Component-based Design of a Flexible Environment Dedicated to Web-based Experimentation

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INTRODUCTION

Experimentation is an essential ingredient to sustain learning activities in engineering education. Nowadays many academic institutions are making great efforts to provide their students with standalone applications for Web-based simulation or remote manipulation of laboratory equipment. However, these resources are not really effective if deployed as such, without additional components which can sustain active learning, interaction, collaboration and knowledge appropriation.

The Board of the Swiss Federal Institutes of Technology currently supports the *eMersion* project (Gillet 2001a) at the Swiss Federal Institute of Technology in Lausanne (EPFL). This new learning technologies project aims at enabling Web-based experimentation, thanks to a comprehensive environment called the *Cockpit*. This environment integrates all the components necessary to carry out hands-on practice in a flexible learning context. In the framework of the project, people from automatic control, fluid mechanics and biomechanics have joined their efforts to build an integrated environment dedicated to Web-based experimentation. A comparative study has been carried out between these three domains to determine the most common elements required to provide the necessary features. Students have also been observed in real laboratory conditions, by pedagogues, to understand their needs and interaction modes. In addition to dramatically improving effectiveness and reducing the development time, this concerted approach has led to a generic solution for engineering education. To guarantee as much as possible the reusability of the deployed environment, advanced techniques of document engineering have been applied. Levert (2000) and Saliah (1999) have also applied similar approaches.

This paper first describes the *Cockpit* components and their pedagogical relevance. Then, the authoring tool provided to the people in charge of designing the *Cockpit* and its pedagogical content is presented. Finally, the results of the first user-case validation with students are commented, the paper ends with some concluding remarks.

THE COCKPIT-LIKE ENVIRONMENT

The *Cockpit* is a Web-based environment designed as a set of components necessary to carry out a given laboratory assignment. The components are presented as browser windows, called consoles. A navigation and supervision area (Figure 1) enables to navigate in the different consoles, displays the objective of the laboratory assignment and provides a progress status, which is indicated using check marks introduced within the list of tasks proposed to the students. This list is called the *Protocol*. The main console is the one dedicated to experimentation (Gillet 2001 b). This *Experimentation* console typically integrates an applet dedicated to simulation or remote manipulation. The second console corresponds to the *Laboratory Journal*. It allows the collecting, editing and sharing of notes, as well as the collaborative creation of structured reports. Other consoles are provided, such as the *Reminders* that summarize the related theory, and the *Environment* that describes the experimentation setup. The *Cockpit* can be used for demonstration, training or examination purposes.

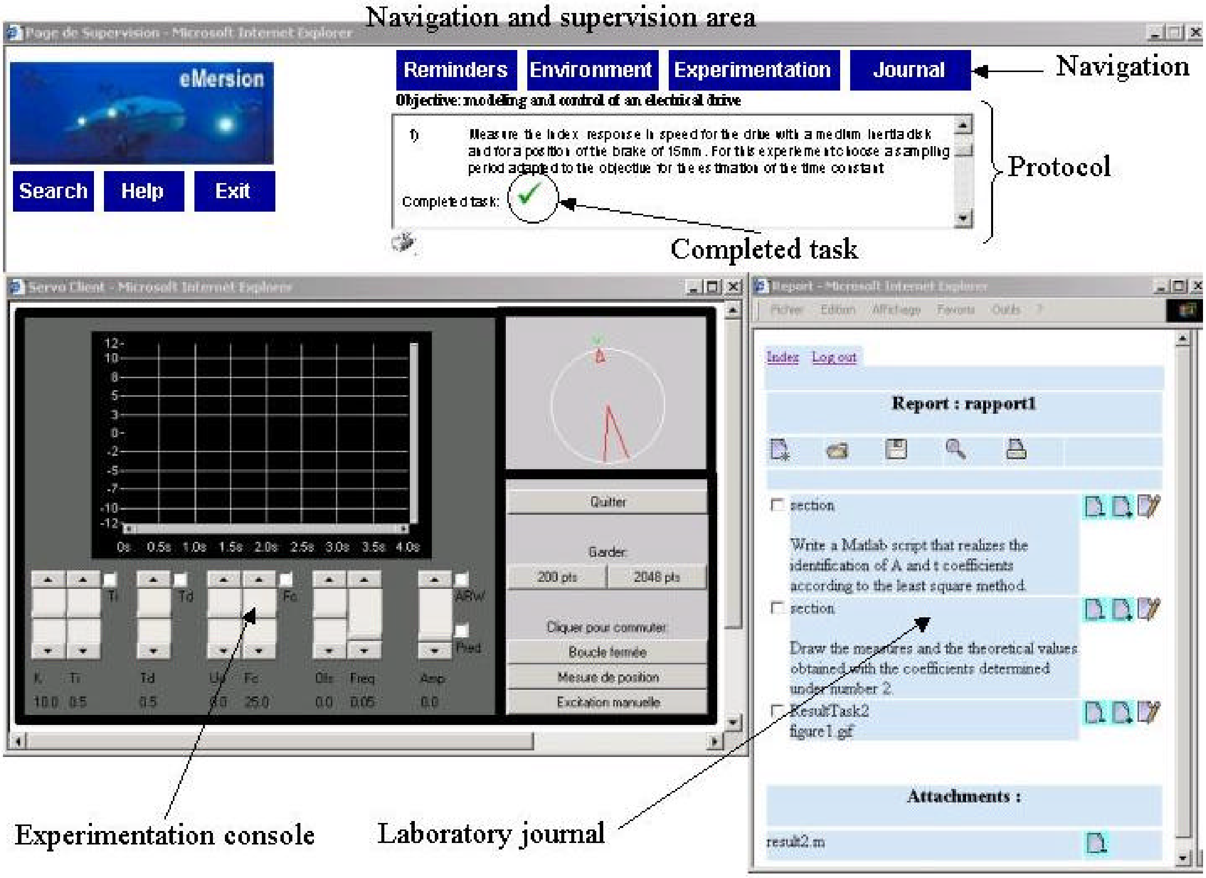

Figure 1: *Sample Cockpit dedicated to an automatic control assignment.*

The students use a group login to access a specific assignment list according to their curriculum. Once an assignment is chosen in the list, the corresponding *Cockpit* is launched. When using it, the students first consult the protocol (Figure 1). Then, according to the assigned tasks and their personal working methodology, they exploit freely the different consoles. They especially work with the *Experimentation* console and the *Laboratory Journal*, which are the most interactive components of the *Cockpit*. These pieces of software have been designed to easily communicate together. For example, a graph produced using the *Experimentation* console can directly be inserted in the *Laboratory Journal*. The *Laboratory Journal* can be made available, partially or entirely, to others (peers, tutors or educators) for feedback or evaluation.

THE COCKPIT AUTHORING TOOL

An authoring tool has been developed to ease the design of cockpits. Before using this tool, the content of a dedicated cockpit is prepared and structured as an XML document. This unique document follows the generic Document Type Definition (DTD) that has been defined as the most common factor between the laboratory assignments encountered in the *eMersion* framework. Then, the authoring tool is used to generate all the cockpit components from the XML document. This tool consists in a series of three forms to be filled in a browser (Figure 2). First, the necessary resources (such as an XML document and URLs to the experimentation applets) are simply loaded using the forms (i). Then, the choice of the information to be displayed for each cockpit type (demonstration, training, examination) is specified (ii) – Finally, the layout for each console of the cockpit is chosen (iii) and all the corresponding components are automatically built.

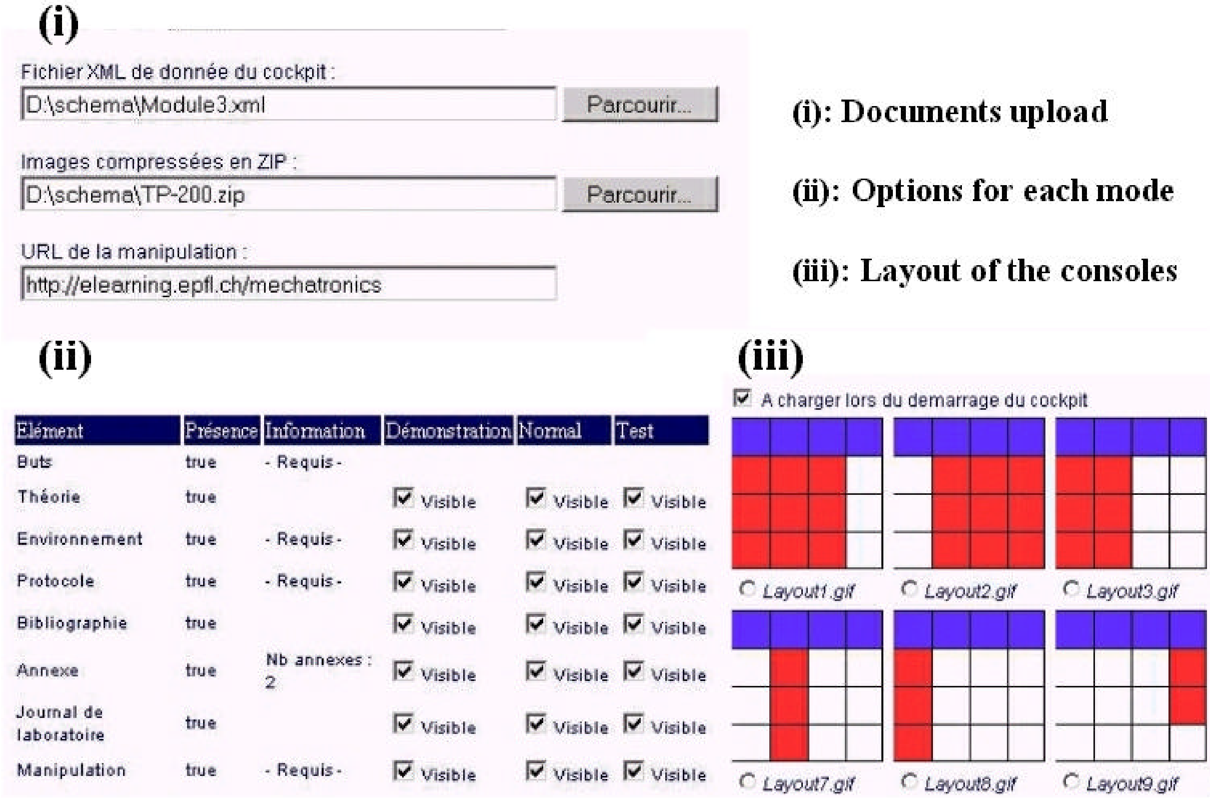

Figure 2: *Authoring tool for the Cockpit generation.*

The same pedagogical content can be delivered in different contexts. For example, part of an XML document can be used to produce cockpits either for demonstration or examination purposes. It is also possible to build from a unique XML document high quality PDF versions for printing. To face with the reusability and structure constraints, the XML and associated technologies are the best suitable solutions. In addition, the JSP (Java Server Pages) technology enables dynamic generation of the cockpits interface.

USER-CASE VALIDATION

Since October 2001, a group of 25 volunteers chosen among EPFL students has used the *Cockpit* environment to carry out laboratory assignments in automatic control. These volunteers had to realize three assignments related with the modeling and digital control of an electrical drive.

The progress of the experiment occurred as follows: Students were asked to answer some preliminary questions listed in the protocol. They answered them by editing notes or attaching documents to the *Laboratory Journal*. When this work was completed, the students marked it visible to the tutor. These answers were corrected and annotated by the tutor within the *Laboratory Journal*. Then, they were authorized to perform the practical part of the experiment assignment using the *Experimentation* console. This activity was also carried out according to a given experimental protocol.

The volunteers have been observed and interviewed by pedagogues to evaluate their reactions regarding the Web-based environment and the flexible learning approach. Although the environment has been easily integrated by students, their rather poor autonomy level has become an obstacle to really capitalize on the added learning flexibility. As a matter of fact, it has been noticed that most of the students asked for more synchronous feedback when they are working on their experimental setup to figure out whether they are or not on the right track.

CONCLUDING REMARKS

A generic Web-based environment called the *Cockpit* has been successfully designed and integrated for flexible learning purposes at EPFL. The introduction of this environment has helped in the rehabilitation of hands-on activities in engineering education, thus reinforcing the opportunities for knowledge and know-how acquisition.

The *Cockpit* deployment has been facilitated, thanks to an authoring tool developed to be used directly by the educators, without the intervention of IT specialists being required. The authoring tool is simple enough to allow the authors to concentrate on the pedagogical relevance of the integrated resources. Furthermore, by relying on structured resources and components, the authoring tool guarantees that the designed environment is satisfactory regarding the consistency, the functionalities, the ergonomics and the user-friendliness of the environment.

Further work is carried out to integrate synchronous feedback facilities through the *Cockpit* in order to sustain the acquisition of autonomy and auto-evaluation skills among students. This is a required step towards getting benefit from the introduction of flexible learning.

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