A MULTI-AGENTS SYSTEM TO SUPPORT A VIRTUAL LABORATORY

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Abstract
In order to show the different possibilities offered by the distance learning, we are looking at the virtual laboratories which benefited from the new training technologies. This approach has the following advantage: reducing the training cost, schedule flexibility, ease of diffusion and the accessibility of the training by a larger audience.

In this paper, we present an agents based generic architecture of a digital teaching environment. Specifically we are interested in distance learning using virtual laboratories on the web. The objective of these virtual laboratories is to train a group of learners in the domain of experimental sciences. We have opted for the agent oriented approach to design our environment. Our approach puts the learner's needs and difficulties as the main factor in the design process and the computer modeling of our system.

Key words: Virtual laboratory, Tele-TP, Design & modelling, SMA and CITs.

1. Introduction

The integration of new communication and information technologies (CIT) in the training process offers the advantage to propose online interactive courses and/or a distant complete training program that can be managed without major difficulties. Even though these kinds of training programs favor the achievement of many pedagogic goals, the effective implementation of practical laboratories on the net is not widely used. It is well known that practical labs are a must complement to the theory teaching of many courses (especially courses in the domain of experimental sciences).

Thus, in addition to the conception of distant teaching platforms, virtual universities and digital working environments, there is interest in designing virtual laboratories. A virtual laboratory is defined as a computerized environment that aims, via the simulation, to understand and learn the practical approach of an experimental science such as physics, chemistry, electric engineering, or mechanical engineering. Also, it gives some explanations of concepts and laws used to describe and explain the concerned phenomena raised during the simulated experiments.

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The work presented in this paper is part of a large research project concerned with the development of a platform for the Algerian Virtual University on the net (AVUNET). The different topics covered by this project are: Cooperative learning, Intelligent Tutoring Systems, Learner's Assistant, Content Design, Platform Evaluation, Intelligent Agent for Distant Education, Learner Behavior, Adaptive Hypermedia, Use of Multimedia to help learning, Virtual Laboratory, User Modeling, CIT in Algeria, Ontology in Distant Education on the Web and Virtual Laboratory Interface.

In this paper we will concentrate only on one part of this research project which concerns the virtual laboratory platform. We propose in this work an agents-based architecture of a prototype of a virtual laboratory for distant experiments and distant measurement on the web. This environment makes it possible to do distant practical work and experiments with virtual tools in experimental sciences. The trainers can conduct interactive sessions of practical work with the help of appropriate scenarios using the metaphor of the practical work's sheet.

In this work we start by describing the concept of a virtual laboratory, the motivation on which we based our design and the desired objectives of this kind of platform in an educative plan. Then we present a conceptual view of a digital work environment of a virtual laboratory designed for the learner to resolve the distant practical work making use of agents-oriented methodologies [3, 4, 6].

2. Motivation and Objectives

According to [8, 9], a virtual laboratory is defined as "An electronic work space for distant collaboration and experiment in research or any other creative activity, produce and deliver results using distributed information and communication technologies."

The virtual laboratory is different from a real laboratory or a traditional laboratory. However, the virtual laboratory is not considered a replacement for or a concurrent to a real laboratory. The virtual laboratories are possible extensions opening new possibilities not doable entirely in a traditional laboratory with an affordable cost. They can cover almost all human intellectual efforts [9].

In general, the development of such an environment requires a multi-discipline competence: knowledge on how to use instruments to do experiments, competence in distributed computing and familiar with communication protocols and web technology. Due to this complexity, in many cases, researchers concentrated on building particular laboratories that are applications-oriented or even for a specific experiment [1].

The motivations that guided us to the development of this work were based initially on the fact that the AVUNET (Algerian Virtual University) platform does not allow practical work from a distance because it does not have a distant laboratory or a virtual laboratory. In our opinion a virtual laboratory is a must component for such an environment to complement the theoretical knowledge acquired by the learners using collaborative or cooperative practical activities. Also, the idea of proposing a conceptual architecture of virtual laboratories is justified by:

- The possibility to do some experiment that can not be done in a traditional laboratory for different reasons: very high cost, time taken by the experiment is excessive; learners' competence is not adequate, etc.
The experiment can be simplified because the operations to be performed are easier and can be done much faster than in a real experiment.

The tools being used for the experiment and the person doing the experiment do not face any danger in case of mistakes.

The computer can guide the learner during the work and also it can save the steps accomplished up until any given moment, so the learner does not have to finish the whole experiment in a continuous manner.

If the simulation is very complex, the learner has the possibility to investigate and collect more information while doing the experiment, which is very difficult (if not impossible) to do in a real experiment. He/she can decide about his/her own strategy, try as many ways as he/she desires which results in a real research.

The computer gives the learner the possibility to make mistakes without major penalties except the loss of time.

3. Multi-Agents Architecture of Distant Practical Work

Distant practical work [10] designates a classical practical work (which we can find in high school or any engineering school) which has modified, in particular extended to be accessed remotely via internet. The distant practical works are very interesting alternative to traditional practical [2] works because of the economical gain and the possibility of access by a wider audience who did not have access to technologic tools very sophisticated for this kind of training. Also the practical work offers excellent occasion for intense exchange between the learner and the trainer supporting the conflicts socio-cognitive thus making easy to learn individually and/or collaboratively via social interactions.

The pedagogical objectives behind the practical works are [5]:

- To provide illustrations and demonstrations of theoretical principles presented in the lecture so that the learners can have a better understanding.
- To motive the students and focus the interactions between students and tutors
- To develop practical competence that are very important in any professional training
- To develop collaborative and team work
- To introduce the students to the real practical work done by engineers and scientists

A distant practical work in a virtual laboratory is composed of the following steps:

- Practical work conception: After the reading of the practical work sheet, the learner chooses the virtual objects that are needed for this specific experiment and assigned to them the required properties.
- Doing the experiment: In this stage the learner manipulates the different objects to do the experiment.
- Saving the results

In order to develop a virtual laboratory platform for distant practical work and to show its dynamic aspects, its implementation is a must. The agent and multi-agents system (MAS) paradigms [7] are used to realize the virtual laboratory. Figure 1 shows the system's hierarchical structure. It is composed of three levels: Interface level, Virtual laboratory MAS, and the databases sets.
Our work is concerned with the second level which is the multi-agents system (MAS) to implement the distant practical work. On one hand this MAS allows the instructors to supervise the learners' activities in real time or at a later time. In order to do that the instructor consults a database of scenes archived instantly when the student was doing the experiment (in the case of delayed supervision). In the case of real time supervision the agents of type Agent_captor are used. On the other hand, this system guarantees the learners a collaborative/cooperative environment to resolve the problems faced in distant practical work.

Based on the expected objectives of multi-agents system, we differentiate two agent categories. The first category of agents are specialized for each kind of human user either learner or instructor. The learner user interacts with three artificial agents: Agent_Interface, Agent_navigator and Agent_Assistant. The instructor interacts with two artificial agents: Agent_Interface and Agent_navigator. The second category gathers agents that manage and control the virtual objects and the virtual environment where the experiment takes place. The agents in this class are: Agent_Workspace, Agent_Captor, Agent_Archivor, Agent_Supervisor and Agent_System.

The role of each agent is described as follow:

- **Interface Agent**: Its role is to display and manage the user's appropriate interface (learner, Instructor, Administrator) for each event.
- **Assistant Agent**: Its role is to help the learner in solving his/her practical work by orienting him/her during each step of the distant step of the practical work.
- **Supervisor Agent**: It allows the instructor to control and supervise the work of a group of learners while they are solving their practical work by exploiting the screens captured by the captor agent.
- **Captor Agent**: The different screen that appear during the manipulation of a distant practical work are captured by the agent called Captor Agent.
- **Archivor Agent**: Its role is to keep track of the learner by saving the scenes at different stages. This action helps the instructor for the learner's evaluation.
- **Workspace Agent**: It has all information concerning the work space and virtual environment where the practical work takes place. It controls and manages the virtual objects present in this work space.
- **System Agent**: Its role is to manage the learner's portfolio and the instructor's notebook, users' account, learners groups, different databases, pedagogical content (practical work sheets, their solution, virtual objects …etc) and to verify the authenticity [12].

3.1. Agents Society

The virtual laboratory deals with the two kinds of users: learners and instructors who access the virtual laboratory via peripheral equipment by specifying a user name and a password. The entire system is modeled as interaction between many artificial agents and human agents (learner, instructor, and administrator) that is shown in figure 2.

![Interaction Diagram](image)

**Figure 2: Interaction Diagram**

The learner is the most active actor in our system. He/she must complement and evaluate his/her theoretical knowledge learned during the lecture by doing the practical work. According to the interaction diagram shown in figure 2, when the learner wants to solve a distant practical work a set of agents is made available by the virtual laboratory multi-agent system. First the learner must read the appropriate practical work sheet using the Interface Agent the Navigator Agent to send the request to the System Agent. The latter agent gets the practical work from a database designed for this purpose. During the solution of the practical work the learner will manipulate the following agents: System Agent, Workspace Agent, Archivor Agent, Captor Agent and Supervisor Agent. During all the stages of the distant practical work, the archivor agent is active keeping track of the scenes and saving them to be used later for evaluation purpose. The instructor can evaluate the
work of the group of learners by accessing the scenes of the concerned learners in the database. He/she can supervise the learners via the supervisor agent and captor agent. The system agent makes sure that the different interactions between agents present in the system are done properly. It participate to search the information saved in an electronic library [11] which contains all theoretical courses taught during a particular training, all kind of references and their content (books, papers, MSc and PhD thesis).

4. Conclusion

In this paper, we have presented an agents based architecture of a virtual laboratory for distant experiment and distant measurement on the Web. It is characterized by a modular and evolutionary structure of independents and reusable components that can be assembled to create new and different experiments. From the architectural point of view, our model is a distributed environment characterized by the presence of collaboration/cooperation concepts. It allows the learners to better experiment with practical work. This architecture reflects in as a close as possible the architecture of a traditional laboratory. In conclusion, an implementation of the proposed solution is a must to validate this architecture.

References


