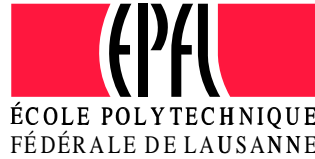

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Java for Teaching and Research

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Abstract

This short report summarizes the contribution of the project: *Java for teaching and research*. A website has been created to allow interested user to download the material produces during the project. The site is reachable at

<http://lca.vvwww.epfl.ch/balmelli/java>.

Also, the site contains a series of web-based presentation for international conferences and workshop. A CD-ROM containing the full project and the website is available on demand at the laboratory. The report gives an introduction to the project and goal. We explain our motivation and give our approach to the problem. We main contribution in teaching, as well as in research are then presented.

1 Introduction

Most lectures today takes place with teacher and students located in the same room. The teacher writes on a blackboard or uses slides while lecturing the s-tudents. In recent years new trends have appeared under the term "Computer Aided Learning" (CAL), and EPFL features a lab (LEAO) which specializes in this research topic. Generally speaking, the World-Wide-Web is a most efficient medium for the distribution of didactic material, and Web browsers offer a wealth of video and audio capabilities which can be very effectively employed to this aim. A Web browser can become an electronic blackboard, onto which students can view course notes while listening to the teacher's comments. Students can "navigate" through the course by redoing some portions not well understood, as in normal CAL. The most obvious advantages of relying on a web browser are: No special programs to setup, since students uses the same WWW browser they already use for other purposes Connections capabilities from virtually anywhere

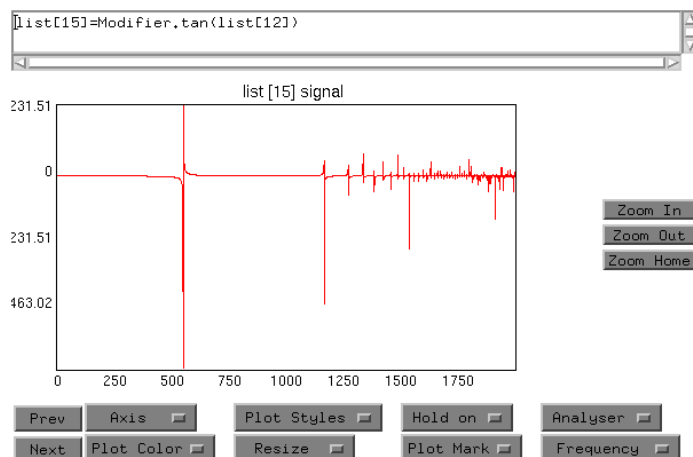


Figure 1: Creation of a digital signal using the LCAV signal processing library.

Courses are always up-to-date as they are fetched from the network. The WWW already is a most valuable tool to complement standard teaching. On-line papers and course outlines complete with HTML slides are currently available at most university Web servers. Although number of successes have been achieved, and some professors do use Web-based CAL for some portions of their courses, the great majority of them still relies on the good old method of the real classroom. We think that there are several reason for this: the methods and software needed to use CAL are not always user-friendly and require a considerable efforts on the part of the teacher in order to yield good results; the student-teacher interaction these methods allow is usually less than in a normal laboratory setting, and, fur-

thermore, Internet traffic can at times pose a serious delay problem when it comes to repeatedly downloading extensive amounts of data.

2 Using Java in research and teaching

The Java programming language offers a number of advantageous improvement to this scenario. Java-based virtual labs provide a homogeneous framework for the development of class demos, they rely on the computing resources of the student's workstation, they provide real and immediate interaction with the user, and they do not require slow and frequent connections to a server. In order to appreciate the further advantages of a Java-based approach to on-line teaching one has to think of the possible integration of these resources with other common tools which are currently used in a didactic framework. One of the most widely employed tools is for instance Matlab; the Matlab programming language and its set of general-purpose graphical user functions provide an extremely useful environment for the development of illustrative examples of the material which, in the classroom, is necessarily taught under a mostly theoretical point of view. By means of "playing" with these examples the students can obtain a more vivid feel for the actual significance of most algorithms and techniques which are the backbone of most

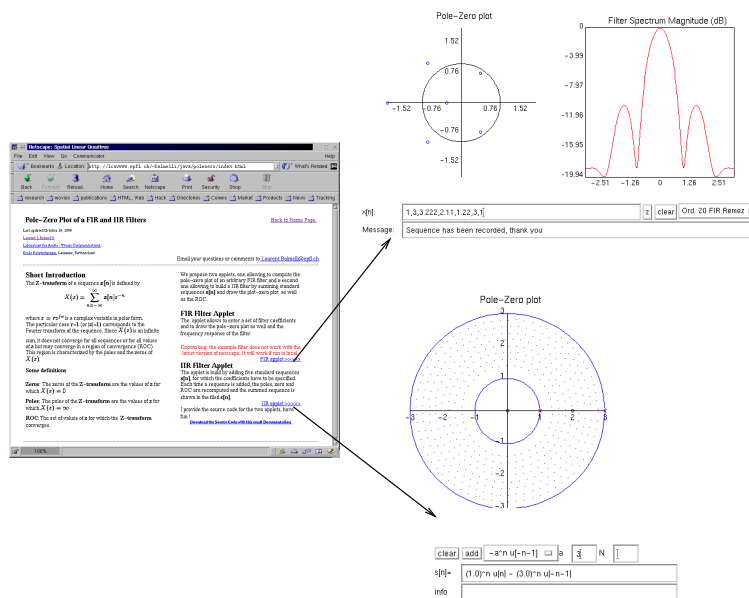
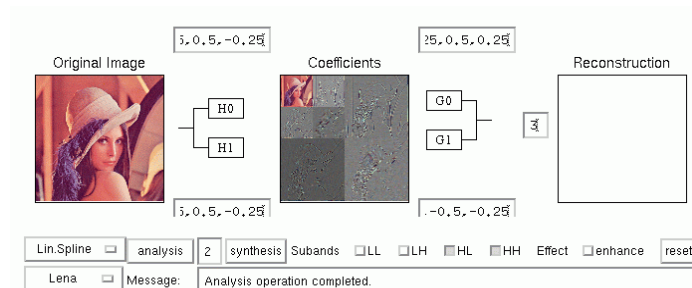


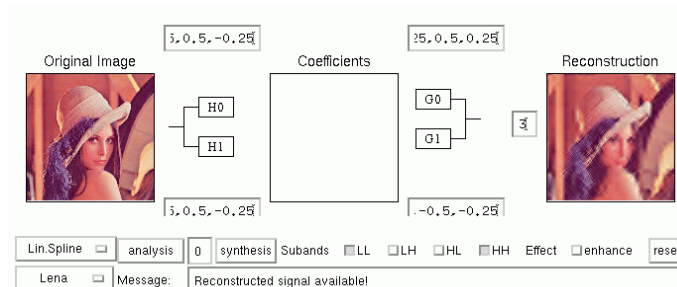
Figure 2: Course support applet for the z-transform of a digital filter.

engineering disciplines. This is all the more true and important for a subject like

digital signal processing. DSP is indeed emerging as a more general-oriented and basic subject in all engineering courses, taking what up to now has been the role of classic circuit theory. In this view, it is important that DSP teaching assume a less abstract formulation in order to provide a “hands-on” feeling to the students. One of the best ways to achieve this is to make available a set of building blocks for DSP algorithms which allows the students to eschew the more strictly technical facets concerning algorithmic implementation and concentrate on the results. As said before, all the Internet-based teaching complements which have been presented so far attain this goal only partially in the sense that HTML documents are inherently “pre-canned”. Very effective presentations can be created,



a.



b.

Figure 3: Interactive wavelet coder: a. The user can transform the image and select the subbands for the reconstruction. b. The synthesis is performed using the selected subbands and the user can immediately see the effect of the reconstructed image.

but these allow for little interaction on the part of the user, which consists mostly in multiple-choice question answering and selective browsing of the material. The envisioned goal of a Java-based approach to online teaching in this case is the creation of a Java library of DSP-oriented general purpose functions. The video and audio capabilities of net browsers provide the ideal setting for the realizations of a large class of fundamental examples in DSP techniques, which will present

the student with a "guided tour" of the possibilities and, why not, the "fun" nature of signal processing. These examples will be built with the library functions just defined, and will thus consist of "open" modules which the student can easily analyze and modify. The examples will then convey a double load of information: an overview of DSP techniques in the more general sense and a series of examples in algorithmic design and implementation. The ease in the distribution and the free accessibility to the Java package in the academic environment are the two strong features of the proposed approach.

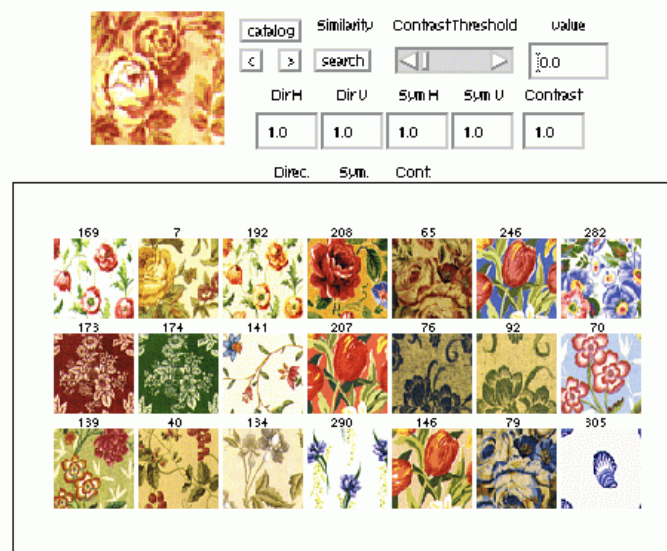


Figure 4: Research demonstrator: texture retrieval using perceptual features.

3 Teaching using Java

We summarize below the main contribution of the project regarding teaching.

3.1 Distance learning framework

In [5] (see Appendix), we presented a framework for digital publishing, virtual labs and interactive exercises sessions. It is composed of a components library, a delivery mechanism (simply the WWW), a solution for edition of hyper-linked scientific texts with interactive illustrations and a virtual environment for exercises sessions and projects

3.2 Digital signal processing library

A set of high-level GUI classes allows easily to build visual scientific applications [3]. Any type of 1D, 2D functions, graphs, images can be displayed (Figure 1). Special visualizers for matrices are also included. The types/utilities group contains new data types for signals, complex numbers and polynomials, routines for conversions (for ex. images into matrices of values), matrix operations, quantizers and several numerical solvers. Finally, the DSP group contains classes for different operations such as FFT, Wavelet transform, DCT, Quadrature Mirror Filters...and so on.

3.3 On-line class support for students

The creation of the DSP library allowed to build an on-line class support for the digital signal processing class taught by the laboratory. The DSP book regroup a set of applet that aims at illustrating the main topics of the course.

We also designed applets providing a mean for the students to check their solutions for the homework. The interactive Z-transform course support was built in this idea. Beside checking their solution, the students can built additional examples and work out their understanding of the important part of the class.

4 Research using Java

4.1 Reproducible research

Beside being a very efficient tool for building on-line demos and electronic books, the Java language remain difficult for rapid prototyping, compared to non-compiled and specialized languages such as Matlab and Maple. However, we found Java very adequate for providing on-line research demos, since it easily permits to reproduce experimentation results.

We experienced two parallel approaches:

- *On-line applet and electronic papers*: Jointly to the submission of a scientific article, we produce a web page with a software demonstrator[2]. The reviewer are able to verify the experimental results reported in the paper. The following figures demonstrate typical software demonstrators

Wavelet image coder (Figure 3).

On-line texture retrieval (Figure 4).

Interactive paper on meshing (Figure 5).

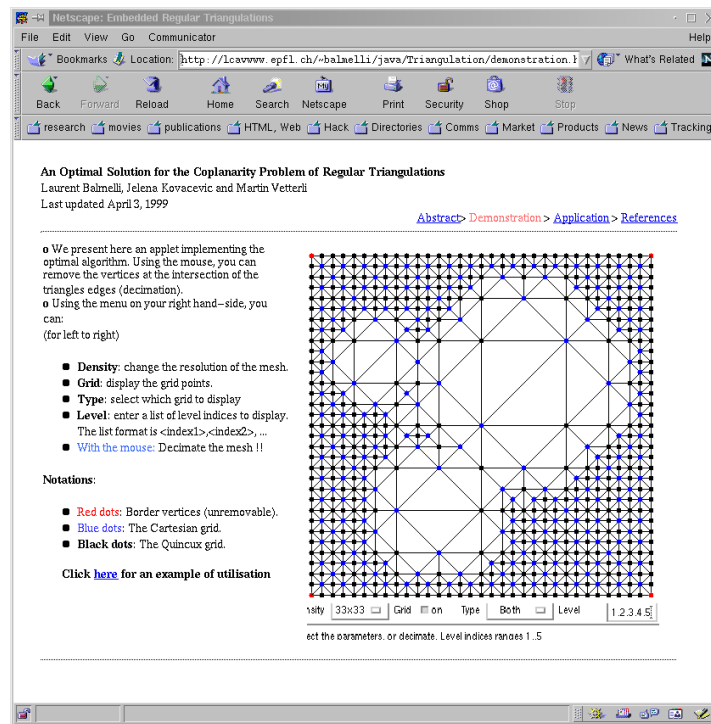


Figure 5: Interactive electronic paper on meshing.

4.2 Floppy-based research demonstrator: the Article Hyper Companion

For conferences, we produced floppy disks containing the presented material, as well as the software demonstrator. We named such disk article hyper companion and their typical content included:

- conference slides,
- software demonstrator,
- source code.

All this material was embedded into a HTML-based presentation. Multiple copies of the floppy were distributed after the conference talk. This approach has been very successful and the attendees very much appreciated to receive the full material of the presentation. The two instances below can be obtained on the webiste related to this report (see Appendix A).

- Quadtree floppy, distributed at IEEE International Conference on Image Processing in Kobe (Japan) in October 1999 [4].

- Research demonstrator distributed at the workshop on Vision, Modeling and Visualization in Erlangen (Germany) in November 1999 [1]

A Java project website

We provide a full web-site containing all the material of the project at the address <http://lcavwww.epfl.ch/~balmelli/java> (Figure 6).

The screenshot shows a Netscape browser window with the address bar set to <http://lcavwww.epfl.ch/~balmelli/java/>. The website content includes:

- EPFL Logo:** ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
- Page Title:** Java for Teaching and Research
- Authors:** Laurent Balmelli, Martin Vetterli, Yves Cheneval
- Department:** Laboratory for Audio-Visual Communications, Communication Systems Department
- Navigation Links:** Project outline, Timeline, Teaching using Java, Research using Java, Web presentations, Papers and reports.
- External Links:** www.epfl.ch, www.sun.com
- Technical Diagram:** A block diagram showing an 'Original Image' being processed by a filter with coefficients $[0.25, 0.5, 1, 0.5, 0]$ to produce 'Coefficients' $[0.25, 0, 0, 25]$. Below this are a 'Pole-Zero plot' and a 'Filter Spectrum Magnitude (dB)' graph.
- Java Beans:** A cartoon character holding a green bean.
- Most-Wanted Applets:** Wavelet image coder, Z-Transform applet, Mesh decimator.
- JOIN THE COMMUNITY:** BROWSE / DISCUSS, LEARN / SHARE
- Footer:** Copyright 2000 - Laboratory for Audio-Visual Communications - EPFL - Switzerland. Web design - Laurent L. Balmelli - February 2000 - Laurent.Balmelli@epfl.ch

Figure 6: Entry page of the Java Project website

B Published papers

The following list of paper have been published during the project:

- A Framework for Interactive Courses and Virtual Laboratories.
Proceedings of Multimedia Signal Processing conference, December 1998, Portofino, USA
- Un prototype pour le télé-enseignement
Flash informatique, EPFL.
- Interactive DSP education using Java
Proceeding of ICASSP 98, Seattle, USA.

All these papers can be obtained on the website at

<http://lca-www.epfl.ch/balmelli/java>

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- [2] L. Balmelli and A. Mojsilovic. Wavelet domain features for texture description, classification and replicability analysis,. *Proc. Int. Conf. Image Processing (ICIP)*, 1999.
- [3] Y. Cheneval, L. Balmelli, P.Prandoni, and M. Vetterli. D.s.p. education using java. *Proceeding of ICASSP 98, invited paper*, 1998.
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- [5] L.Balmelli, S.Ayer, Y.Cheneval, and M.Vetterli. A framework for interactive courses and virtual laboratories. *Proceedings of IEEE Multimedia Signal Processing Conference (to appear)*, 1998.