An interactive statistics module using WWW

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Abstract: - The paper describes an application of computer-aided learning to a course about Statistics. The delivery tool we have chosen is the World Wide Web. The course material consists of theory, interactive exercises, student-teacher communication mechanism, navigational aids, student evaluation, a glossary. The use of the WWW provides a much greater flexibility in course planning in that students will be able to access material or participate in discussions from their homes.

Key-Words: - Web based course, interactive step by step exercises, Mathematica

1 Introduction

Many educators and institutions are realizing the reality of the new face of distance learning and are building courses available in Internet ([7]-[11]). The Web can be used either as a teaching tool or used as a supplement to other forms of instruction.

The development of HTML and supporting tools has made it possible to develop learning environments that reflect, to various degrees, constructivists tenets of faith. These basic tenets can be summarized as follows:

- learners construct their knowledge, building own meaning and interpretation of instruction;
- task and content analysis would focus on identifying and prescribing a single best sequences for learning, but would instead identify several alternatives;
- the responsibility of organizing what is to be learned is in the hands of the learner lending to a more diverse range of learning styles.

A widely benefit of the use of Webtechnology is the increased flexibility that it offers, enabling students from widely varying mathematical backgrounds to study at their own place and at the most convenient time.

The purpose of this work is to introduce an example of instructional module (Elementary Statistics) through the WWW. The module consists of an index of hyperlinked subjects, with correlated exercises and tests of examination. The innovation regarding the existing modules is that the exercises are generated randomly on the WWW. Such innovation has been obtained by running a kernel of numerical and symbolic calculation like MATHEMATICA on Web. In order to approach the course the students are requested to register themselves inserting an identification password that allows to store the visited pages and the results obtained answering to the tests. A student can study the theory and then s/he can verify his/her degree of learning through the resolution of exercises and test. It is evident that the content of a computer-based module, its style of presentation, reliability and the level of interaction will all contribute towards its ability to motivate students and assist learning.

In a typical interactive exercise the computer will pose a problem and ask the student to fill in an online form. A part of the problem data is randomized so that the students can successively work out several problems of the same type. The exercises have been organized in a such way that it is possible to visualize the final result or the intermediate main steps so the student can control step by step if his/her resolution is correct. The students have a chance to notice by themselves possible mistakes they make during exercises solving. To the end of the module there is a final examination composed by random exercises that allow the students to simulate their test of examination and understand if they are able to exceed it. Moreover through an electronic mail box they can subject eventual questions to the teacher for clarifications. This feature has been used to give the students personal assistance, to receive their solutions to given problems, and to give them personal feedback. The possibility of attaching documents with E-mail is especially useful, since it allows the sender to point out details on the WWW material.

In an organized complete course with various modules it is possible to introduce intermediate examinations in such way that the passage to the successive module is bound to the overcoming of a test relative to the running module.

The described module has been experienced locally in the course of Mathematical Methods for Engineering (Mathematics 4 New Ordering) in the didactic laboratory of Mathematics of D.I.I.M.A.(Department of Information Engineering and Applied Mathematics) in which 20 computers connected in network have been arranged.

The software was used not to replace the teacher but as a tool for investigating and solving problems.

For many years we are trying to experiment Information Technology and Computer Aided Learning with the aim to improve teaching-learning process ([1]-[6]).

2 System architecture

The architecture is reasonably of type Client -Server, in which the Client, supported by a friendly interface, interacts via Web browser with the Server on which it resides, and beyond to several didactic supports, with a mathematical (Mathematica 3.0 of Wolfram Research) thanks to which it is possible to carry out not only numerical computations, but also symbolic and graphical ones.

2.1 Mathematica on the web

We have thought to realize a Server application for the Mathematica Kernel to be integrated to a Web server called Math Server. Therefore it is the same application, always in execution, that receives the computations to execute, sends them to the Kernel and gives back the results.

The benefits of this architecture are the following:

- the Math Server can manage a high number of Kernel (limited only by the capacity of the Server machine) and shunt with methodologies of queue type the computations on the several open Kernel;
- the Kernel is already in execution, therefore the times of access to the system are reduced;
- the interaction between Client and Server is possible through simple CGI-Bin or Win-CGI, so, from the architectural point of view, the Server is active and the Client is static.

2.2 Static Client in communication with an active server

A static Client unloads via Web browser only HTML pages, containing cells for the insertion of the criteria of demand and push-buttons to send the criteria in shape of strings. When the text is sent, the Server, after having processed the demand, gives back a customized HTML page, through calls to functions or other applications.

It is possible to render a server active through Win-CGI that reside on the Server and that are executed like true and own programs. To make this it is necessary to recall them through some detailed specifics in HTML pages.

Residing exclusively on the Server, the Win-CGI carry not little advantages. Beyond to the comfort in the management of the demands for the Client, in fact, they allow elevated degree of integration with other applications residents on the Server (for example with the Math Server) and remarkable compatibility with Web server for platforms Windows 95/98/NT.

The dialogue between Client and Server doesn't happen via MathLink, but through a simple exchange in which in a direction (Client to Server) is exchanged only text and in the opposite direction (Server to Client) travel HTML pages. They consist of texts and images (eventually also audio and animations) turning out from the processing.



Figure 1: System architecture

Figure 1 outlines the architecture of system EMI, in which it is possible to characterize the key elements. The interaction with the customer has been realized through Web browser, therefore the application, i.e. the Client module is a Web browser as Microsoft Explorer.

It is equipped of two interfaces of communication: one towards the customer and the other back to the Web Server resident exactly on the Server machine. The first is dictated by the wide diffuse standards of interactivity, the second one is defined as follows.

The interface module Client- module Web server clearly sees two directions of exchange of information: one from the Client towards the Server is given from the possibility to send textual information through actions of POST, the other in opposite direction through which the Client, under HTML shape, receives information from the Server. Every information that travels in last direction must be therefore organized under shape of HTML pages. The module Web server is an application installed on the Server computer. Its task is to route through Internet HTML pages generated by the system EMI and to receive information from the Client. Communication requirement are relative to the effective link between static Client and active Server and can be described as the ability to send in execution the Win-CGI associated to the actions of POST or GET inserted in HTML pages .

Win-CGI module is an application on the server machine even if it doesn't look like a running program , but it seems a process that the Client sends in execution.

There could be different Win-CGI modules, everyone with the task to generate dynamic HTML pages in function of the demands for the customer. In order to understand the architecture of the system it is sufficient to suppose that it is composed from a module.

Every customer connected to the Web server and demanding the execution of an action, provokes the appropriation of a Win-CGI process on the server machine. It receives the demands for the Client and produces, according to the latter and to the processing on the Math Server, HTML pages for the Web server. The module must be equipped with two interfaces: one towards the Web-Server and the other back to the Math Server. The first is implicit in the Web server since the communication happens through the access to some variables declared in HTML page and visible from the allocated Win-CGI process.

The second one is a protocol of communication between processes and it can be implemented like a channel Socket TCP/IP or UDP.

The Win-CGI send on the channel the text that corresponds to the demand, the Math Server receives it, processes it and gives back the result that will be used in order to generate HTML pages.

The module Math Server is the heart of system EMI. It dialogues directly with the Win-CGI relative to several customers, processes the demands communicating with the mathematical motor and the base of data. Due to the requirements multicustomer of the system, the present module is conceived in order to dedicate a process to every client, so it manages and processes the received demands avoiding possible interferences between different customers. The main interfaces, beyond the Win-CGI described, are two and they are oriented towards the database and the Mathematica Kernel. Now we have used an Access database and therefore a communication directed from the Math Server. It is not excluded that in future we could use a DBMS of greater potentialities and a communication through ODBC.

The interface of connection with the Mathematica kernel happens through MathLink, that is a library of the same Mathematica that supplies the detailed specifics in order to integrate the Mathematica kernel in an owner application.

2.3 Web pages

We report some web pages to explain the structure of the system. Figure 2 shows the first page that appears when an user connects to the homepage of the Statistics course.



Figure 2: Homepage of the Statistics course

To approach the course the user has to insert an identification password that allows to store all the information about his/her action and the visited pages (Figure 3). After this step, s/he has the possibility to attend an elementary course on the mean statistical concepts. The developed module has a very rich and interactive structure, in fact different tools are available. Navigating through the screens of an interesting friendly Web site maintains student's interest and can keep their brains active. Students select the order of the material trey are studing.





The course is split with 3 sections: Theory, Exercise, Showcase linked together in a flexible learning environment. Students can read the FAQ about statistics and the answers of teachers. A student can ask his/her own question and wait for an answer.

The theory is organized so that when a student enters only the hyperlink to the first chapter is activated (Figure 4-5). She/he cannot study the next chapter until s/he hasn't reached a certain score at the final text of the previous chapter. Tests enable students to assess their own strengths and weakness and to allow teacher to monitor individual progress.



Figure 4: Contents of the Statistics module



Figure 5: Theory section on Bayes theorem with navigation window

In the exercise session the student can solve exercise step by step introducing intermediary results or s/he can visualize the final one (Figure 6). If the intermediary results are wrong s/he can control the correct solution. The section is articulated so that the user can give another look to the appropriate theory, read some examples and suggestions for the solution.

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Figure 6: Section on exercises: independent events

The developed structure is very flexible in fact entering in the course as teacher is possible to introduce new theory pages and to create new exercises template (Figure 7).



Figure 7: Structure for the creation of exercises templates

3 Conclusion

We have described a Web course on statistics to stimulate learning and satisfy students needs. The innovation is that the exercises students are asked to solve are generated randomly on the WWW using Mathematica.

It can be used to improve the existing learning environment and it can guide our research and development work further in the field on web-based open learning environments.

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