HUMAN-MACHINE SYSTEMS AND PERFORMING ART

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Abstract: Some installations of human-machine interactions aiming at a close integration of art, science and technology will be presented. Several projects originating from a course *Production Informatics* have resulted in public performances demonstrating some aspects of a combination of real and virtual, human and machine performances: Theater of Machines, Media and Theatre (Methea), Theater in virtual Worlds, Mixed Reality Stages. *Copyright © 2004 IFAC*

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1. INTRODUCTION

The Art and Science of Mechanics, Automata and Computer Technology has a long tradition in performing arts, rooting back to the ancient Greeks. Theatre has always been influenced by imaginations of constructed humans and "born" artificial objects, like puppets or surprising mechanisms, deus ex machina. However, it has only been recently, that Computer Scientists recognised, that there may be interesting perspectives from performing art to inspire human-computer interaction solutions (Laurel, 1991; Stelarc, 1991; Murray, 2001; Leeker, 2001). In the subject area *Production Informatics,* being part of Bremen University Studies of Computer Science, we ask students to develop small products and present a final performance of their real and virtual machines. However, only recently this work intensified into larger 2-4 semester-projects with an explicit performing art orientation together with J. Richard (Richard, 2002). Students from the subject area *Informatics* cooperated with students from *Digital Media* and *Culture-Sciences.* Some performances with a strong focus on human-computer interaction will be presented and reflections undertaken, how these experiences could influence further education in human-computer interaction courses.

2. PERFORMANCES

2.1 Theater of Machines

In a struggle between two robots, a human robot player, a symphonic cellist, an avatar, a wooden marionette on a stage, the question acted upon was: "Who controls whom in the system man-machine-nature?". The cellist artist, played with great intuition and sensuousness some classical music in front of the stage, during which time an avatar, being projected on the wall started to move to this music, controlling at the same time a real puppet, hanging in an implemented actor mechanism. The cellist was then asked by some superior ghost to take over the control of the marionette and the avatar, as they started to develope an independent behaviour. The cellist thus moved into some gallows-device, where he could use several strings connected to his arms and limbs to control the marionette and the avatar. While he was trying to control the machinery, it could also be interpreted, as if he was just another living marionette controlled by the programmers behind the curtain in charge of the whole installation. A human

robot player then tried to take over the cello of the musician who opposed him and it came to a struggle between the robot player, two robots and the cellist with an open end left to the fantasy of the spectators.
The installation was run on a dedicated LAN of three computers, responsible for visualisation of the avatar, control of the marionette, sensing of the gallows and sound/music generation, interactively driven by some students behind the curtain.
The performance was presented at the 2nd International Theatre Meeting Stuttgart 2000. From a spectators point of view, it was not obvious, how the control mechanism in the scenario was working. The performing students had to undertake intensive work to develop the control algorithms and the graphical user interfaces to be able to act and react life in a sensible way on the course of the play.

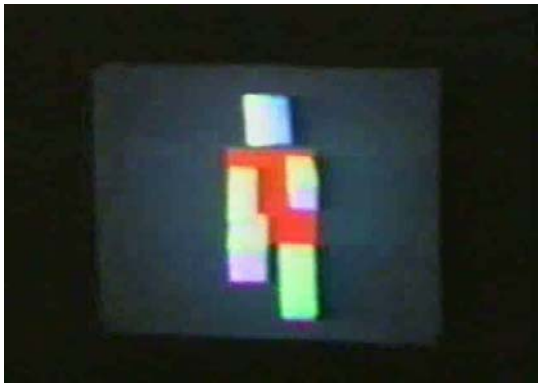

Fig. 1. Abstract Avatar on Screen

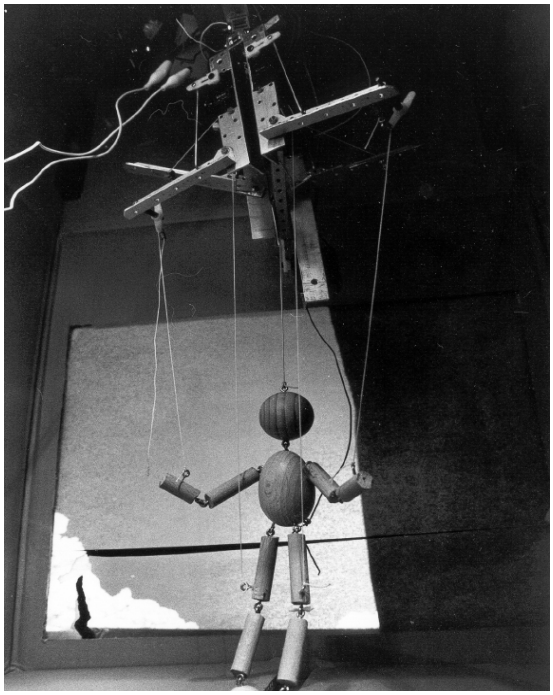

Fig. 2. Concrete Marionette controlled by Servo-motors

Fig. 3. Marionette in a Box on Stage

Fig. 4. Cellist in a sensory Gallows controlling a Marionette

Fig. 5. Stage with Robots and Actors

2.2. Sensory Garden

In a nightly open air performance within a Bremen public Park hosting an exhibition of roses ("A rose is a rose is a rose …"), students presented seven installations as a sensory garden, where visitors could experience various forms of human-machine interaction on the journey of a beauty statue through metamorphoses in real and virtual worlds. Some of them were

- Aegina, a sculpture, became alive as an avatar and could be moved by visitors via sensory foot-mat through a virtual world, being an abstract projection of the park on a planet surface, Fig. 6.
- Temple of Philosophers was half of a real temple-model expanded on a projection wall into virtuality in which two philosophers were reasoning about reality and virtuality, reacting on visitor's questions in a Weizenbaum-Eliza manner. When visitors pushed a forbidden button, the temple caught fire and could only be saved by using a real sensory air-pump to generate a simulated water-stream, Fig. 7.
- Flirt-bench. Visitors could sit on a park-bank holding and exchanging paper-symbols, seeing their video-image on a projection curtain in front of them. By Augmented Reality technology (AR Toolkit from M. Billinghurst) the symbols in their hands were recognised by the system and overlaid with 3D-objects, like flowers, avatars or animals, resulting in some interesting actions and reactions of visitors with regard to their augmented duplication, fig. 8.
- Foot-Keyboard. Visitors could dance on a floor-keyboard and synchronously generate sound and light, giving the impression they were dancing very accurate to a given music.

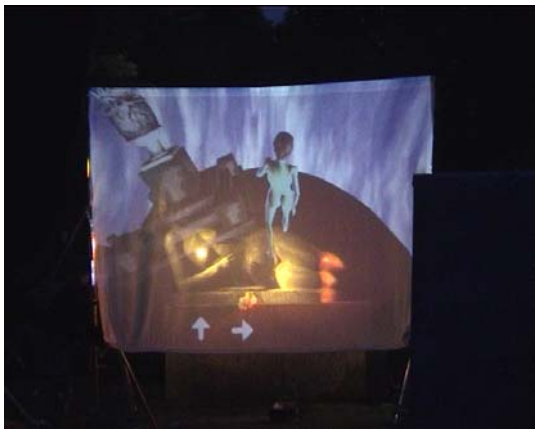

Fig. 6: Statue Aegina and her double on a projection wall

A virtual interactive post-presentation of the event has been produced by Osterloh & Schoch, 2002.

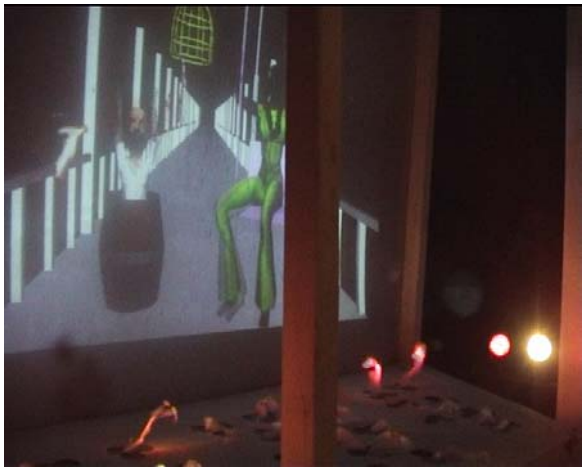

Fig. 7: Two philosophers under fire and water

Fig. 8: Video-Image capturing augmented by 3D-Images

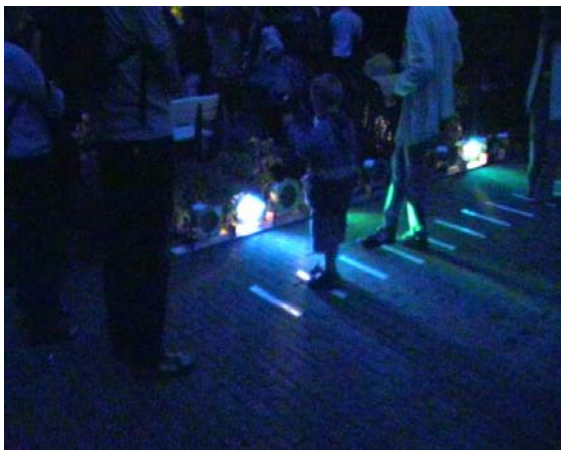

Fig. 9: Sensory Keyboard generating sound and light

An approach to explain the attractiveness of certain installations by categories of interaction design can be found in Hornecker et al. (2004).

2.3. Mixed Reality Stages

The course introduced various techniques and tools to mix real and virtual theatre scenes (AR-Toolkit,

Hyper-Bonds and Lego sensors, Fig. 10). With LegoMindstorm programmable bricks, various creatures and mechanical devices where created to animate a paper model of the before-mentioned public park.

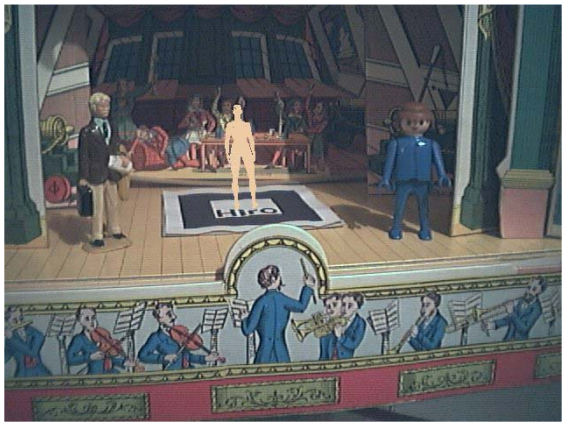

Fig. 10: Mixed Reality Stage

2.4. Theater in virtual Worlds

This project aimed at a play in a virtual world (Cybertown) and a performance of real actors in a room with real spectators. Students were asked to imagine and concretise a character of their choice. Eighteen participants each wrote a short introductory biography, designed a 3D-VRML avatar with a form and some movement patterns and developed a common short storyboard for a play: *A Wedding Rehearsal in Cybertown*. The nonsense story was about a group of people on a way to a wedding somewhere in the Galaxy, but as the space shuttle did not arrive, they played a Wedding Rehearsal. Real players were sitting at their PCs surrounding an auditorium in the centre of the real room (Fig. 11). They controlled their avatars in a common web-based multi-user virtual 3D environment (cybertown), Fig. 12, all having their own perspective on the screen, looking through the eyes of their avatar. An additional player controlled a camera-avatar and this view was projected on the central wall in the performance room (Fig. 11). The interactions in this performance where manifold: avatars of the actors, the real actors, the avatars of remote Internet-visitors and the real spectators could all interact in a specific way. This performance has been further investigated by Alder & Söhle, (2003) and compared with MEDEAEX_, a similar performance of Neora Berger Shem-Shaul (2003).

Fig. 11. Real Part of Wedding Rehearsal

Fig. 12. Wedding Scene in Cybertown

3. ENGINEERING DESIGN LESSONS LEARNED

The above projects offered different possibilities, intended and non-intended, to learn for engineering design.

Theater of Machines revealed the experience that a full automated system, as it was first intended by the students designers, requires much more insight, foresight and formal completeness than today offered by security and safety methodologies at a university Computer Science course level and probably available to most practical software-engineers. Often it is more cost-efficient, stable, designable and usable to aim at a semi-automatic solution. Designing a system with adequate freedom for man and machines, human-centred and interactively controlled within the course of action, requires other qualifications than formal thinking. In a former research and design project, we evaluated alternatives of degrees of automation of a planed large Container Terminal by modelling and simulation, Fig. 13. Rather than relying on a full automated, man-less, solution (with Container Bridges loading and unloading automatic guided vehicles), the design and simulation group recognised possible risks and burdens and preferred a semi-automated solution. This decision was probably promoted by the interdisciplinary of the simulation team.

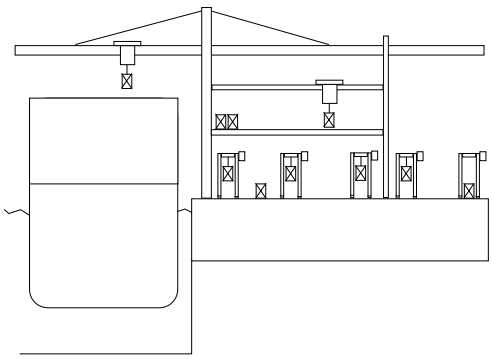

Fig. 13: Semi-automatic Container-Bridge

Sensory Garden was a system design with focus on joy of use and not primarily on usefulness (Crampton-Smith 2002; Crawford 2002).. Therefore traditional categories of usability and efficiency were not adequate to evaluate the installations. For a more detailed analysis see Hornecker et al. (2004) on this conference.

Mixed Reality Stages was an experience with new interface technology. Instead of reducing mixed reality to the augmented reality edge of the continuum AR (augmented reality) – AV (augmented virtuality), students discovered the whole range. Augmentation of reality was experienced not only as visual overlay of video images of reality with computer generated images, but also by other enriching computer generated physical phenomena, like air-pressure and electricity projected into the real world. Augmentation of virtuality by real physical phenomena (force-feedback, real object handles) opened up new perspectives on this topic: the importance of our focus of intention rather than the technical solution offering more virtual or real objects.

Theater in Virtual Worlds mainly demonstrated how restricted today's possibilities are to reach a theater-performance level as dense and immersive as traditional theater can be. Low bandwidth of the Internet based multi-user world *Cybertown*, too simple forms and behavior patterns of the avatars, too simple synthetic and remote speech and sound possibilities were at first disappointing for the students and the spectators having high expectations. Nevertheless, it was surprising, at least for students and advisors, how many interesting possibilities of interaction and expression using rather abstract objects, integrated in a real play, opened up. In future projects this could be a dedication to a design principle of simplicity and low cost.

4. CONCLUSION

Human-Computer systems have long been studied from a usability perspective, designing ergonomic interaction interfaces. Later, it was recognised to take a broader view on interaction design, seeing the function and the environment of a system in a more holistic way (Roger et al, 2000). Böhle & Milkau (1988), supported by empirical studies of automated systems in industrial applications, asked for a double perspective for the design of human-machine systems, one aiming at a rational objective distant design and one aiming at the support of a subjective emphatic relation to the machine in order to reach an overall optimal situation, in which "ironies of automation" are minimised. With our examples we try to support an education in automation technology in which the art perspective is emphasised. What could students learn in these projects beside traditional engineering knowledge and skills, like sensor technology, motor-control, micro-controller technology, computer-graphics, object brokerage in networks, virtual reality modelling, pattern recognition, interaction design, sound synthesis, software engineering, project-management, social and group dynamic behaviour …? As moderator in these projects, we sensed another quality of floating in non-scientific thoughts and fantasies. Hard- and soft-machines and their relation to human use and operation were considered more on a partner level than on a distant scientific level. The non-intended miss-use of an artefact became as important as its teleological use. Usability and joy of association became equally important. The sensitivity for constraints between man and machines has been expanded by experience.

Human-centred systems design is a multi-perspective and highly creative act. The German Society of Engineers (VDI) recommended a *Dual Approach* in automation design (VDI 1989), iterating between a technological and a work-activity oriented perspective, but few implementations of this recommendation can be found. It may be assumed that one reason for this lack is a one-sided rational education of many engineers. Offering a playground for humans and machines in computer science and engineering, would open up new perspectives on algorithms, mechanisms and aesthetics. Interesting experiments in this field have been initiated by Paul Fishwick (Fishwick, 2002) resulting in a recent *Aesthetic Computing Manifesto* (2002) of artists and computer scientists. Bringing together students from engineering and performing art, fruitfully may contrast two types of characters described by Richard (2004): the expressive, social oriented and the immersive, introspective.

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