Learning Techniques For Teaching Multimedia Communication Systems

RODICA STOIAN*, LUCIAN ANDREI PERIŞOARĂ*, 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
** Freescale Semiconductors Romania, T. Vladimirescu Bvd, no. 45, Tati Center, Sector 5, Bucharest ROMANIA

rodicastoian2004@yahoo.com, lperisoara@yahoo.com, electroradu@yahoo.com, adrianrai@yahoo.com, www.orfeu.pub.ro

Abstract: - The Multimedia Communication Systems 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, Interactive Learning, Control and Performance Parameters, Multimedia.

1 An Overview of the Multimedia Communication Systems Course

The Multimedia Communication Systems 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 the theoretical and applicative knowledge (concepts, principles, algorithms and standards) concerning the representation and transmission of multimedia signals over communications networks, covering [1]-[5]:

- techniques and algorithms for lossy and lossless compression of multimedia data (e.g. sampling, quantization, Discrete Cosinus Transformation - DCT, motion estimation and compensation, etc.);
- image, video and audio compression standards (e.g. JPEG, MPEG, mp3);
- 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 interactively [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 to get 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 Multimedia Communication Systems course objectives rely 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 Multimedia Communication Systems course allows such fundamental concepts to emerge from all subsystems and techniques descriptions, illustrating how they are applied in every particular case (e.g. 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 thought 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 that engineering students be able to acquire new knowledge rapidly and process it in situations where changes are normally, so 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 loosing sight of the purpose of the lecture between formulae and details. This is why each system, algorithm or concept present in a lecture of the Multimedia Communication Systems 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 lecture proceeds to elaborate on actual implementation details and standard specifics.

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 /algorithm.

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

Our approach was to rely again on the system view approach, most of the illustrations on systems and algorithms outlining the parameters that control or just influence them.

Another area of focus was related to hands on applications. As it will be detailed in a later section, hands on applications were created with the illustration concept 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), for example see Fig. 1.

There are several types of parameters (and associated system descriptions) that 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/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.
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 Multimedia Communication Systems 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
As it is known, learning efficiency increases when theory is accompanied by practical application of algorithms and concepts. Arguably, the “learning by doing” is the most effective training technique. There are three “hands-on” methods used in the learning process of Multimedia Communication Systems: course presentations (15 % of final grade), labs (15 % of final grade) and semester projects (30 % of final grade). One pedagogical aim of this course was that the students must study regularly during the semester.

4.1 Course Presentations
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 lecturers. The course notes are available to the students in pdf format prior to the lectures with two weeks [5].

As a preparation for the topic of the day, the students must read the course notes so they would be familiarized with the day’s topic and they have to do presentations for some of discussed topics. The presentations are realized in Powerpoint or Flash and must illustrate in the best way possible the concepts, algorithms and techniques of the Multimedia Communication Systems course which assure the development of students’ communication skills.

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. 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 students that made the presentations and participate to the discussions were assessed for their activity and 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.

The course format also includes students taking part actively as presenters, as opponents asking questions, as chairmen for discussions and giving feedback to their peers. In this way, we suppose that they had understood what they had read and heard [9].

In the final lecture, the students give a feedback questionnaire which contains questions regarding the course organizations, how could it be improved, what the students still like to know, what is remain unclear to them, the lecturer and teaching assistant evaluation and other positive and negative issues regarding the Multimedia Communication Systems course [7].

4.2 Laboratory Overview
The labs are based on case studies chosen to illustrate principle of compression techniques, the students acquiring basic practical knowledge about different compression algorithms. Special attention is given to control parameters and performance parameters of a system. Also, the lab work provides
practical experience necessary to form and develop the students’ skills to design, implement and conduct experiments (e.g. the dependence between the control parameters and performance parameters) and to analyze and interpret obtained data in a qualitative and quantitative manner.

The laboratory platforms are based on 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 (DCT, DPCM);
- 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 computing) performance parameters for specific combinations of control parameters of subsystems or the entire JPEG or MPEG system;
- comparative analysis of obtained results.

All the items presented below were developed based on system view approach described in detail in Section 2. As an example, for the MPEG-1 video codec are used [4]:

- **control parameters**: bitrate (quantization steps), frames per second (fps), group of pictures (GOP), search strategy for motion estimation;
- **objective performance parameters**: compression ratio, peak signal to noise ratio (PSNR) of decoded image; variance of difference frame between the initial frame and the predicted frame;
- **subjective performance parameters**: decoded image 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 students’ evaluation is based on quiz tests given on the PCs in the end of each lab. The testing application is based on client-server architecture, is compatible with Internet Explorer and allows to the students the visualization of obtained scores and wrong answers.

4.2 Semester Projects

The semester projects includes the development of hands-on software applications, which form and develop the following students skills and capacities:

- to identify, formulate and solve particular engineering problems;
- to search for and process information;
- to design, implement and test the compression algorithms;
- to write a report, to prepare the presentation slides and give the oral presentation.

The students are organized in teams of 3-4 students, coordinated by a team-leader, which is an interface with the lecturer.

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

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).

During the semester, the students are supervised by the lecturer and once at two weeks are organized feedback meetings with each team to control the development of the projects.

An example of the outcome of such a project (interactive grayscale image compression with DCT, quantization and Huffman encoding) is given in the application screenshots shown in Fig. 2-4 below:
5 Applications Reuse

One of the requirements of the course presentations and semester projects is to illustrate the best 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 SCMEduImageDatabase 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:


