WEB-BASED COOPERATIVE TEACHING AND LEARNING OF MECHATRONICS IN VOCATIONAL EDUCATION – NEW FORMS OF MIXED REALITY -

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Distributing mixed realities in learning environments will open up new possibilities of local and distant cooperation in teaching and learning processes. Some requirements from the new vocational learning field mechatronics will be presented and our approach to meet them in a European Project, DERIVE-Distributed Real and Virtual Learning Environment, is shown.

Motivation

Vocational education in Germany is based on the Dual System, where students partly work in a company and partly go to a vocational school. Although this model theoretically provides a good combination of practical concrete work for the acquisition of skills and generalized theoretical knowledge, it often suffers from a large gap between learning at school and learning at the workplace. The claim for a better cooperation between learning places is lasting. The emerging profession of mechatronics (an integration of electrical, mechanical and information technology) requires even more cooperation, as the integration of the former professions industrial electronics, industrial mechanics and information technology will highly depend on the ability of the learner to work together with experts filling the unavoidable gaps of their now threefold learning and work areas. The curriculum explicitly states the necessity to work in teams, to cooperate and to communicate using data-processing means [13]. More than this, we are convinced, that it is necessary to come to a closer cooperation between teachers and learners at workplaces and schools, system providers, research institutes and teacher education institutions. The challenge is not only, to verbally communicate via distance about theoretical subjects or work activities, but to act on a common distributed and shared technical system in a verbal and non-verbal manner. In a European project consortium[1] we are developing a new distributed learning platform to support this.

A new learning environment

In a former European Joint Project on Educational Multimedia, we developed a local learning environment for the application area of pneumatics, where we coupled real equipment with different virtual representations (BREVIE, Bridging Reality and Virtuality with a Graspable User Interface) to support traditional group work and the process of abstraction and formal representation on a computer (*Fig. 1-3*).

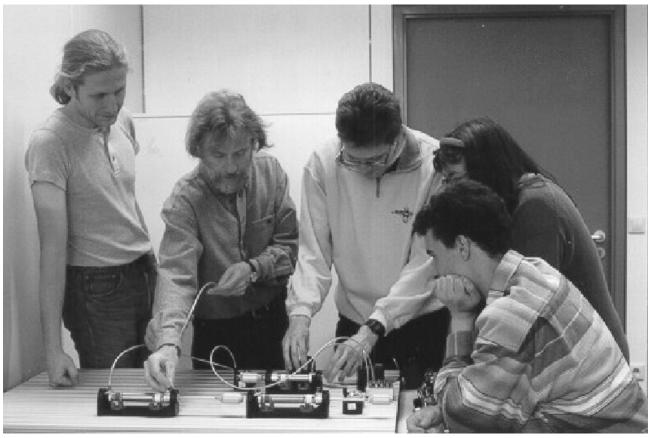

Fig. 1: Cooperative Learning in Reality

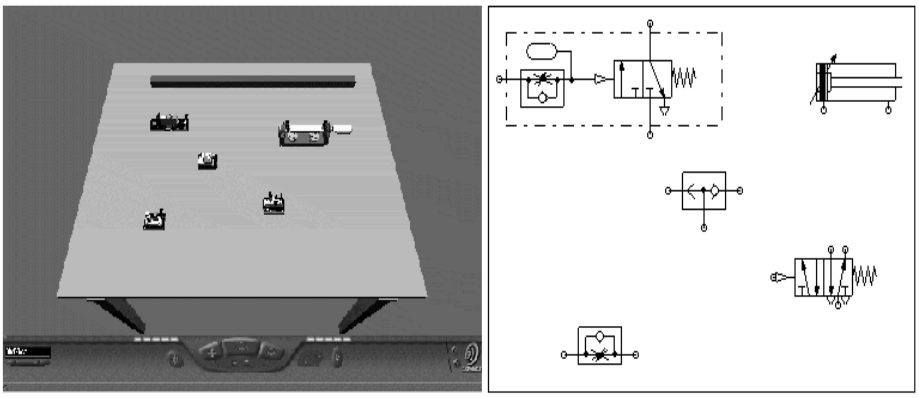

Fig. 2: Different Levels of Abstraction

[1] Festo Didactic, Stockport College, Escola Superior de Tecnologia y Gestao /Leiria, Schulzentrum Holter Feld/Bremen, Inst. Work Psychology-ETH-Zuerich, Inst. ARTEC-University Bremen

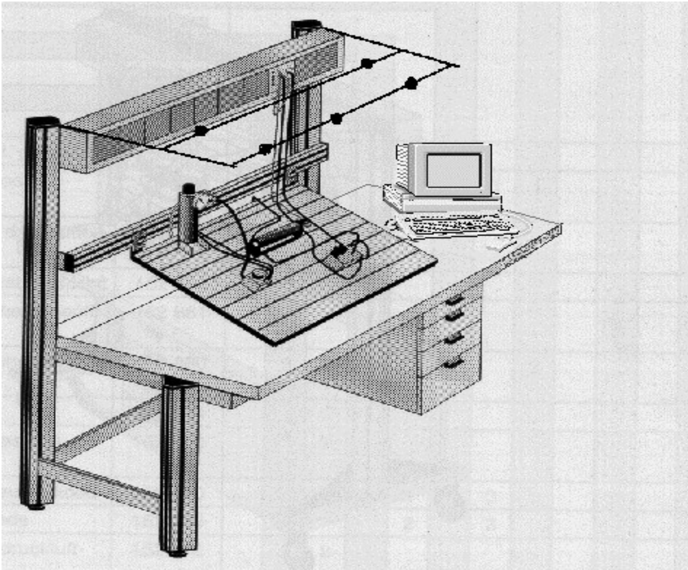

Fig. 3: Synchronous Modeling in different Worlds

Manipulating the real parts automatically generates and changes the virtual counterparts correspondingly. The coupling is done by an interface based on image recognition. We applied this concept for the design of pneumatic circuits and evaluated its use in several European vocational schools (*Fig. 4*). In our learning environment it is possible to freely shift between a) working with real components on a laboratory-desk, b) initiating from there some multi-media background help and c) working at the PC with simulators and VR-worlds. The environment strongly supports collaboration within learning groups.

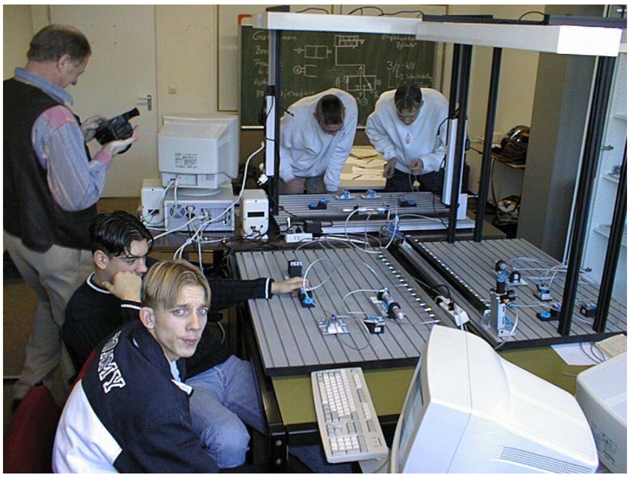

Fig. 4: Constructive Learning Environment in Use

The close coupling of real and virtual worlds brought up the idea, to distribute the virtual representation and use it as a bridge between different locations via Internet to support also co-operation between dislocated learners and learning groups.

In the European project DERIVE (Distributed Real and Virtual Learning Environment for Mechatronics and Tele-Service), we extended the application field from pure pneumatics to mechatronics, an integrated qualification for electrical, mechanical and information tasks. Learning of mechatronics requires even more cooperation between learners and workers, as their knowledge is rather incomplete because of the broadness of necessary facts and methods. Students should therefore learn to communicate and cooperate on complex tasks in multidisciplinary groups. In a contribution to the I3 workshop on collaborative learning (San Francisco, 2000), we concentrated on the aspect of bi-directional coupling of real and virtual phenomena and its pedagogical implications [7]. This presentation will concentrate on the aspect of web-based cooperation, *Fig. 5*.

Our close coupling of real and virtual objects is based on a concept of *Hyper-Bonds* which is a generalized mechanism to sense and generate various physical phenomena using the unifying concept of bond graphs and electro-mechanical I/O-devices as interface between the real and the virtual world [8]. Hyper-Bonds support a bi-directional connection between reality->virtuality and virtuality->reality. This concept allows a cooperative modeling, where parts of the system are within reality at one place, others being at a different location in virtuality, *Fig. 6*.

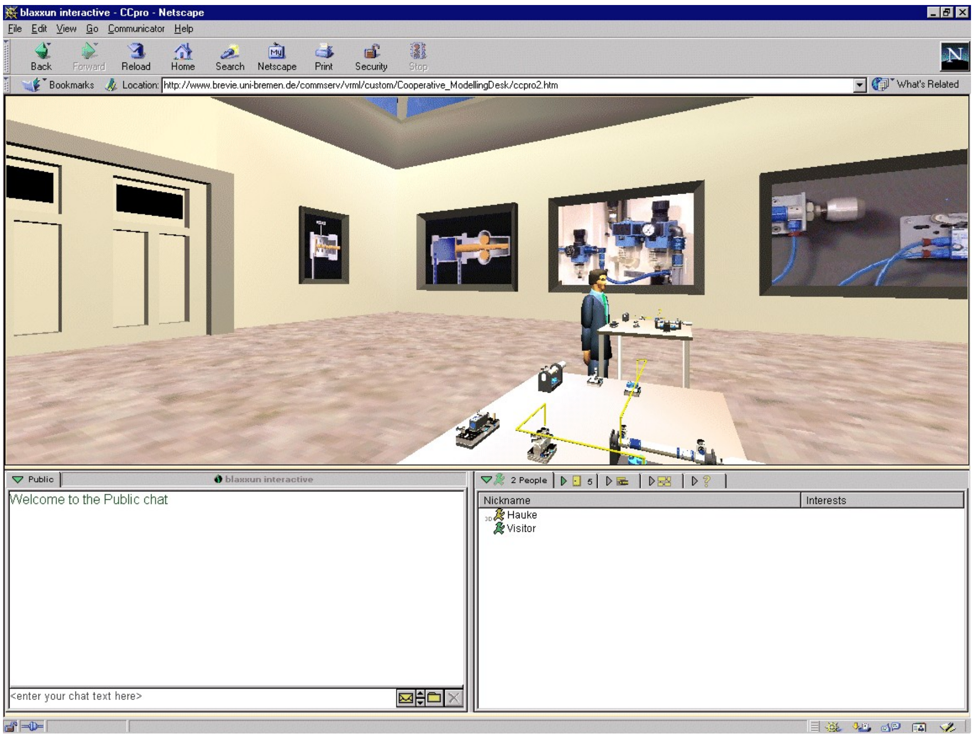

Fig. 5: Distributed virtual Learning Environment coupled to reality

If we want to investigate parts of a complex virtual system in reality, we select the virtual object and draw it to the lower edge of the screen. It disappears from the screen and its connections end on a virtual connection bar on the lower part of the screen. A corresponding real connection bar in front of the screen, controlled by an interface processor, allows the connection of a corresponding real part, being placed on the laboratory desk. The system still behaves as a whole, even if it is distributed in reality and virtuality. This is possible because physical phenomena are sensed or generated, depending on the recognized overall structure of the system and the sensing and generating mechanism in the interface.

The work can also be done in the opposite direction. We have a real system of some parts and want to replace a sub-collection of parts by their virtual representations but still have a physical behavior of the whole system. We disconnect the real parts and move them towards the screen. As this action is recognized by the camera system, virtual duplicates show up on the screen. Connecting their open ends to the virtual connection bar and correspondingly the open real ends to the real connection bar will preserve the overall behavior.

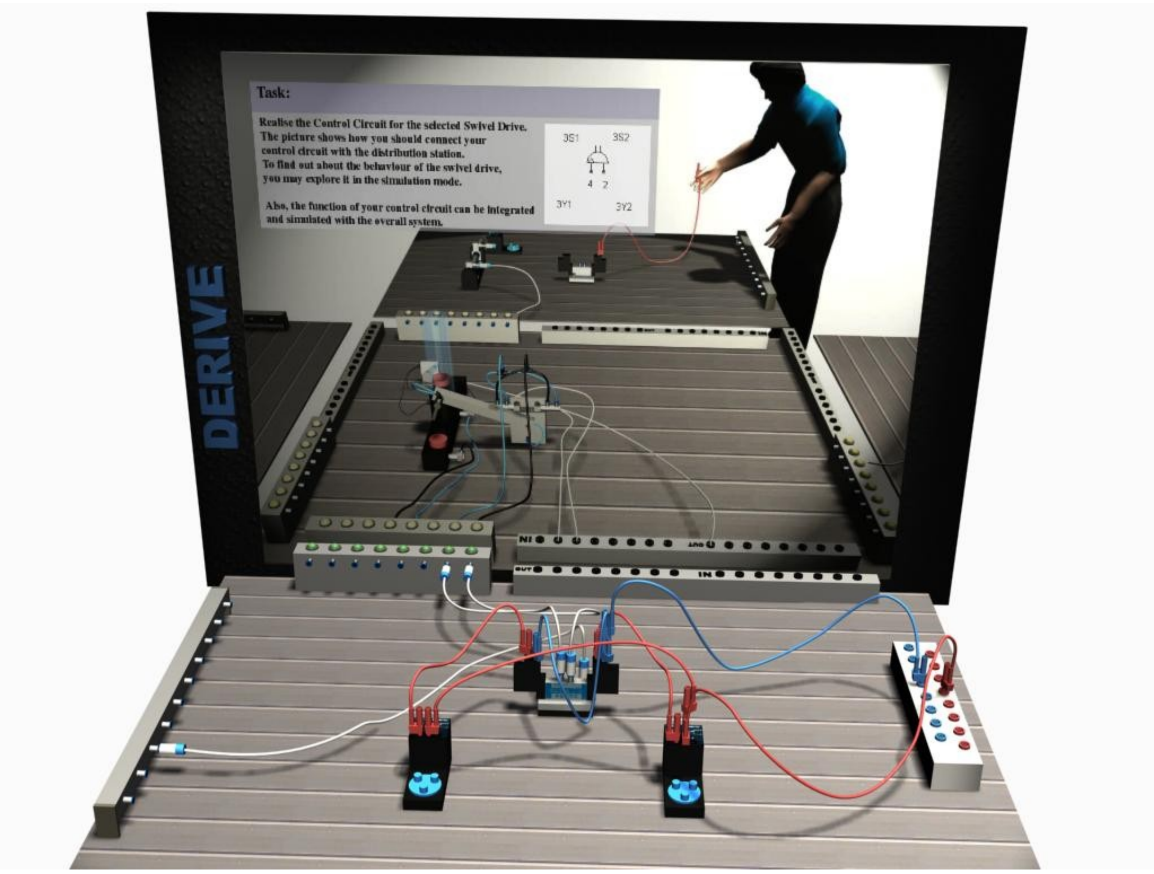

Fig. 6: Cooperative learning in distributed virtual and real spaces

This environment allows several forms of cooperation:

a) a local group, standing around a real table, is cooperating on a task to build a technical solution in reality, but having the possibility to integrate the solution in a more complex virtual context (simulated work situation)

b) a distributed group is working on a common solution of a complex task. Parts or aspects of the system may be isolated and locally handled but may be published to the common ground (WEB-VR) to open a discussion and cooperative actions.
c) teachers may present systems with black boxes, to be specified in detail by distributed concurrent learning groups, finally presenting, discussing and improving their individual solution against the overall system.
d) teachers may present faulty systems challenging distributed learners to cooperatively find the faults by analytical discussion and experimental trials.

Related Work

Coupling tangible objects of real work spaces with information spaces of digital representation has been subject of increasing interest during the last decade. Weiser [18] set up the vision of a room with ubiquitous computer generated information and action. Wellner [19] emphasized the paradigmatic shift of computer-augmented environments: back to the real world. Fitzmaurice et al [9] lay the foundations for graspable user interfaces. Resnick [14] introduced behavior construction kits based on real objects. Since then, many prototypical applications have been published. To name only a few: Kang & Ickeuchi [12] proposed a concept of programming robots by concrete teaching, the MIT Media Lab is hosting a strong research group working on tangible objects, see Ishii & Ullmer[10] and Brave/Ishii/Dahley [2]. Suzuki & Kato [17] use real AlgoBlocks for programming, Rekimoto [15] developed intelligent rooms, Rauterberg et. al [16] modeling desks with projection and real handles and a series of workshops now has a focus on the integration of information into real Buildings (Streitz et al. [17]). Breretron & McGarry [3] and Grund & Grote [11] give some empirical support for the importance of tangible media.
Our own approaches to couple real and virtual worlds are described in [4-8].
The bi-directional distributed coupling has not been found elsewhere.

Conclusion

By introducing a new kind of coupling between real and virtual objects, we are able to build systems as a connection of distributed real and virtual elements. This allows the cooperative learning based on real actions. One further challenge in our work will be the support of verbal communication by distant pointing and further projection devices.

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