JORNADAS DE SEGUIMIENTO

PROYECTOS EN TECNOLOGÍAS DE LA INFORMACIÓN

DESCRIPCIÓN DE RESULTADOS

Referencia del proyecto: TIC99-0252
Título:
INGA_LAN: Herramientas inteligentes basadas en Realidad Virtual para ayuda a la Formación y Evaluación de capacidades técnicas del personal

Investigador principal: Isabel Fernández de Castro

Dirección de contacto:
Fac. de Informática UPV/EHU, Departamento de L.S.I.
Paseo Manuel de Lardizabal 1, 20018 SAN SEBASTIÁN
jipfecai@si.ehu.es

Datos sobre el grupo investigador:

¿Se trata de un proyecto coordinado? NO

Referencia del proyecto:
Investigador principal:
Dirección de contacto:

Referencia del proyecto:
Investigador principal:
Dirección de contacto:

1. PROJECT OBJECTIVES

In this project we planned to develop a set of tools to provide and facilitate training and assessment for technical skills of industrial operators. Knowledge-Based Systems technology integrated within 3D virtual reality environments had been proposed as a basis, besides a demonstrator linked to vocational training in professional developments was intended to prove the technology.

INGALAN was based on the results of a previous project —FROGALAN—, which explored the use of the above-mentioned techniques. One of its main results was an experimental prototype to assess operators in the process of mechanising by cutting chip. So two main objectives were proposed:

A. To refine and generalise the FROGALAN prototype in order to build a set of knowledge acquisition tools referred to the mechanising procedures. Such tools will facilitate the teachers' labour allowing them to define a variety of scenarios and evaluation criteria, and even to plan different activities for each trainee.

B. To build a prototype of intelligent training system to repair the skill lacks in the mechanising domain. The system will be autonomous in the sense that it will not need external technical support. Taking as a basis a diagnosis of the user's knowledge lacks and her characteristics, the system will produce an adequate instructional plan and execute it by dynamically adapting it to the concrete development of the current session. In addition, it will use several strategies fundamentally based on the virtual reality training potential.

These general objectives have been refined into a series of concrete tasks grouped around three main activities:

T1: To build the knowledge acquisition prototype concerning the mechanising procedures. FROGALAN will be taken as initial basis. It must allow: to add new exercises, to include new students, to visualize the information of the existing pupils, to plan the student's activities.

Tasks

- **T1.1.1**: Frogalan experimental evaluation
- **T1.1.2**: Study of experimental results and prototype refinement
- **T1.1.3**: Generalizing of the target machine-tool
- **T1.1.4**: Defining the structure and contents of a generalized graphical system
- **T1.1.5**: Designing the knowledge acquisition module
- **T1.1.6**: Designing the interface of the knowledge acquisition module for the teacher
- **T1.1.7**: Designing the visualization system for the student interface
- **T1.1.8**: Developing the knowledge acquisition module
- **T1.1.9**: Developing the interface for the teacher
- **T1.2.1**: Modules Integration
- **T1.2.2**: Experimental validation
- **T1.2.3**: Improvement of the system from experimental results

T2: Exploration and evaluation of low cost virtual reality techniques to be used in the learning system: non-immersion stereoscopic systems, dialogue systems based on 3D sensors.

Tasks

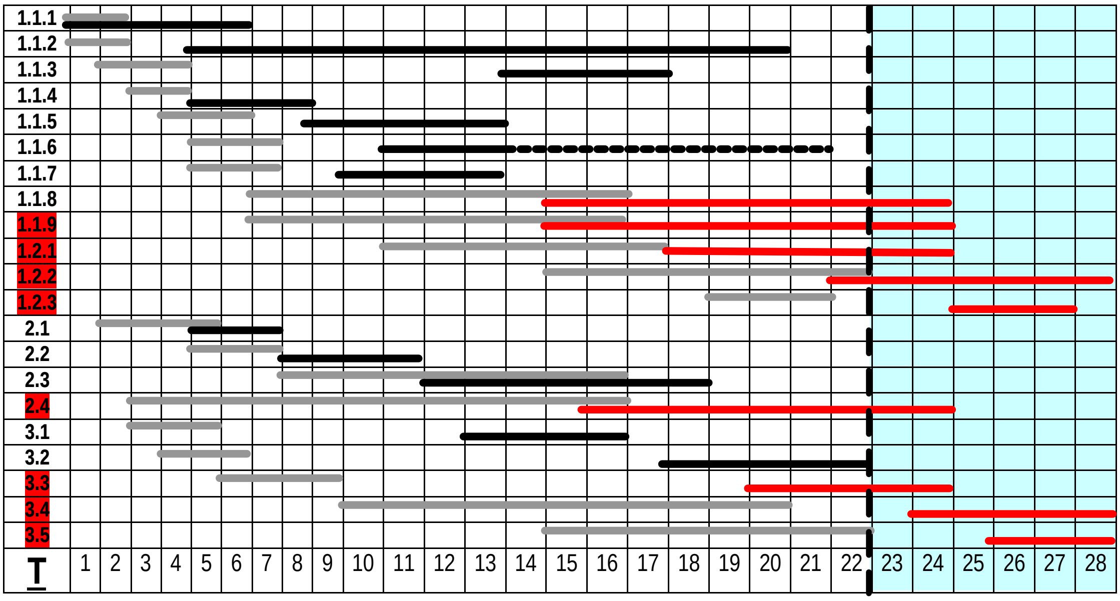
- **T2.1**: To explore the use of 3D sensors to pick up user actions.
- **T2.2**: To design the 3D pick up module
- **T2.3**: To develop the 3D pick up module
- **T2.4**: To develop the visualization system

T3: Development of the demonstrator prototype of an intelligent training environment. It will produce an instructional plan taking as a basis the user's knowledge.

Tasks

- **T3.1**: Defining the general problem of learning and its requirements, in the mechanising context.
- **T3.2**: Definition of the contents of the teaching task and the selection strategies.
- **T3.3**: Analysing the instructional goals and strategies of the teaching-learning process.
- **T3.4**: Building the prototype by using the IRIS authoring tool
- **T3.5**: System experimental evaluation

The time planning below shows the estimate schedule (light grey bars) for the project together with the actual development (black bars). Some internal problems in the observer-promoter partner have caused connected delays that affect most of the exposed tasks. In spite of it, several activities have finished as was foreseen in the project planning; however some others, those shadowed in the figure, need an extra development. Six new months have been included in the planning to cover the non finished activities



2. LEVEL OF SUCCESS

2.1. Development of the knowledge acquisition prototype. T1.

This area is organized around three main aspects: the knowledge acquisition system, the 3D-virtual reality user interface and the integration process. All of them are based on FROGALAN, a system oriented to assess students' knowledge in the machine tool domain.

Therefore, the project started by evaluating experimentally the use of FROGALAN (T1.1.1) (Ferrero *et al.* 1999). Its results formed the basis to improve and extend the assessment system. Several questionnaires were used with students and a collection of users protocols were recorded (D6.1). A deep analysis of the results was carried out by the observer entity (IMH – Institute of Machine Tooling), and their critics and comments formed the new requirements for refining the system. Several main lacks were found whose treatment produced a very improved second prototype. They referred to: the manageabilility of the student's interface, the fiability-certainty of the errors detected, the criteria to valuate the student's answers and the style of errors report. The experiences showed that: a good set of errors was due to an uncomfortable, and many times unintelligible, interface; the initial catalogue of errors provided by the IMH was neither correct nor complete; different teachers used different assessment criteria; and the errors inform generated by the system for each student was too full or exhaustive to provide any advantage or to be a valuable help for the teacher. Besides, new functionalities about the assessment exercises were demanded. The second prototype has tried to solve all these problems, although it has required an effort greater than the planned one (T1.1.2). We hope it works properly but it must still be tested.

Next concern was the generalization of the target machine tool, as the student must be sufficiently skilled in all of them and the assessment system must allow for their definitions and uses. This generalization involves the knowledge representation problem and the graphical visualization aspect.

The knowledge representation problem is faced with a double analysis, from IMH and us, of the structural and functional characteristics of two machine tools: the lathe —used in FROGALAN— and the milling machine. It shows evident parallelisms between them (T1.1.3) (D9, D11). Therefore, a first positive conclusion about the possibility of building a generalized assessment system for students on machine tooling is obtained.

The graphical visualization aspect has been defined through several iterations obtaining a "configuration definition file" that encapsulates relationships. For object definition we have selected wavefront's ".obj" format (T1.1.4).

The new requirements for FROGALAN concerning the exercises characteristics were very useful to define the requisites and architecture of the knowledge acquisition tools —KAT— (T1.1.5)

(Ferrero *et al.* 2000). The KAT will allow the teacher to define a set of exercises and automatically will generate an assessment system usable directly by the student. The teacher interface was also designed with these bases (T1.1.6). The knowledge acquisition tools are now being implemented together with the teacher's interface (T1.1.8, T1.1.9).

Due to the initial severe delay, several tasks from this group remain to be done: module integration (T1.2.1), evaluation of the knowledge acquisition prototype (T1.2.2) and new refinements (T1.2.3). They should be carried out during the next six months.

2.2. Exploration and evaluation of low cost virtual reality techniques (3D). T2.

The main goal within INGALAN's second activity has been to investigate how 3-D manipulation can be brought into the teaching and training activities in vocational and technical schools. In our case, this goal has one main constraint: the manipulation system must work tightly coupled with an AI training system. The nature of our target users imposes the following physical restrictions:

- The cost of the H/W required to run the new system must be proportional to the usual investments in schools. So it must not be much different from the H/W required for other teaching or training activities like: CAD, calculations, planning, multimedia learning, etc.
- The system should not demand either much more room than that used by a PC user.

Our first problem was to select the characteristics of the hardware. We were completely sure that we needed 3D graphic acceleration. We considered that stereoscopic images could be very useful, and found that the technology was developing so fast that they should be considered within the project. In the beginning we studied the viability of using hand sensors (globes and tracking h/w) (T2.1). However, we discovered that the evolution of those products was slow and their cost/performance ratio did not seem to improve very fast. As hand gestures had to be discarded, we looked for another solution. We started studying different h/w that could allow a natural 3D interface to navigate through the virtual environment and perform the actions. We selected one of the multiple game-pads that were available at the moment.

Now, that two years have passed, we have been confirmed in our earlier expectations that lead to our current h/w architecture: common PCs now integrate 3D cards that meet the requirements that allow basic 3D interactive visualization, and hand gear have not evolved much more in the direction of our requirements. On the other hand, we feel very happy with the common game pad we have selected: most young people are used to them and to the 3D gaming environments that have spread their use.

A second problem was to select the programming environment. In a previous project we had developed both user interface and 3D visualization using Java and Java 3D. However we met serious problems with Java 3D when trying to use the stereoscopic abilities of the graphic card: there were no available drivers and, even worse, they were not neither promised nor expected. We also found problems to communicate with the gamepads. We also considered that the program would require running in full screen mode. So, 2D interfaces, if needed, would have to be placed in a different process either in a neighbour computer or display. At last, we decided to move into C++. We selected OpenGL to generate the images and DirectX to communicate with the gamepad. Using other alternatives provided a slower global response of the system.

In the research for background information we found descriptions of several 3D manipulation systems. However, they provided very little information about their system architecture. So, we had to figure our own architecture (T2.2).

The user is present in the scene through a textured representation of his/her hand (T2.3, T2.4). Actions on the gamepad are traduced into movements of the viewpoint. The hand remains in the centre of the screen and the motion feeling is produced by the changing of position of the hand respect to the environment.

Our current system allows the user to pick the different elements (tools, machining tools, etc.) that are present in the environment. They can be placed into position or removed and carried back to any shelve. When the user sets a specific item near a possible target (i.e. an screw driver to an screw) the system provides a 3D feedback. The user can issue a command, and following the command, the item is automatically placed into position. In this way we try to provide the user with a simple mechanism that allows demonstrating his/her knowledge but at the same time does not place the burden of placing accurately each object. Similarly, levers, buttons and other gadgets can be manipulated by the user.

Most systems devote a lot of effort to the problem of geometric interference. We have tested some available collision detection systems, but we decided that in our case, we needed a different approach. On the one hand we prefer to provide the user with a motion as free as possible, on the other hand, some restrictions should be applied. We are currently working in a scheme that will allow some sort of penetration among objects and at the same time will avoid the disappearance of one object within another.

On the other hand, as the current trends in educational technology promote the use of Internet and the observer organization —IMH— was very interested in this possibility, we tried to evaluate the difficulties of a cooperative visualization. In order to transport our developments to Internet we used the 3D visualization module, originally written in Java and Java3D, to create a small tool that allows the cooperative visualization of CAD models through the Internet.

2.3. Prototype of intelligent training environment. T3.

Finally, the project schedule included the development of a demonstrator prototype of an intelligent training environment -DITE. It should be based on the assessment process developed in T1 as well as include new teaching–learning activities, those identified by the IMH teachers and suitable to be considered in an automatic system provided with a 3D student interface. The system must produce an instructional plan taking into account the diagnosis of the user's knowledge and her characteristics, and to execute and adapt it dynamically according to the development of the current session.

This activity forms the last part of the project and therefore accumulates all the previous delays. So, just a partial objective has been covered: the teachers of IMH have defined the educational general requirements (T3.1). They include the contents, concepts and procedures, to be conveyed to the student together with the set of learning activities developed currently at the institute (D10).

D10 document was used as a knowledge source to define the content and pedagogical structure of the teaching domain (T3.2). The pedagogical relationships among domain elements will be used to establish a partial ordering which will sequence the student's learning focuses. This task is being developed currently according to the necessities of the IRIS authoring tool, which will be used for developing DITE.

Besides, D10 document will provide the actual strategies and teaching-learning objectives used in IMH. They should be analysed to determine their suitability for an automatic training system (T3.3). This task remains to be done together with the construction of the prototype (T3.4) and its evaluation (T3.5).

3. RESULTS

3.1. Training

Several training courses have been attended:

- Aspectos tecnológicos para enseñanza y aprendizaje colaborativo. *B. Barros, Universidad Nacional de Enseñanza a Distancia, Madrid*. Febrero de 2001.
- Nuevos planteamientos en la resolución de problemas I: *Sistemas multiagentes*. *A. García, Universidad Politécnica de Madrid*. Febrero de 2001.
- Nuevos planteamientos en la resolución de problemas II: *Ontologías*. *A. Gómez, Universidad Politécnica de Madrid*. Julio de 2001.
- Multi-Agent Systems & Applications. ECCAI Advance Course, European Agent System Summer School. Czech Technical University. Praga, Julio 2001.
- Tutorial: A technical Overview of Computer Supported Cooperative Work CSCW. ACM, Filadelfia, Diciembre 2000.

3.2. Publications

- "Herramientas de autor para enseñanza y diagnóstico: IRIS-D". *B. Ferrero, I. Fernández y M. Urretavizcaya*. Inteligencia Artificial, pag. 13-28. Primavera 2001.
- "Multiple paradigms for a generic diagnostic proposal". *B. Ferrero, I. Fernández de Castro y M. Urretavizcaya.* Procc. Intelligent Tutoring Systems (ITS 2000). Poster pag. 653. Junio 2000.
- "Diagnostic et évaluation dan las systèmes de "training" industriel". *B. Ferrero, I. Fernández-Castro y M. Urretavizcaya*. Science et techniques éducatives- Simulation et formation profesionnelle dans l'industrie. Hermes Science Pub. ISBN 2-7462-0168-2. pp.189-217 (1999).

- “CSCW for foundry design using Java 3D”, D. Borro, L. Matey, H. Sánchez, I. Recio, A. M. Garcia-Alonso. Presentation at ACM 2000 Conference on Computer Supported Cooperative Work, Philadelphia, Dec 4-6, 2000.
- “Visualización Cooperativa en Internet”, D. Borro, L.M. Matey, H. Sánchez, J. Ruiz, I. Recio, A. García-Alonso, XI Cong. Esp. Informática Gráfica (CEIG 01), Girona, Julio 2001, pp 309-312.
- “Herramientas flexibles de ayuda a la formación y evaluación de capacidades técnicas”. I. Fernández. *Sistemas de Interacción Persona-Computador.* M. Ortega y J. Bravo (Eds.)., pp 375-390 Ediciones de la Universidad Castilla – La Mancha, Colección Ciencia y Técnica Vol 32. 2000. ISBN 84-8427-093-9

Research reports and internal documents

- “Diagnóstico y evaluacion en sistemas de entrenamiento aplicados en entornos industriales”. B. Ferrero, I. Fernández de Castro, M. Urretavizcaya. UPV/EHU/LSI/TR 02-2000
- “Enhancing ITS authoring tools with procedural diagnostic capabilities” *B. Ferrero, A.* Arruarte, I. Fernández-Castro, M. Urretavizcaya. Research Report UPV/EHU/LSI/TR6-2001.
- D6.1.Estudio de campo. *Galan: Apoyo a la docencia.* Enero 2001.
- D7. Integración de la interfaz de usuario con el sistema de diagnóstico. *Grupo de Realidad Virtual*. Junio 2000.
- D8. Experimentar la captación de gestos: sistema de manipulación del operador sobre el entorno de trabajo virtual. *Grupo de realidad virtual*. Diciembre 2000.
- D9. Trabajo en la fresadora. Departamento de fabricación, Instituto de Máquina Herramienta (IMH). Enero 2001.
- D10.Unidad didáctica. Operaciones de torneado. Instituto de Máquina Herramienta (IMH). *Galan: Apoyo a la docencia.* Octubre 2001.
- D11.Generalización de la Máquina Herramienta y sus operaciones. *Galan: Apoyo a la docencia.* Julio 2001.

3.3. Technology transfer

In March 2001 we made a presentation of the state of the art of cooperative visualization and its applications to the companies in the Machine Tooling area. We received an attendance of more than 50 companies and over 70 individuals. We have tested the system with up to 13 users visualizing the same CAD model.

We have provided advice to several companies and we have made tests in the premises of five of them (CEIT, DDM, FUNCASA, Ibermatica C4, Ormola).

Ibermatica C4, San Sebastián
CEIT, San Sebastián
MEIN, Ezkio-Itsaso (Guipúzcoa)
Ormola, Azkoitia (Guipúzcoa)
DDM (Distribucion Diseño Mecanizado), Eibar (Guipúzcoa)

The UPV/EHU has promoted the creation of Multidisciplinary Universitary Groups (GUM-Grupos Universitarios Multidisciplinares), one of which is devoted to the application of new Technologies in Education. INGALAN project has been presented to this community.

3.4. Collaboration with other research groups

Several collaboration lines have been opened that will facilitate the adaptation of the INGALAN project to new trends: system architecture based on modular components and oriented to Internet by means of agents’ technology, structures for promoting collaborative work, and knowledge acquisition based on domain ontologies. These groups are:

Agents group, UPM. Ana García Serrano
Ontologies group , UPM. Asunción Gómez
Collaborative learning. UNED. Beatriz Barros

Concerning the graphical visualization area, we have recently started conversations with other groups. CEIT (San Sebastian) is currently engaged with a European research project whose results could be enriched with our AI expertise, so both sides consider that our future work could be complementary