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Multi-Modal Multi-User Telepresence and Teleaction System

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The video shows a rich multi-modal multi-user telepresence system, which was developed within the SFB453 funded by the German Research Foundation (www.sfb453.de). As a complex application scenario, the remote repairing of a broken pipe is presented, see Fig. 1.

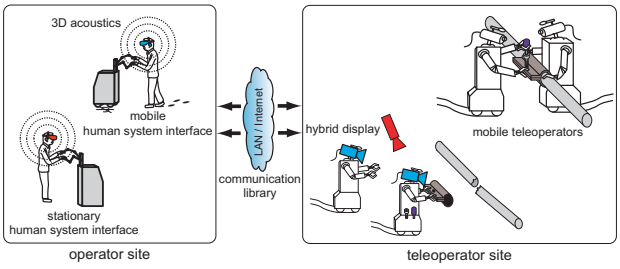

Fig. 1. Application scenario: repairing of a broken pipe

The system basically consists of two operator-teleoperator-pairs. The corresponding hardware setup is shown in Fig. 2. While one of the operators interacts with a stationary human-system-interface, the other operator uses a mobile one. Both systems provide visual, auditory, and haptic feedback and enable to control the motion of head, arms, and grippers as well as the locomotion of the corresponding teleoperator. In contrast to the stationary human-system-interface [1], where a pedal is used to control the locomotion of the remote teleoperator, the mobile haptic interface [2] allows controlling it by simply moving about. In order to cope with space restrictions on the operator site "motion compression" is used in the latter case [3]. The technique is based on mapping straight motions in the remote environment on circular motions in the local environment. In this way, the operator can travel arbitrarily large distances without running out of space.

In order to present location unbound views of the teleoperators' surroundings, a PMD sensor is mounted above the cameras. While panning over the scene depth images are captured and processed to form a 3D model. The geometry information is transmitted continuously to the operator site by the use of MPEG-4 BIFS. By combining the geometry information with the video streams of the RGB Cameras a photorealistic model of the scene can be presented to the human operator [4], [5].

In order to increase the degree of immersion and the feeling of co-presence for both operators, the acoustic modality is added. By using real-time 3D sound synthesis over headphones, the voices of the peer are spatially rendered according to the relative positions of the teleoperators [6], [7]. On this account the voice of one operator is sent, along with the tracking information of the corresponding teleoperator, to the second operator and vice versa.

The maintenance tasks consists in repairing a broken pipe by mounting and fixing an appropriate clamp around it. The videos shows how one of the operators moves the clamp over one end of the pipe and aligns both ends, while the second operator centers the clamp at the breakage and tightens the screw.

The whole demonstration course is shown in Fig. 3.

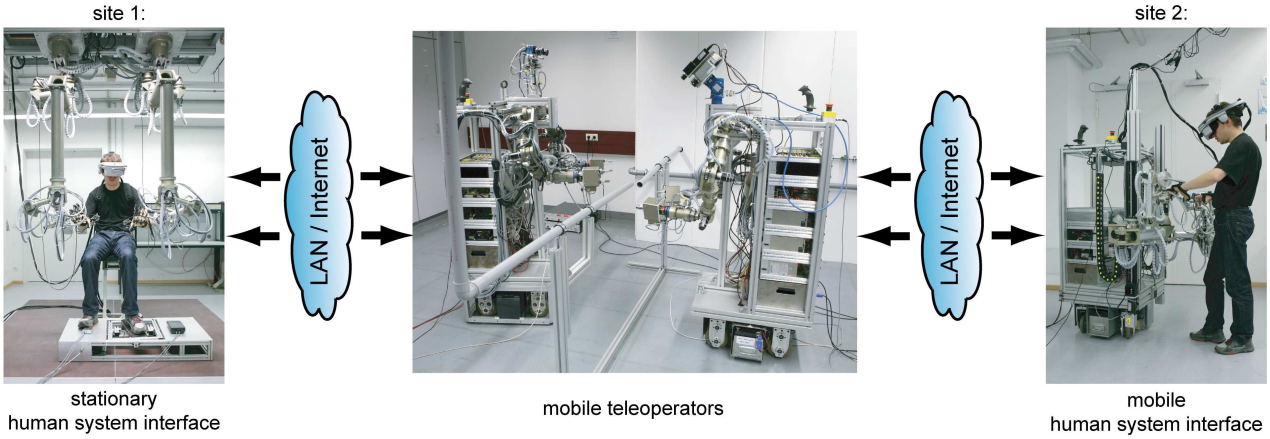

Fig. 2. Hardware setup, left: stationary human-system-interface, middle: teleoperators, right: mobile human-system-interface

Fig. 3. Photo story of demonstration course

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REFERENCES

[1] A. Peer, U. Unterhinninghofen, and M. Buss, "Tele-assembly in Wide Remote Environments," in *2nd International Workshop on Human-Centered Robotic Systems*, Munich, Germany, 2006.

[2] A. Peer, T. Schauß, U. Unterhinninghofen, and M. Buss, "A mobile haptic interface for bimanual manipulations in extended remote/virtual environments," in *Robotics Research Trends*. Nova Science Publishers, Inc., 2007.

[3] N. Nitzsche, U. Hanebeck, and G. Schmidt, "Motion compression for telepresent walking in large target environments," *Presence*, vol. 13, no. 1, pp. 44 – 60, 2004.

[4] J. Leupold, "Geometry compression with mpeg-4 bifs in telepresencescenarios," in *2nd Workshop on Human Centered Robotic Systems (HCRS)*, 2006.

[5] S. Behrendt, "Rendering dynamic real-world scenes using image spheres," in *Advances in Visual Computing*. Lecture Notes in Computer Science, Springer, 2006, pp. 467–479.

[6] F. Keyrouz and K. Diepold, "Binaural source localization and spatial audio reproduction for telepresence applications," *Presence Journal: Teleoperators and Virtual Environments, Special Issue on High Fidelity Telepresence II*, vol. 16, pp. 509–522, 2007.

[7] ——, "A new hrtf interpolation approach for fast synthesis of dynamic environmental interaction," *Audio Engineering Society (AES) Journal*, vol. 56 (1/2), February 2008.