CyberProf

An Intelligent Human-Computer Interface for Asynchronous Wide Area Training and Teaching

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Abstract

We introduce CyberProf, a robust software package which utilizes the full capabilities of a World Wide Web server as an intelligent human-computer interface for grading, creating, and presenting educational course materials. Students can solve course problems presented with text, graphics, animations, and sound on the Web and can receive instant feedback from a sophisticated grading package which makes use of the latest complex systems data analysis tools to handle ambiguous input in an intelligent manner. Fully integrated lecture notes and help files are hyperlinked to assist the student in solving an exercise. Instructors can make use of built-in problem set and lecture notes editors to create an entire online course customized for their needs. Early results of the system are promising. In the first university course in which CyberProf was used, class attendance rates were significantly higher, dropout rates were lower, and grade distributions were higher when compared to figures from the same course in previous semesters. ***Keywords:*** *CyberProf, educational complex systems, online course grading*

Introduction

The Center for Complex Systems Research at the Beckman Institute of the University of Illinois at Urbana-Champaign has devoted much of its research efforts over the past seven years to developing tools for the analysis of complex data using diverse methodologies such as simulated annealing, neural networks, fuzzy logic, and those found in the relatively new field of complexity [1, 2, 3]. Now, with the emergence of the Internet as a primary medium of electronic communication and, in particular, the World Wide Web as a globally recognized standard for the rapid transfer of textual, graphical, and audio information, a unique opportunity is afforded software developers: the ability to combine the latest in complex systems modeling with a distributed computing interface to create truly multimedia educational software capable of handling ambiguous human input and providing access to the vast resources of the Web. CyberProf was specifically designed to take full advantage of this opportunity.

CyberProf is an intelligent human-computer interface for asynchronous wide area training and teaching which is being developed at the Department of Physics and the Center for Complex Systems Research at the Beckman Institute of the University of Illinois at Urbana-Champaign. Interested persons are always welcome to visit the CyberProf page on the World Wide Web at the following URL:

> *http://www.ccsr.uiuc.edu/cyberprof-docs/general/*

The next section of this paper discusses the motivation behind the development of CyberProf. This is followed by a detailed description of the features of the system with particular emphasis placed on the grading module of the package. The following entails a brief description of the implementation details of the system, followed by a discussion of preliminary results of CyberProf in terms of its impact on student performance in the first classes to use it extensively. Finally, future ehancements to the system are proposed.

Motivation

Previous online networked educational systems developed at the University of Illinois such as PLATO [4] and NovaNET [5] were partially successful, but somewhat limited by the technologies and methods of their time. Students could perform exercises online, receive instant feedback on their solutions, and have their grades automatically recorded. However, these systems were not capable of particularly sophisticated handling of student input nor were they able to take advantage of the enormous amount of information available on the Web. Furthermore, it was difficult to integrate lecture notes, labs, and homework into a cohesive package.

Cyberprof was conceived with the notion of addressing these shortcomings by synthesizing all of the functionalities of the above systems with the new technologies of the World Wide Web and a much more robust student/computer interface engine based on modeling the human-computer interaction as a complex system. In recent years several key paradigms have been developed in complex systems research, such as adaptation to the edge of chaos, the principle of the dynamical key, the principle of least resistance, neural nets, associative memories, etc. In the fall of 1994, A. Hubler proposed to employ and test these paradigms with the objective to make the learning process more efficient; i.e., create an intelligent learning environment for the student.

Features of CyberProf

Essentially, CyberProf acts as a Web interface between four agents: the student, the instructor, the World Wide Web, and an intelligent grading engine based on complex systems methods. Figure 1, below, illustrates this paradigm.

Along the student/system interface, students can:

- Submit solutions to online homework and quiz problems
- Receive immediate grading and obtain detailed information on how or why their solutions are incorrect from the complex systems engine
- Obtain appropriate hyperlinked references to resources on the Web
- Communicate with the instructor via a Web bulletin board

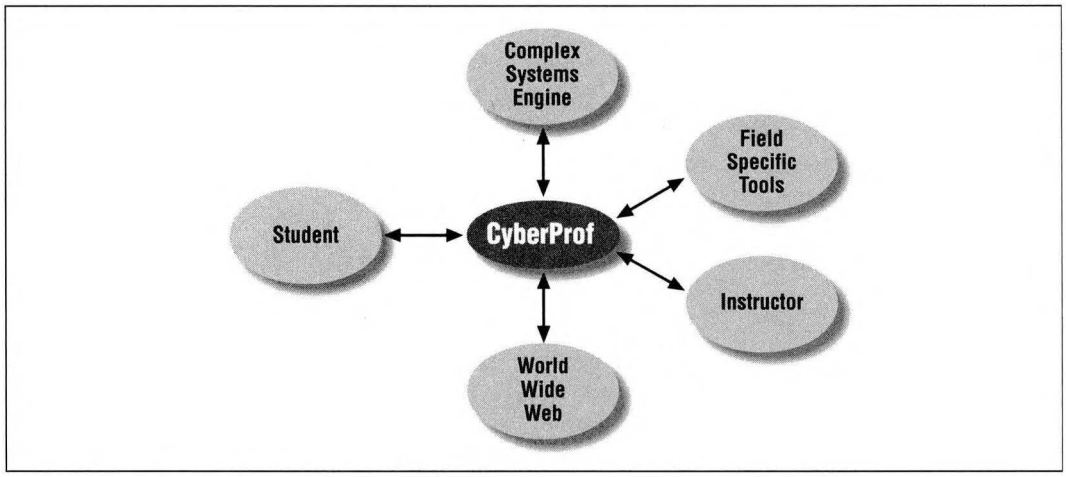

Figure 1: The CyberProf system

- Access a Web gradebook to monitor their progress

Along the instructor/system interface, an instructor can:

- Create problem sets with a Web problem set editor
- Utilize field specific tools for creating problems specific to his/her field
- Create online lecture notes
- Communicate with students via a Web bulletin board

The following three sections list some of the important general features, problem-set generation capabilities, and features of the grading package of the system, respectively.

General Features

- Students and instructors have fast and easy access to the system using platform-independent Web browsers available at no cost.
- CyberProf, itself, is free.
- Students are encouraged to make use of the most recent technologies available on the Web.
- Integrated conferencing software helps the student to communicate with network teaching assistants and the instructor.
- Integrated Web tools allow for interactive drawing of pictures and creation of animations.

Problem Set Generation Features

- Extensive use can be made of graphical information and movies instead of text to describe complex situations. Instead of unrealistic oversimplifications, we encourage the instructor to use realistic, possibly quite complicated situations in problem sets and computer lessons. The complexity of the situation is communicated by images, movies, and sound. Written text is kept at a minimum.
- The instructor can match the educational and social background of each individual student with appropriate language and presentation in the problem sets and computer lessons.
- Problem sets can take full advantage of (i) sound and other multimedia features of PowerMacs and other PC level computers and (ii) high data-transfer rates on the Internet.
- Problem sets, help files for problem sets, and lecture notes can be hyperlinked to form a coherent package.
- The source code of the problem sets is very simple and can be generated by a lay person. Complicated equations are typed in LATEX notation and displayed on the Web page.
- Integrated conferencing software helps the student to communicate with network teaching assistants and the lecturer.

Features of the Grading Software

- Careful analysis of student answers based on the most recent complex systems data-analysis techniques (e.g., physical number theory, fuzzy logic, associative memory) gives partial credit when appropriate.
- Careful study of the student answers: checks for sign errors, unit errors, and numerical errors are made. Specific hyperlinked help is offered, based on the error analysis.
- The time which the student takes to solve a problem is monitored and displayed on the student's Web page and can be compared with the "expected" time a student should need to solve that type of problem on an exam.

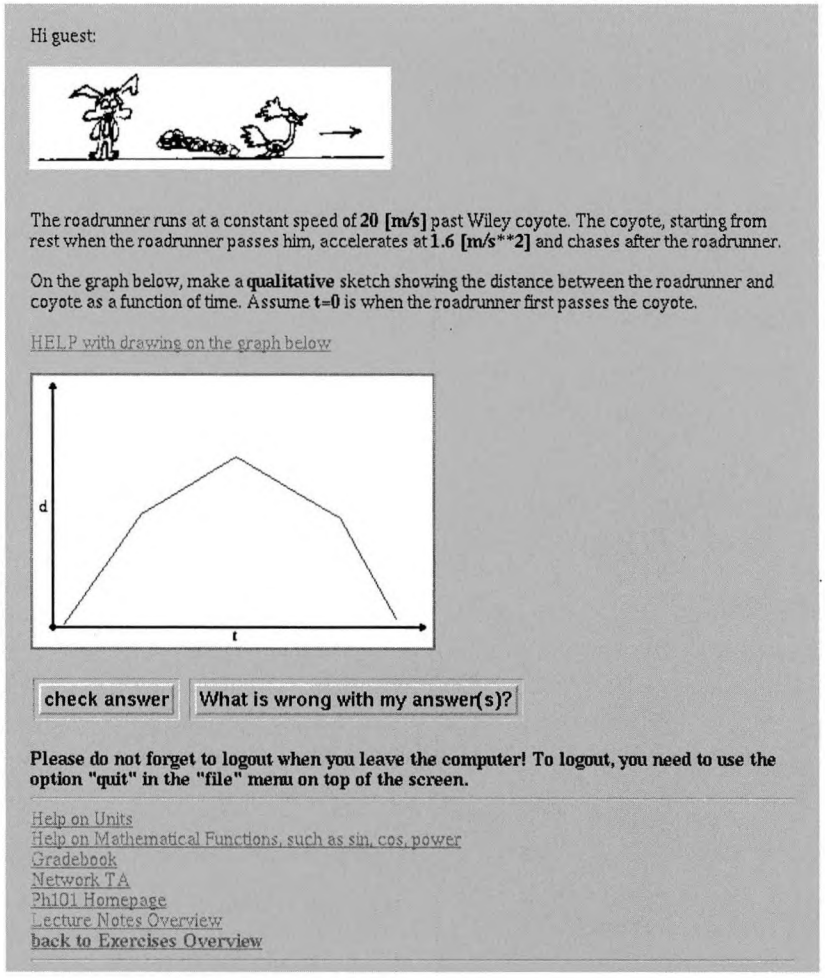

Figure 2: An example CyberProf problem form

- Every student gets a different set of numbers, which are chosen by a personalized random-number generator.
- Every student gets a different set of problems, which are selected fom a large pool with a personalized random-number generator.
- Upon request by the student, a problem can be explained in detail in audio. Often a problem can be faster and more easily understood if it is explained with different words from a second perspective. The audio feature makes it possible to give more detailed explanations which would be time-consuming and cumbersome to read as text.
- The grading program can check symbolic expressions, numerical equations, and differential equations with symbolic expressions.
- Students can use an interactive drawing tool to draw graphs of functions on an XY plot which are instantly graded by comparing them to a theoretical curve generated by an instructor-specified function.

- The grading program keeps track of the progress of every student and saves the information instantly in a grade book. Students will not lose credit in case of network errors, power failures, or other interruptions of service.

Implementation

Cyberprof is implemented as a package of Perl scripts and C routines which handle student and instructor input via HTML forms submitted to a Web server running httpd. A typical problem HTML form is depicted in Figure 2.

This form illustrates most of the key features of the interface to the grading software. The student is presented at the top of the form with text and/or images describing a situation and asking a question. On this particular form, the student is expected to draw a curve on the graph presented as an "image" type HTML input to the form utilizing CyberProf's interactive drawing capabilities. In general, depending upon the type of problem, a student might input text or numbers in a "text" HTML input on the form, or might be asked to choose an answer from a "select" type HTML input.

Once the student has entered an answer, he can press the "check answer" button to submit the form. The grading software is then invoked by the Web server to grade the student's answer. This software responds to the student by generating another HTML form which again presents the problem as described above, informs the student if his answer was correct or not, and provides specific hypertext references to locations in the online lecture notes which might assist the student in the event of an incorrect answer.

For some problems, the student might also be able obtain more detailed information on why his answer is incorrect by clicking on the "What's wrong with my answer?" button. Additionally, standard "help" and "hint" buttons which produce instructor-specified assistance to the student can be included in a problem.

Hyperlinks to references and other aspects of the system such as the gradebook, course bulletin board, and lecture notes are available at the bottom of the form.

Results

An early prototype of CyberProf, called PHYSICA, was first used in an actual course, Physics 101, at the University of Illinois at Urbana-Champaign during the spring semester of 1995. This section presents data taken from that class regarding student enrollment, attendance, and exam performance, comparing it to data from the same course offered in previous semesters.

Table 1 compares enrollment figures and dropout rates for Physics 101 courses since the spring semester of 1993.

As can be seen in Table 1, the dropout rate for the course for the semester in which CyberProf was introduced (Spring 1995) was 3.5%, almost three times lower than the average dropout rate, 10.0%, for the same course over the previous four semesters.

Figures 3 and 4 depict final exam score distributions for the Spring 1994 Physics 101 course and the Spring 1995 Physics 101 course, respectively.

Table 1: Enrollment Figures for Physics 101

	Spring 95	***Fall 94***	*Spring 94*	***Fall 93***	***Spring 93***
Initial Number Enrolled	317	407	306	434	351
Final Number Enrolled	306	362	285	384	314
Dropout Rate	3.5%	11.1%	6.9%	11.5%	10.5%

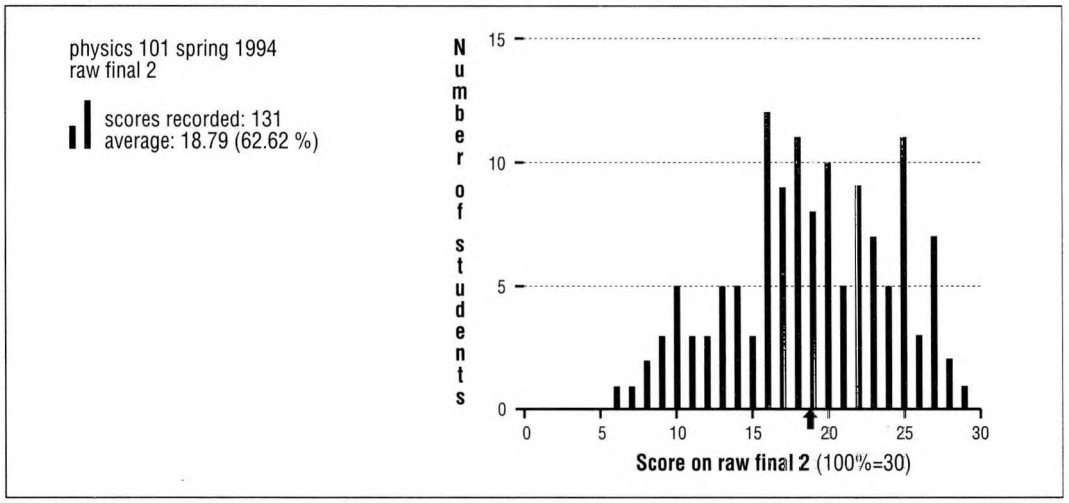

Figure 3: Score distribution for final exam, Spring 1994

The major discernible difference between these distributions would appear to be the lack of the lower tail in the final exam score distribution for the Spring 1995 semester (Figure 4), when CyberProf was integrated into the course, compared to the score distribution for the Spring 1994 course which did not use CyberProf. In fact, this difference appeared fairly consistently when comparing the grade distributions for the three midterm exams given during the Spring 1994 and 1995 semesters as well.

In addition to the enrollment numbers and exam score distributions mentioned above, the instructor who taught the Spring 1995 course with CyberProf noticed a significant increase in lecture attendance, perhaps as much as 10 to 20 percent, compared to previous semesters when he taught the same course. Although the results of one course don't provide conclusive evidence that CyberProf was directly responsible for these perceived improvements in student performance, they seem to indicate, along with the generally enthusiastic response to the system from the students in that class, that CyberProf has a struck a resonant chord with the students. Enthusiasm for the system has spread rapidly within the university across many disciplines. CyberProf is currently being used to develop online Web courses at the University of Illinois in several different departments such as Physics, Agriculture, Economics, Electrical Engineering, Chemistry, Bioengineering, and Theoretical and Applied Mechanics. A full listing of hyperlinks to these courses is available on the Web at:

http://www.ccsr.uiuc.edu/cyberprof-docs/general/courses.html

Future Work

The CyberProf team continues to enhance the software package to improve the existing interface and to add enhancements which address the needs of an expanding user base. Our main efforts for the immediate future are listed below:

- Improving and expanding the ability of the grading module to intelligently analyze a student's solution and answer questions about why a solution was incorrect
- Expanding Web communication tools to allow for easier online communication between the student and instructor
- Improving the user interface to allow for greater flexibility in inputting graphical infor-

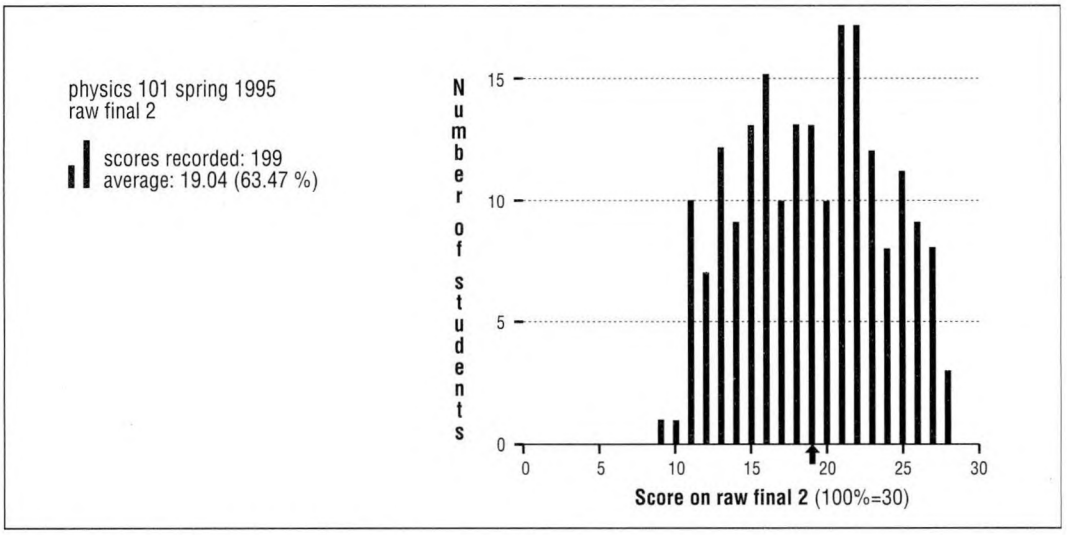

Figure 4: Score distribution for final exam, Spring 1995

mation, whether it be in creating or answering an exercise

- Development of a fully featured Web drawing program which is comparable to a commercial drawing package AND is fully integrated with CyberProf's grading package and problem set editor
- Improving the interface for instructors to create problem sets and lecture notes ■

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