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THE MERGING TO E-LEARNING IN MOBILE ROBOTICS

A. Khamis, F. Rodríguez, M. Salichs

Electric, Electronics and Control Systems Department
Carlos III University of Madrid
Avda. Universidad 30, 28911 Leganes, Spain
Phone: +34916249495
Fax: +34916249430
E-mail: {akhamis,urbano, salichs}@ing.uc3m.es

Abstract: The evolution of the Internet is one of the most exciting technological advances in recent history. One of the most interesting aspects of this evolution is the emergence of electronic learning (e-Learning) as an innovative educational approach. Robotics education provides an ideal setting in which to test this new educational approach because its flexibility and its dynamic nature. This paper describes the development of a world wide web-based courseware in mobile robotics.

Keywords: Mobile Robots, Robotic Education, Virtual Laboratory, e Learning, Telerobotcis.

1. INTRODUCTION

Engineering education is on the brink of a new era based on the telecommunication revolution and the explosion in the use of the Internet. This information highway has made participation in e-Learning a reality for anyone. E-Learning is defined as the process of using electronic technology to map the traditional teaching and learning activities in an educational process where the instructor and the students are geographically separated. What is important to the understanding of e-Learning is not the evolution of the hardware or underlying network but the evolution of the usage of the Internet, and the role that it plays in the lives of users.

Clearly as bandwidth increases and higher speed network access reaches users, these factors play a role in user adoption of e-Learning. Such types of systems provide the accessing and searching for updated material and also increase system flexibility and availability. This leads to an expected growth of participation level in the education process.

Nowadays many contributions are presented in the field of building e-Learning systems in mobile robotics. A transatlantic virtual laboratory accessible via Internet in the field of Autonomous and Tele-Operated Systems is currently being developed (IECAT, 2001). A tele-education system in aerospace and mechatronics using a virtual laboratory is also being developed to build an international virtual mechatronics laboratory (TEAM, 2001). A virtual laboratory for mobile robot experiments has been discussed in (Eliane and Antonio, 2001) to provide an access to mobile robots infrastructure. Perez et al have described a communication architecture that allows access to a mobile robot from a remote node (Pérez, et al., 2001). A new CORBA-based middleware for autonomous mobile robots has been presented in (Enderle, et al., 2001). Schilling has presented a model design for remote mobile robots (Schilling, 2001).

2. DEVELOPMENT OF A TELE-EDUCATION SYSTEM

Gathering requirements is the first and the most critical step in the development process of any e-Learning project. It describes what the system should do and what are the system requirements. If we are to create materials on-line, the creation and presentation of these materials should be driven from a metal model of what engineering students should learn? This is not a trivial question. Testing the question on some students, the most often repeated answer is “the basics”, followed closely by “how to solve problems” (Bourne, et al, 1996). If time and resources allow, it is recommended to collect the information about the system needs using more than one of the following methods discussed in (IEEE Guide, 2001).

There are two traditional methodologies that can be used to develop a tele-education system.

2.1 Waterfall Methodology

There are many variation on the waterfall methodology, but the basic idea is that the analysis is done up front, followed by the design, the implementation, the testing and, finally, the deployment (Subrahmanyam, et al., 2001). This is called waterfall methodology because each phase flows into the nest like a series of waterfalls as shown in figure 1.

There are many advantages of this methodology such as its simplicity and it ensures that nothing will be done without all the steps before it thus, the team is fully prepared for each step of the process. The weaknesses of this methodology are the time consuming and the leak of the feedback.

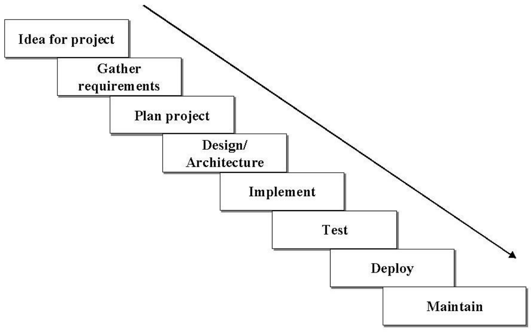

Fig.1 Waterfall Methodology

2.2 Rational Unified Process (RUP)

This process differs from the waterfall methodology in that it creates a very clear set of deliverables for each phase of the process as shown in figure 2. In many ways, RUP is one of the most detailed methodologies available, and helps the team through every step of the way (Rational, 2001).

The Inception Phase

The purposes of this phase are to establish the business case for the system and to specify the project scope. In order to accomplish this, all external entities with which the system will interact (actors) are identified and the nature of this interaction is defined at a high level (use cases). The business case includes success criteria, risk assessment, an estimate of the resources required and a phase plan.

The Elaboration Phase

The purposes of the elaboration phase are to analyze the problem domain, establish an architectural foundation, develop the project plan, and to eliminate the highest risk elements of the project. During this phase scenario and class diagrams are created and matured. Objects and classes are discovered by examining the use cases developed during the inception phase. Scenarios (instances of a use case) are developed and graphically depicted in sequence diagrams. Objects in the scenarios are identified and grouped into classes. Classes are then grouped into packages.

The Construction Phase

The purpose of this phase is to develop a software product, which is ready to be introduced into the user community. The product is evolved as a series of iterations.

The Transition Phase

The purpose of the transition phase is to deploy the software product into the user community and train the users. This phase typically starts with a beta release of the software product to selected users. Typically problems are discovered in the bets release and corrected in subsequent beta releases. After the beta period is complete, the product is released to the community.

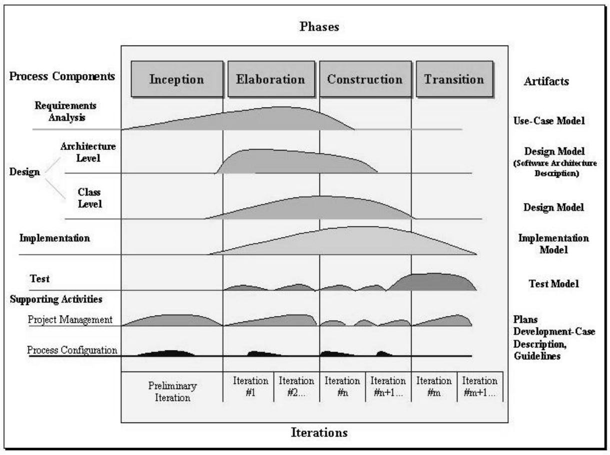

Fig.2 RUP Methodology

Each phase in the development process can be further broken down into iterations. An iteration is a complete development loop resulting in a release of an executable product, a subset of the final product under development, which grows incrementally from iteration to iteration to become the final system.

RUP is designed and structured around the Web, making it a good choice for Web application. Moreover, it is well defined yet flexible, making it easy to adopt even when unfamiliar with the process. But this methodology is complex and many people find it overwhelming to use regardless of the support available.

3. CASE STUDY

Robotics education provides an ideal field for teleeducation systems because its flexibility. Unlike traditional fields, robotics is still an emerging area. Relatively few programs exist at the graduate level, and even fewer exist at the undergraduate level. The courses in existence are still new and are open to rapid change and new approaches. Course goals can change from year to year as new technologies and theories are introduced into the field at large. To develop a reliable and extensible architecture, we will follow the RUP methodology mentioned earlier.

3.1 Business Goals and Needs

We build this system to be an innovative educational tool, which can be used to deepen and apply the learned systematic knowledge of mobile robotics via Web.

3.2 Definitions of Actors

The following actors will interact with the system being developed:

▪ Student… someone who is registered to take a tutoring tour.

▪ Tutor… someone who is licensed to assist students during the tutoring process.
▪ Author… someone who has a wide knowledge in mobile robotics and who is capable enough to prepare and design the tutoring tour.
▪ Administrator… someone who is responsible to administrate the system.

3.3 Definition of Use Cases

A use case is a narrative document that describes the sequence of events of an actor using the system to complete a process (Jacobson, 1992). They are stories or cases of using a system. Use cases are not exactly requirements or functional specification, but they illustrate and imply requirements in the stories they tell. The use case model is essential for both the user, who needs to validate that the system will become what he expected, and for the developers, who need the model to get a better understanding of the requirements on the system. This model is relevant to all people involved in the project. The following use cases are elaborated for each actor:

▪ Student:

- Register for tutoring tours.
- Select tour to enter from demonstration, guided and free tutoring tours.
- Communicate with the tutor or with other student synchronously or asynchronously.

▪ Tutor:

- Communicate with student synchronously or asynchronously.
- Evaluate online graded test.
- Download materials.

▪ Author

- Add new tutoring tour.
- Modify tours.
- Delete tour.
- Communicate with other author or tutor.

▪ Administrator

- Add user/user group.
- Remove user/user group.
- Modify entity.
- Statistical analysis.
- System evaluation.

3.4 Drawing a Use Case Diagram

In the use case diagram, actors are shown as stickmen and use cases are shown as ovals. The overall use case diagram is shown in figure 3

Authoring Process

It enables mobile robots experts to define, modify or remove their own tutoring processes. This process has the following requirements:
- Authors on every platform should be able to use the system;
- Authors should be able to telecollaborate with others authors to exchange and improve authoring methods; Authors from everywhere should be able to use the system; several experts should be able to use the system at a time.

Tutoring Process

It presents the tutoring tour to a student and let him navigate it in order to learn certain mobile robotics facts. This process demands the following:
- Students and tutors from everywhere should be able to use the system;
- Students and tutors on every platform should be able to use it;
- Students should be able to telecollaborate with other students by using new media to improve the learning effect:
- Students should be supported by automatically generated feedback, information pages, tips and explanations.

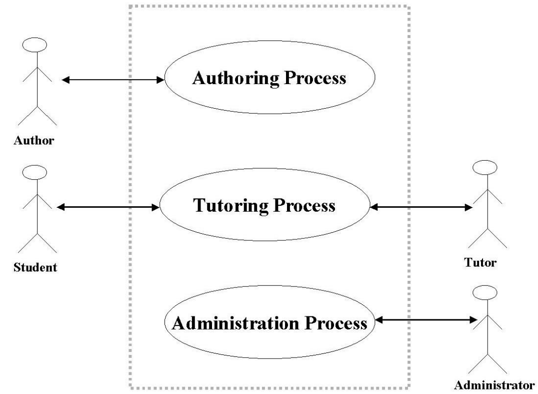

Fig.3 Use Case Diagram

3.5 System Overview

To obtain maximum level of portability, an important design decision was that all interactions with the proposed system could be accomplished with only a Web-browser as an interface, no additional software or plug-ins should be needed for the use of the system. This system will cover different theoretical and experimental issues of mobile robotics. Figure 4 depicts the used architecture to implement the direct control experiment.

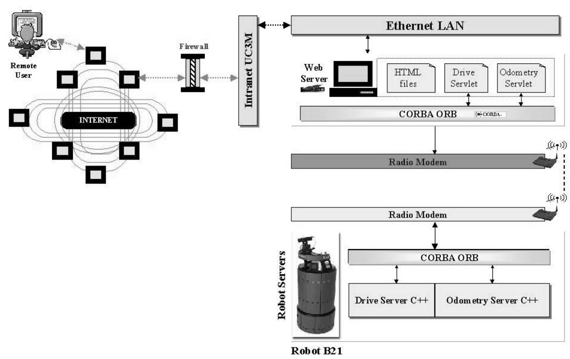

Fig. 4 Architecture of the Direct Control Experiment

User requests are received by Java applets and then sent to the corresponding Java servlet. The communication between the servlet and the remote robot server is done via the Object Request Broker (ORB) of the Common Object Request Broker Architecture (CORBA) where the

Java servlet acts as a client to a remote object server. The ORB provides the communication via the unified interface language Interface Definition Language (IDL) and based on the Internet Inter-ORB protocol (IIOP).

3.6 Web Site Structuring

Figure 5 shows the suggested Web site structure for the teleeducation system to be developed. This structure combines of the “look and fell” of the pages in a Web-based educational system and the navigation paths the visitor can take through the site. It actually supports multiple presentation structures (hierarchical, sequential and hypermedia).

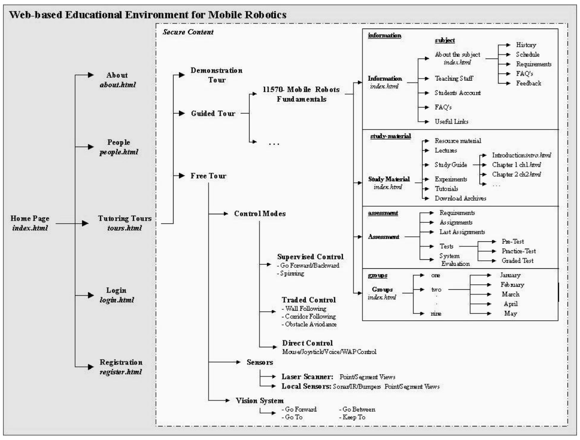

Fig. 5 Web Site Structure

3.7 System's Courseware

Three tutoring tours can be presented to the student to deepen and apply the learned systematic knowledge of mobile robotics. They are classified according to the guidance level into fully guided tour or demonstration tour, guided tour and free tour. By using these tours, student can learn different theoretical and experimental issues of mobile robots.

3.8 Live Performance Lab

The concept of virtual laboratories has been proposed in the expert meeting on virtual laboratories. It has been defined as an electronic workspace for distance collaboration and experimentation in research or other creative activity, to generate and deliver results using distributed information and communication technologies (IITAP, 1999).

The virtual laboratory provides a live performance laboratory accessible via Internet, which can be used to cover the experimental issues in any Web-based education system.

A direct control experiment has been developed in the proposed system to familiarize students with the mobile robot motion control and positioning. By using the applet shown in figure 6, the user can use the mouse to control the robot motion.

Another experiment has been introduced as shown in figure 7. The objective of this experiment is the environment perception using multisensor data (sonar and laser). After finishing the experiment steps, the user can have accumulated sensorial data about the environment as shown in figures 7.

From these results, the user can easily predict the obstacles zones and s/he can draw the environment map from the sensorial data. The out of range unpredicted values in both sonar and laser readings are due to existence of some transparent objects in the lab as windows or firebox or due to the sharp edges reflections.

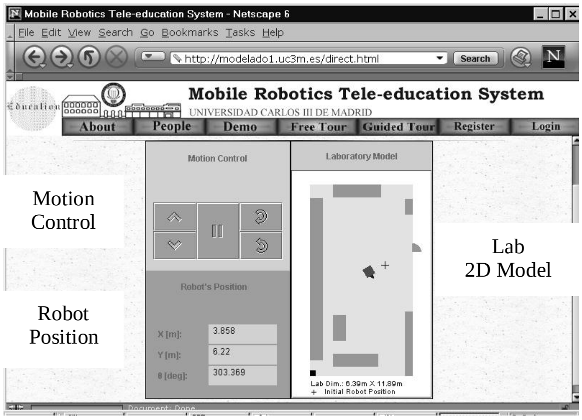

Fig.6 Direct Control Experiment

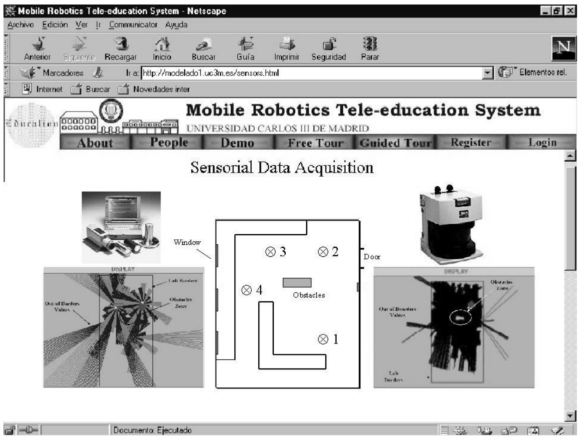

Fig.7 Environment Perception Experiment

4. CONCLUSION

E-Learning presents the evolution of the usage of the Internet, and the role that it plays in the lives of users. Clearly as bandwidth increases and higher speed network access reaches users, these factors play a role in user adoption of e-Learning. Robotics education provides an ideal field for e-Learning systems because its flexibility. Unlike traditional fields, robotics is still an emerging area. Relatively few programs exist at the graduate level, and even fewer exist at the undergraduate level. The courses in existence are still new and are open to rapid change and new approaches. Course goals can change from year to year as new technologies and theories are introduced into the field at large.

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