Abstract

At FIE 1995, a work in progress paper describing the plan for the image processing distance learning project was presented. In this paper, the results of the first year of the NSF funded effort are described.

The project addresses methods to deliver courses over boundaries of time and space where at least one laboratory component required for the project is too costly for an individual student. Hence, the challenge is to deliver distance learning in a fashion that does not financially disenfranchise students and simultaneously does not give distant students a less complete educational experience. To meet this challenge, we have developed new media rich communication tools accessible via the internet and WWW allowing students to easily exchange media-rich documents, a client-server based interface to a powerful image processing system, KHOROS (which we call WebKHOROS), and several other components.

Introduction

In this paper, a methodology and laboratory environment for teaching image processing to students with mixed backgrounds, possibly separated by time and space is described. The environment is designed to empower students to learn image processing by processing images and implementing image processing systems. The system is designed so that student projects are highly re-usable modules for teaching the course. In this fashion, the efforts of developing the necessary tools for demonstrating and illustrating image processing concepts are distributed to the student workforce.

Course Goals

The course consists of several components, all designed to achieve different goals.

Theory:

Ensure the student understands the fundamental theories associated with image processing. These include the theory of signals and systems, linear systems theory, and various concepts from mathematics. The student should be competent in using mathematical tools such as Fourier analysis in the context of image processing.

Physical Phenomenon:

Ensure the student understands how the mathematical and theoretical relate to the "real world" of images, what they look like, and what to expect as the output of a particular system.

System Design:

Based on their understanding of the physical phenomenon and underlying theory, students should be able to interconnect basic image processing blocks to achieve desired goals in a robust fashion. The system design and implementation should be modular so that they can be re-used at a future date as part of larger systems.

System Implementation:

Students should be able to implement the low-level basic image processing blocks and then interconnect these blocks achieve a system design.

Methods

To achieve the goals stated above, the following methodologies are used:

Traditional Lectures:

Traditional lectures are a major tool used in the course to deliver information to the student. The lectures are distributed over a two-way audio/video system to three branch campuses in the state of Washington. The lectures are video taped for students that can not attend the lecture can view them at a future time, or so students can simply review the lectures at a later time for review.

Example Image Database:

Traditional lectures are augmented by a rich collection of example processed images. The example image database is available as transparencies for classroom use, and via the World-Wide-Web for student access outside of in class experiences. Several screen-shots of the WWW version of the Example Image Database are shown in the following figure. Each area
of the example image database consists of a tutorial section and a collection of several “before and after” images.

**Mathematica Notebooks:**

Mathematica Notebooks (a form of hypertext) are available and used as part of the homework assignments. These notebooks contain over 30 modules on linear systems theory including dynamic animations demonstrating fundamental concepts such as sampling and aliasing. These modules are available as Mathematica Notebooks (Mathematica is available on all EECS systems). In addition, non-interactive versions are viewable as HTML documents via the WWW. Finally, a Mathematica-WWW interface is available to allow students at distant sights access to the interactive features of Mathematica. The Mathematica Notebooks are based on the Signal Processing Packages by Brian Evans. These include a symbolic transform engines which provide students with a dialogue indicating how the transform was achieved. These transform engines can be used by expert students to reduce the tedium and likelihood of error and by beginning students to help master their mathematical skills. Some of the available modules are shown in the following figure:

A sample screen shot of a module on the sampling theorem follows. This page demonstrates the ability to publish MPEG movies and dynamic, images in a simple fashion.
Image Processing Tools:

Students currently use KHOROS 2.0 and its visual programming language, cantata, to quickly interconnect image processing components to design systems. To overcome the need to have a UNIX workstation or a fast network connection, a WWW interface to KHOROS has been developed and is available. The WWW interface allows students to run KHOROS workspaces (visual programs) over the WWW on a WSU provided server and view the results on their local browser. Students can tweak parameters in the workspaces to ask “What If” questions.

A sample WebKHOROS workspace used in a homework assignment is shown below:

In this mode, students can select a particular part of the algorithm and “tweak” the parameters. Upon running the workspace, students can view all output images. In this fashion, an instructor can easily assign students to investigate an image processing algorithm without incurring the additional overhead of having to teach KHOROS programming. A sample screen-shot of a user editing a particular parameter set is shown next.

Image Processing Library:

To complete the exercise, students are given a coding standard, an Applications Programmers Interface (API) to low level image processing routines, and a revision control system. Students are asked to implement higher level functions (such as convolution) using the published coding standard and API. These routines are used to implement a large scale project. The projects are written to published standards which enable them to be easily added to interactive documents for distribution over the WWW. The final project report is an interactive WWW document. Hence, the final project report serves as a graphical user interface to the student software.

Due to the interactive hypertext nature of these projects, it is difficult for a single screen-shot to convey much of the flavor of the project report. Hence, no such examples are included in this version of the document. For interactive examples of all of these projects (and materials discussed in this paper), use the following URL and access the CS445-Digital Image Processing area --- http://www.eecs.wsu.edu/cgi-bin/ButchsPlace/.

Workgroup support:

To support student learning, the course has a designated mailing list (and WWW interface to mailing list archive that supports threading of topics), "online office hours" via Chat and IRC programs, and other communication tools. All tools allow the exchange of multimedia documents.

The main tool developed for this course is ButchsPlace, a Virtual Coffee House. ButchsPlace was written to allow students to easily exchange media rich information using a threaded discussion list type metaphor. In ButchsPlace, different users have different access levels. For example, administrators can create new discussion topics, change topic properties, delete posts, etc. A user with regular access priveledges can only do whatever was specified by the group administrators. The lowest level of user priveledges are for “guests”. Guests can only read material, but can not post or modify any information. ButchsPlace currently allows anyone to become a user by simply filling out an interactive registration form. Some areas do not allow users to post whereas other areas allow users to post new material. In this fashion, ButchsPlace can be used as a tool for an instructor to place course materials, or to create interactive discussion areas for students to use.

Among the unique features of ButchsPlace, is the ability to incorporate entire HTML document trees. This makes it possible for students to create sophisticated WWW
documents and then post them to ButchsPlace for others to view. In this fashion, ButchsPlace creates archives of all files so that when a user’s account is deactivated, all of their interactive documents are not lost. Sample screen shots of ButchsPlace are shown below. Note that articles that have not been read have an “Unread” icon. Similarly, articles that have been created since the last time a user logged in to ButchsPlace will be designated with a “New” icon. All user interactions are stored on the server system so that a detailed history of how people utilize ButchsPlace is stored for each user for further analysis and assessment.

Closing Comments

The methods and tools described in this paper were successfully field tested at Washington State University. The course was delivered over the Washington Higher Education Telecommunications system (WHETS) which provides a two way audio/video link. Two students at a remote location started and completed the course. As evidenced by all student projects, it is clear that students mastered the basic concepts of digital image processing. Furthermore, student evaluations indicated that their knowledge of the WWW and other hypertext systems was greatly increased and they would be likely to better utilize such resources in the future.

All courseware developed for this project is available through ButchsPlace (http://www.eecs.wsu.edu/cgi-bin/ButchsPlace) in the CS 445 Digital Image Processing area. ButchsPlace is also used for several other courses at WSU. For further details, simply browse through the system.

In the figure below, students are allowed to upload URL’s pointing to HTML document trees by using the “new URL” button. This was the most common format used by students to post their homework solutions. Another important feature of ButchsPlace is it allows the user to specify what time window a particular item is visible allowing instructors and students to post homework solutions at their leisure. Only administrators can view material when it is not “visible”.

![ButchsPlace Interface](image1.png)

![ButchsPlace Interface](image2.png)