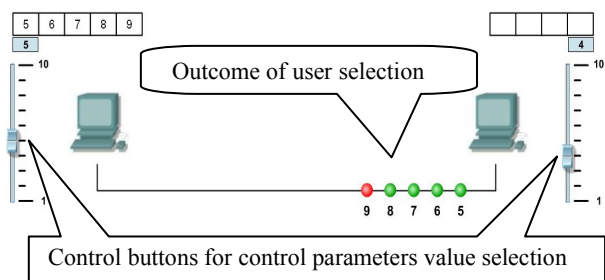


Fig. 1. Student project illustrating interactively the influence of network parameters on transmission.

3.3 Creating the Concept Networks

By characterizing a system mainly by its parameters and not necessarily focusing on details about how it is done, the students can identify easier systems with similar behaviors (either controlled the same way, or governed by the same performance criteria). This can transcend the scope of the MCS course allowing students to make connections with systems from other fields that can fall under the same classification. In the end, this allows achieving the underlying goal of illustrating how most system parameters and behaviors can be mapped back to a reduced set of fundamental concepts like energy, entropy etc.

4 Learning by Doing

Learning efficiency increases when theory is accompanied by practical applications of algorithms and concepts. Arguably, the “learning by doing” is the most effective training technique. Also, the learning process must be continuously and uniformly distributed and the students must study regularly during the semester.

There are three “hands-on” methods used in the learning process of MCS discipline:

- course presentations (15% of final grade),
- labs (15% of final grade)
- semester projects (40% of final grade).

The rest of 30% of the final grade is acquired from the written final exam.

4.1 Course Presentations

The course is designed to cover 14 lectures of 2 hours per lecture with the following topics:

1. multimedia communications: an introduction;
2. theoretical bases of data compression based on Information Theory: lossless coding techniques (Shannon-Fano, Huffman, arithmetic); lossy coding techniques (rate distortion theory; scalar and vector quantization; predictive coding; orthogonal transformations; motion estimation and compensation);
3. compression standards for images (JPEG, JPEG 2000), video (H.261, H.263, MPEG-1, MPEG-2, MPEG-4, MPEG-7) and audio (MPEG-1 Layer 1, Layer 2, Layer 3 – MP3);
4. multimedia communications across networks: communication networks; system standards for multimedia communications over PSTN (H.324), ISDN (H.320), ATM (H.310, H.321) and LAN (H.322, H.323); relations and compatibilities between system standards and compression standards;
5. control of multimedia data transmission: techniques for rate control; techniques for error control.

In the first lecture, the course goals are discussed, the organizing rules and semester schedule are set and the assessment criteria are presented, all of these being agreed by the students and teachers.

The course notes are given to the students in pdf format two weeks before the presentation session [5]. As a preparation for the topics of the day, the students must read the course notes so they would be familiarized with the day’s topics. The students are grouped into teams of four or five. Each team is given different topics for which they have to do presentations. The presentations are done in PowerPoint or Flash and must illustrate in the best way possible the concepts, algorithms and techniques of the assigned topics, which also assures the development of students’ communication skills.

Each lecture contains three parts. In the first part of 70 minutes, the lecturer delivers his presentation using different illustrative examples for a better understanding of concepts, algorithms and techniques used. In the second part of 20 minutes, the students make their presentations, which contain new illustrations and animations related to the lecture topics, taking an active role in their learning process [7]-[11]. Once the students have done their presentations, we can assume that the presenter should understand and know the topic well enough to be able to teach the other students. At the end of the lectures (the last 10 minutes), the students that made the presentations and participate to the discussions are assessed for their activity and they receive constructive feedback [11]. In some cases,

the students' presentations are compared with those made on the same subjects in the previous years, the strong points being observed and scored.

During the presentations, the problems are discussed and analyzed, the activity being focused on conceptual understanding and comprehension, which requires that the students must have to articulate their ideas, to test those ideas through conversation and to consider connections between them.

The course format includes students taking part actively as presenters, as opponents asking questions, as chairmen for discussions and giving feedback to their peers. This way, we suppose that they had understood what they had read and heard [9]. This active involvement of the students in the learning process is actually an active learning method, as it is described in detail in [16].

Some topics not covered by the laboratory classes are covered in detailed lectures by the professor.

In the final lecture, the students are given a survey questionnaire to provide feedback to the teachers on the level of satisfaction related to the MCS course [7], which contains questions like:

- What did you like at the course / lab / project and what did you not? How can it be improved?
- What would you still like to know?
- Which issues or concepts were insufficiently or unclearly presented?
- How much time have you spent to learn for this course?
- How do you consider that this course will help you in the future (for example, a job)?
- What issues would you like to learn deeper in the future?
- Evaluate the activity of the teachers, using a scale from 1 (worst) to 5 (best).

4.2 Labs

In a traditional way of handling the laboratory work (the passive learning), the students listen passively to the teacher, read the theoretical introduction from the laboratory guide and then run the experiments without knowing why each experiment is run and what is the relationship between theory and practice. The students' reports are low in quality and usually are copied from each other. There are also students who gain marks without doing experiments. The ability to solve a problem is limited to lectures content and laboratory guide without acquiring other references [16].

For the MCS discipline, the previous

disadvantages are eliminated through the strategy adopted, the problem based learning, which is an active learning method.

The students are dealing with real engineering problems (case studies) chosen to illustrate principles of compression techniques, so they can acquire basic practical knowledge about different compression algorithms. Special attention is given to control parameters and performance parameters of a system.

For the MCS discipline, the curriculum contains 7 labs of 2 hours, which cover:

1. lossless entropy coding techniques: Huffman coding, arithmetic coding;
2. lossy coding techniques: DPCM, DCT, wavelets;
3. JPEG compression standard;
4. coding techniques for video: motion estimation and compensation;
5. MPEG-1 Video compression standard;
6. MPEG-1 Audio Layer 3 (MP3) compression standard;
7. JPEG 2000 compression standard.

The laboratory work provides practical experience necessary to form and develop the following students' skills:

- identify, formulate and solve particular engineering problems;
- design, implement and conduct experiments (e.g. the dependence between the control parameters and performance parameters);
- analyze and interpret obtained data in a qualitative and quantitative manner;
- develop models using the obtained data,

which are general skills for an engineering course not only for the MCS course.

The laboratory platforms are based on computer assisted learning using classical educational software applications (VcDemo) [6], specialized software applications (VirtualDub, CoolEdit) or educational software applications (SCMEduPack) developed in semester projects or diploma projects during the years 2000 - 2006. Using these applications, the following operation modes and study possibilities are available:

- selection of compression techniques for individual study (DPCM, DCT);
- selection of the control parameters of subsystems which implement different compression techniques and/or of system represented by the JPEG or MPEG codec;
- selection of power noise levels of the channel between the source and the user;

- evaluation of subjective (through visualization) or objective (through measuring and computing) performance parameters for specific combinations of control parameters of subsystems or the entire JPEG or MPEG system;
- comparative analysis and interpretation of obtained results.

All the items presented below were developed based on the system view approach described in Section 2.

As an example, see [4], for the MPEG-1 Video codec the following items are used:

- *control parameters*: bitrate (quantization step), frames per second (fps), group of pictures (GOP), search strategy for motion estimation;
- *objective performance parameters*: compression ratio, peak signal to noise ration (PSNR) of decoded image; variance of difference frame between the original frame and the predicted frame;
- *subjective performance parameters*: decoded video quality;
- *study possibilities*: the dependence of compression ratio and image quality on bitrate; the dependence of compression ratio and image quality on GOP; the dependence of image quality and variance on search strategy; the dependence of image quality and variance on noise level.

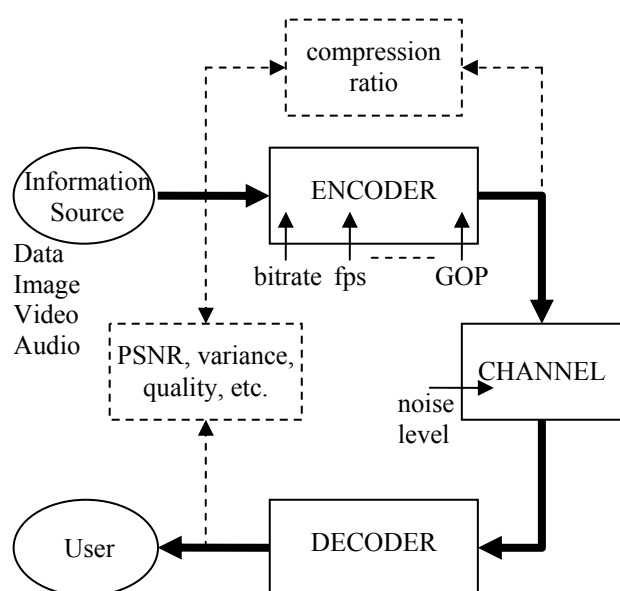


Fig. 2. A system view approach for a multimedia communication system.

Fig. 2 shows the entire multimedia communication system for which the performance parameters are evaluated as a function of control parameters and noise level.

In the end of each lab (the last 10 minutes), the evaluation of students is made based on quiz-tests given on PCs. The questions are related to basic concepts and require interpreting and analyzing information, creating connections between different things, recognizing problems and finding solutions to problems. The testing application is based on a client-server architecture, is compatible with Internet Explorer and allows the students, after the testing, to see the obtained scores and the wrong answers.

4.3 Semester Projects

The semester projects cover various subjects of the Multimedia System course (e.g. coding algorithms and standards, network protocols, etc).

The semester projects include the development of hands-on software applications, which forms and develops the following students' skills and capacities:

- identify, formulate and solve particular engineering problems;
- search for information from various sources (Internet, library);
- process, understand and classify the information;
- design, implement and test the compression algorithms;
- write a report about the work done;
- make a presentation and present it.

The aim of this learning method is to encourage students to learn how to apply skills acquired in the classroom and to contemplate innovative ways of solving problems. One of the benefits of this learning method is the students' intrinsic rewards that come with solving real-life problems. It is believed that such projects lay the foundation for lifelong learning [13], [17].

On each project, specific requirements are enforced from the beginning:

- system parameters (all three classes) must be clearly identified and clarified;
- the project deliverable is an executable program (programming language is not enforced, only the run-time for the executable must be available on the computers in the labs);
- the focus of the project should be on the best graphical representation of the system

parameters identified (interactive programs are a plus; minimum required are animations showing the system behavior when varying the illustrated parameters);

- the final report must contain the following issues: problem formulation; learning objectives; methodology adopted to solve the problem; work payload between team members; solutions to the problem.

The students are grouped in teams of 3-4 students, coordinated by a team-leader, who organizes the work distribution (tasks) between team members and who is an interface with the teacher. During the semester, the students are supervised by the teacher and every two weeks feedback meetings are organized with each team to control the development of the projects.

The first example of such a project is "Quantization in JPEG and JPEG 2000". The application is done in Visual C and performs all the coding and decoding steps (DCT, zig-zag scanning, Huffman encoding, etc.) for both JPEG and JPEG 2000 standards, in a transparent manner to the user, the only control parameter which can be modified being the quantization step. After the original bitmap image is loaded, from the "Quantization" ("Cuantizare") menu (Fig. 3) we can choose between the two systems JPEG and JPEG 2000. For the "JPEG" system, the quantization step ("Pasul de cuantizare") can be set to encode the original image, see Fig. 4.



Fig. 3. The "Quantization in JPEG and JPEG 2000" application menu.

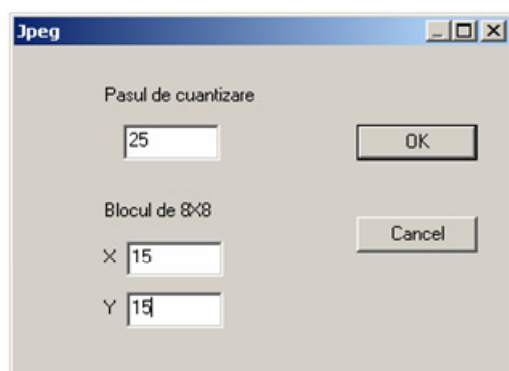


Fig. 4. A control parameter (quantization step) identified and interactively changeable.

Also, we can set the coordinates (X,Y) of one macroblock for which the DCT coefficients before and after the quantization can be further visualized, see Fig. 5.

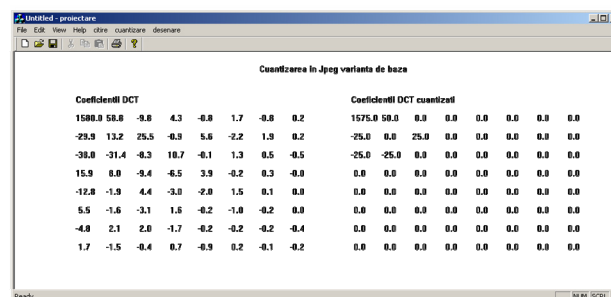


Fig. 5. The visualization of the DCT coefficients of a macroblock before and after the quantization.

In the last screenshot, Fig. 6, if we choose the option "Drawing" ("Desenare"), the application shows the original image, the reconstructed (decoded) image and the difference image for performance evaluation (subjective) of the entire image compression system.

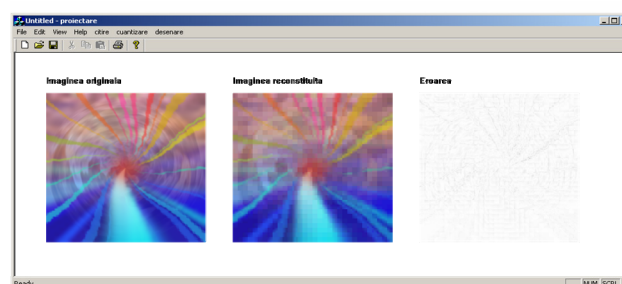


Fig. 6. The visualization of the original image, the reconstructed image and the difference image.

From Fig. 3, if we choose the "JPEG 2000" system, we can set another control parameter for the encoding process, the number of neglected bits for the dead zone, beside the quantization step.

The second example is the "MP3 Presentation" project (Fig. 7), a Flash application showing the MP3 standard from a system view approach. The entire application is structured like a tree, starting from a general view (the root) of the encoder or decoder (Fig. 8) and at each step entering in higher details at a lower level (the leaves).

At the end of the presentation, the user can choose from the menu (Fig. 7) to play an MP3 audio file compressed at different bitrates (160, 128, 64, 32 or 16 kbps). This allows to evaluate qualitatively the dependence on bitrate (control parameter) of the quality of the decoded audio file (performance parameter). Also, the MP3 compressed file size is given.

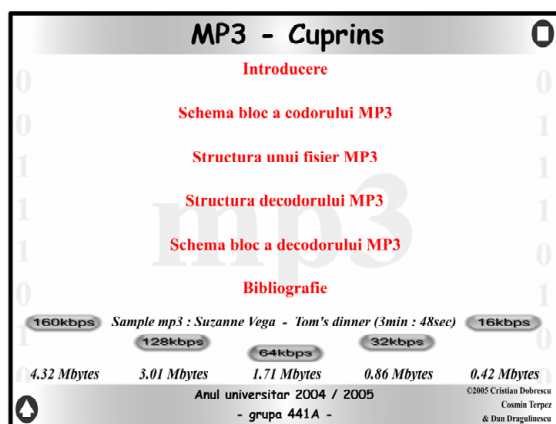


Fig. 7. The “MP3 Presentation” menu.

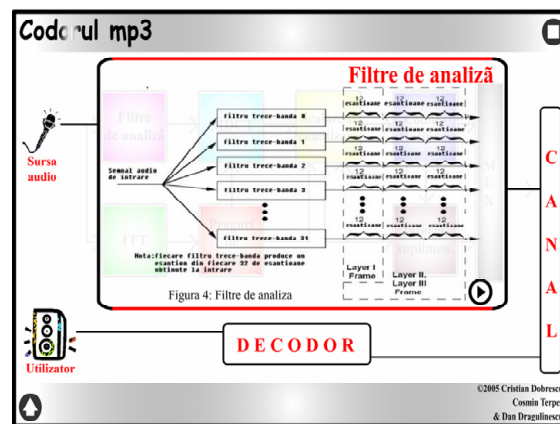


Fig. 10. The 32 sub-band filters of the filter bank.

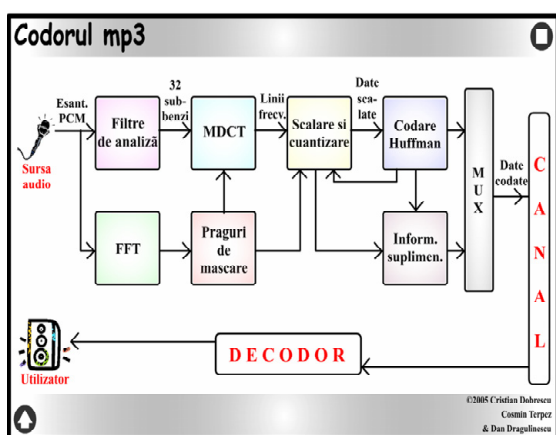


Fig. 8. The MP3 encoder diagram illustrated in the entire audio communication system.

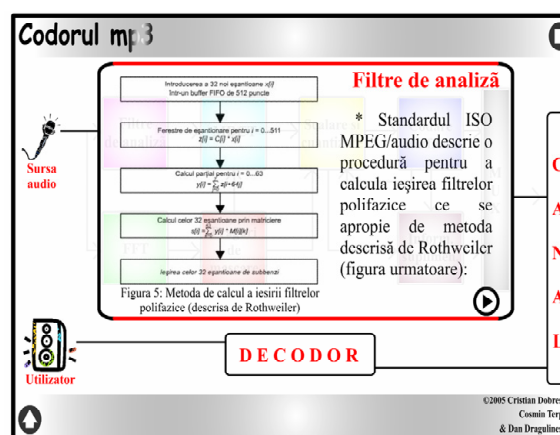


Fig. 11. The computing algorithm for the outputs of bank filter.

If the user chooses with the mouse the “Filter bank” (“Filtre de analiză”) he can see its main role (Fig. 9).

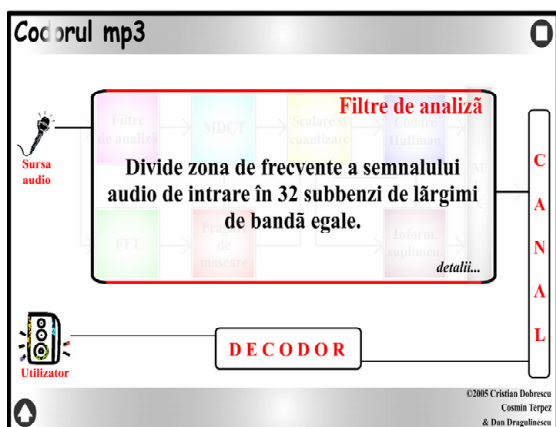


Fig. 9. The main role of the filter bank.

If he chooses the option “Details” (“Detalii”) then some details are shown at a deeper level like the 32 sub-band filters (Fig. 10) and the computing algorithm for the outputs from the filters (Fig. 11).

The third example is the “Image compression with progressive and sequential DCT and PCM” project. The application is done in Visual C and allows the user to change the operation mode (a work parameter as it is defined in section 3.2) of the image encoder, from the sequential mode (the DCT coefficients are transmitted sequentially, first the DC coefficient, then the higher AC coefficients) to three different progressive operation modes, see Fig. 12.

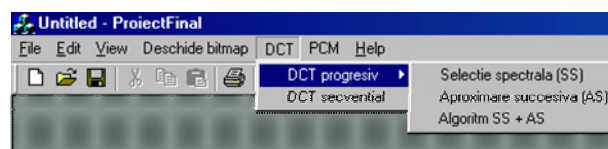


Fig. 12. The “Image compression with progressive and sequential DCT and PCM” application menu.

After the original bitmap image is loaded, if the user selects the option “Spectral selection” (“Selectie spectrala (SS)”) from the DCT menu, the application shows the original image, the reconstructed image, the difference image and the difference image multiplied with 8, see Fig. 13.

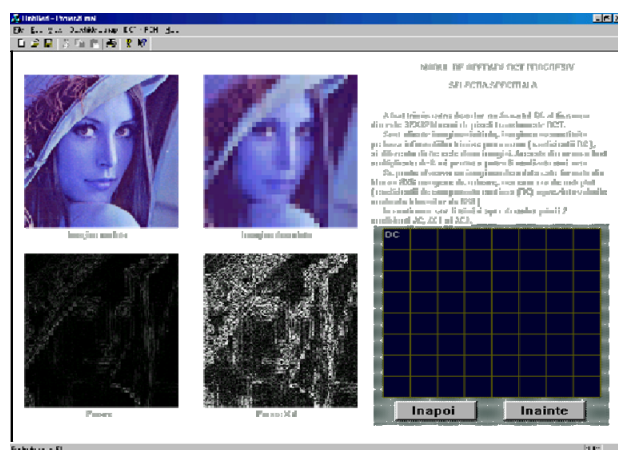


Fig. 13. Image compression with progressive DCT and spectral selection of the DCT coefficients.

In the lower right corner, we can choose with the mouse the DCT spectral coefficients that are transmitted, see Fig. 14. After each selection of DCT coefficients the application shows the original image, the decoded image and the difference images. This way, the user can determine the number of transmitted DCT coefficients (control parameter), for a good quality (performance parameter) of the decoded image.

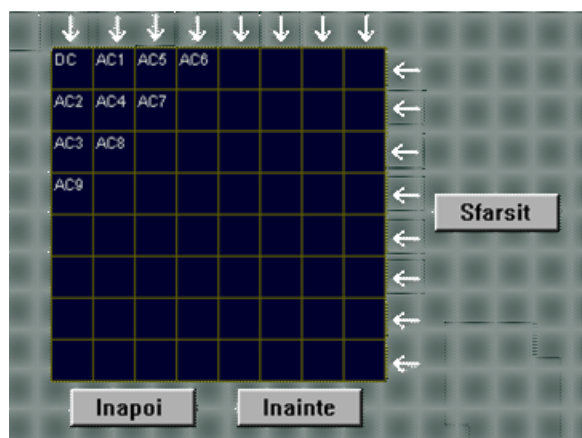


Fig. 14. Selection of the DCT coefficients.

If we choose the option “Successive approximation” (“Aproximare succesiva (AS)”) from the DCT menu, then in the lower right corner of the application the selection of the number of bits used for binary representation of the DCT coefficients is shown. Each coefficient is encoded using 11 bits, 10 bits for amplitude and 1 bit for sign. After selection, the application shows the original image, the decoded image and the difference images.

The third progressive operation mode is a combination of the previous two modes.



Fig. 15. Selection of the number of bits to represent the DCT coefficients.

The students' evaluation is done according to the individual contributions to the project and tasks performed.

The software development assures the complete knowledge of fundamental concepts and practical implementation techniques according with the compression standards and system standards, which is just the initial benefit of these semester projects. The main benefit is described in the next section.

4.4 Learning Results

Using the previous presented teaching methods for course, labs and projects, the students are able to improve their communication and problem-solving skills. Most importantly, according to the final grades obtained during the years 2003-2008, the students achieve better learning results (average grades) from one year to another. Table 1 and Fig. 16 compare students' performances across grades and years.

We must mention that during these years the same teachers taught all the students.

A challenging problem for the teachers was to guide the students to fulfill their tasks. Sometimes the students had to be redirected from the learning path they were following, to facilitate them to finding solutions to some problems while maximizing the number of learning objectives achieved. This guidance was important, because the students tend to try to find shortcuts while they solve their tasks. Other times, when the students were found to be on a path that would not lead to a viable solution, the teacher provides them a clue to get them back on the path.

The students' feedback questionnaires show us that they spend more time to learn from one year to another to gain a better level of knowledge, which tell us that they give more significance to this course, having a great level of motivation to learn.

Table 1. Students' performances during the years.

	2004	2005	2006	2007	2008
Total number of students	49	39	46	59	54
Number of students scoring < 60 %	30 61.22%	10 25.64%	7 15.22%	11 18.64%	14 25.93%
Number of students scoring 60 – 70 %	7 14.29%	18 46.15%	16 34.78%	16 27.12%	15 27.78%
Number of students scoring 70 – 80 %	6 12.24%	6 15.38%	12 26.09%	17 28.81%	13 24.07%
Number of students scoring 80 – 90 %	3 6.12%	4 10.26%	7 15.22%	14 23.73%	5 9.26%
Number of students scoring > 90 %	3 6.12%	1 2.56%	4 8.70%	1 1.69%	7 12.96%
Average score, %	64.1	67.7	71.7	72.0	71.5
Standard deviation, %	14.3	11.0	13.6	12.2	15.3

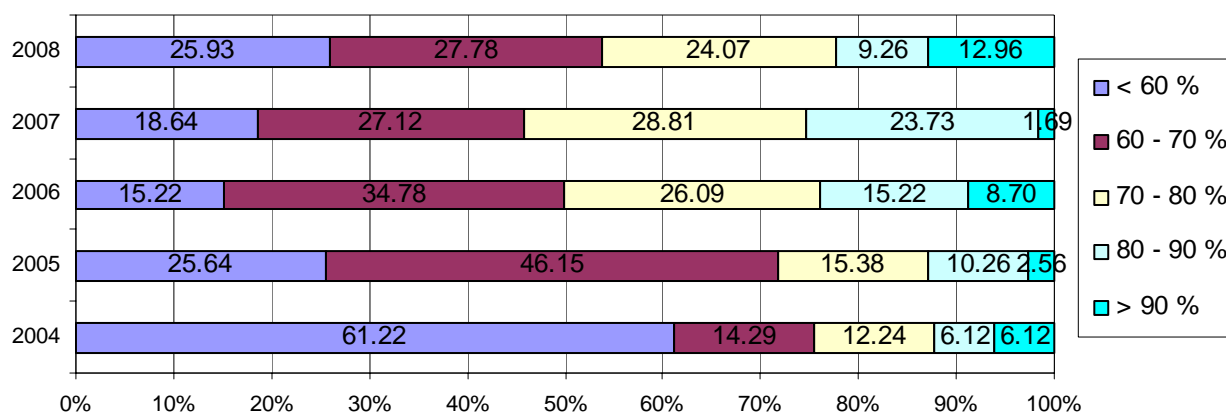


Fig. 16. Students' performances during the years.

5 Applications Reuse

One of the requirements of the course presentations and semester projects is to illustrate the best as possible the basic concepts of the Multimedia Communication Systems course. This requirement makes them perfect candidates for reuse in the training material for next classes of students. The best illustrations from semester projects are included in SCMEduImage database and are used for the next course lectures, while the most intuitive applications can be reused in the lab sessions.

In a sense, this continuous improvement of the training material of the Multimedia Communication Systems course is aligned to the same basic ideas taught in the course: identify system parameters and improve them (concepts and algorithms illustrations being an example of performance parameter for the course notes). The course itself (the way it is build and functions) is an example of systemic approach, with a feedback loop between lectures, labs and semester projects.

6 Expanding the Vision

Several teaching techniques were illustrated in this paper (creating the system view mindset, learning by doing, using meaningful illustrations for algorithms and concepts, classifying systems based on relevant parameters, identifying the derivation of system parameters from the fundamental concepts from the Information Theory). These techniques can however have a generic deployment (beyond multimedia or systems related courses). They can help create the right mindset for students and allow them to master easier new standards and algorithms. Aside from improving learning efficiency, such techniques allow creating relevant networks between concepts and methodologies with cross-field relevance. And this is the most fertile ground for driving innovation.

References:

- [1] Iain E.G. Richardson, *H.264 and MPEG-4 Video Compression: Video Coding for Next-generation Multimedia*, John Wiley & Sons, 2003.
- [2] K. R. Rao, Z. S. Bojkovic, D. A. Milovanonic, *Multimedia Communications Systems. Techniques, Standards & Networks*, Prentice Hall, 2002.
- [3] Rodica Stoian, *Data compression. Prediction algorithms*, Scientific and Enciclopedic Publishing House, Bucharest, Romania, 1988.
- [4] Rodica Stoian, L.A. Perișoară, R.F. Pavel, A. Răileanu, *Multimedia Communication Systems: Compression Techniques and Standards. Laboratory guide - I*, Printech Publishing House, Bucharest, Romania, 2005.
- [5] Rodica Stoian, *Multimedia Communication Systems*, course notes, 2003-2008.
- [6] <http://www-ict.its.tudelft.nl>, ICT Group, Delft University of Tehnology.
- [7] S. Kolari, "An active role for students in the learning process in engineering education: Interactive teaching methods in promoting understanding," Ph.D. dissertation, Dept. Material Engineering, Tampere Univ. Technology, Tampere, Finland, 2003.
- [8] C. Savander-Ranne, "An active role for students in the learning process in engineering education: A means to develop conceptual understanding", Ph.D. dissertation, Dept. Material Engineering, Tampere Univ. Technology, Tampere, Finland, 2003.
- [9] C. Savander-Ranne and S. Kolari, "Students' seminar presentations promote active learning in engineering subjects," in *Proc. 5th Global Congress on Engineering Education*, New York, 2006, pp. 81-84.
- [10] L. E. Bernold, W. L. Bingham, P. H. McDonald, and T. M. Attia, "Impact of holistic and learning-oriented teaching of academic success," *J. Eng. Educ.*, vol. 89, pp. 191-199, Apr. 2000.
- [11] L. A. v. Dijk, G. C. v. d. Berg, and H. v. Keulen, "Interactive lectures in engineering education," *Eur. J. Eng. Educ.*, vol. 26, pp. 15-28, Mar. 2001.
- [12] B. Ando, A. Beninato, S. La malfa and N. Pitrone, "Didactic Tool Assisting Visually Impaired Students During Laboratory Sessions, in *Proc. 7th WSEAS Int. Conf. on Education and Educational Technology (EDU'08)*, Venice, Italy, pp. 190-193, Nov. 21-23, 2008.
- [13] C.Y. Teo, D. J. Ho, "A systematic approach to the implementation of final year project in an electrical engineering undergraduate course", *IEEE Trans. Educ.*, vol. 41, no. 1, pp. 25-30, Feb. 1998.
- [14] K. Aleksic-Maslac, M. Magzan, I. Maslac, "The Development of the E-learning Course Sociology", in *Proc. 7th WSEAS Int. Conf. on Education and Educational Technology (EDU'08)*, Venice, Italy, pp. 135-140, Nov. 21-23, 2008.
- [15] Rodica Stoian, L. A. Perișoară, R. F. Pavel, A. V. Răileanu, "Learning techniques for teaching Multimedia Communication Systems", in *Proc. 6th WSEAS Int. Conf. on Engineering Education (Education '09)*, Rodos Island, Greece, July 22-24, 2009.
- [16] R. Hamid, K. M. Yusof, S. A. Osman, R. A. O. K. Rahmat, "Improvement of Delivery Methods in Teaching Materials Technology", *WSEAS Trans. on Advances in Engineering Education*, vol. 6, issue 3, pp. 77-86, Mar. 2009.
- [17] A. J. Araújo, J. C. Alves, "A Project Based Methodology to Teach a Course on Advanced Digital Systems Design", *WSEAS Trans. on Advances in Engineering Education*, vol. 5, issue 6, pp. 437-446, June 2008.