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Hardware and software components for a new internet-based multimodal tele-control experiment with haptic sensation

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The application of theoretical knowledge to practical problems is an essential part of scientific control engineering education. Especially doing experimentation on real plants students gain experience. They improve engeneering skills in systematic approach and understanding of subsystem interaction through multimodal perception. Offering realistic emulation of a real experiment situation tele-experiments serve the same purpose. Additionally they offer students flexibility and free experimentation without time pressure because tele-experiments are available day and night. At the the same time efforts for supervision and costs for experimental setups can be reduced. Overall students get experience in future tele-working situation. In order to make tele-experiments as useful and efficient as a conventional laboratory experiment on tele-experimental side multimodal immersion including visual, auditory and haptic modality is needed. Therefore ingenieur appropriate tele-experimentation requires multimodal teleworking places including active 3D-visual and auditory contact with the experiment, transfer of haptic impressions and intervention in the experiment. But for general application on tele-experimental side affordable technology should be provided and therefore some restriction on multimodality have to be accepted nowadays.

This contribution describes a praxis-oriented affordable state-of-the-art solution for the basic experiment "magnetic levitation" and its realization in hard and software is proposed. Based on internet and using a standard multimedia PC with a monitor for 2D-graphic and a low cost force feedback device on operator side adequate realistic emulation of a real experiment can be performed. The complete system was developed in the framework of the joint research project Learnet sponsored by BMBF.[1]

Lab-site there are a server-PC, a realtime-PC, the tele-operator and the levitation setup consisting of two coils, an iron test body, position sensor and a power amplifier. Components providing the tele-operation are a camera, microphone, a position-controlled grasp axis including a force sensor and a pneumatic controlled three jaw gripper for placing the iron body into the magnetic field. A pentium-PC is used as a realtime-PC for controlling and for data recording. Running Matlab/Simulink with RealtimeWorkshop and X-PC-Target on the server-PC the realtime software is provided. For operating the experiment operator-site there is a Java-Applet with several GUI's running in every standard

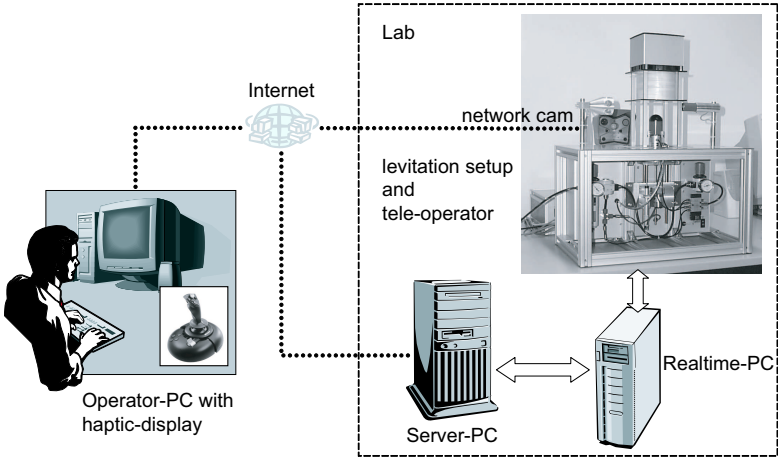

Fig. 1. Total system architecture

browser. Besides demonstration of audio- and videodata it is used for transmission of control signals and control parameters of the experimental setup as well as for demonstration and analysis of recorded data.

Visual and auditory modality are implemented using a Mobotix network camera. The kinestaethic interaction is implemented as 1 DOF offline representation of the previously recorded force position characteristic. The haptic sensation is assisted by a photorealistic animation of the levitation-body. As an affordable haptic display a 2 DOF force feedback joystick designed for computer games is used on operator side.[2] [3]

A tutorial, a XML document, navigates the student through the tele-experiment. It's build up of small units and divided in question and instruction parts. The learning progress is checked by multiple choice tasks and hyperlinks manage the individual learning process.

At this time the experimental setup ist operating day and night. The tele-experiment can be used at the conference and the experimental setup can be visited. For more details see http://www.lsr.ei.tum.de/~lear-net/.

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