Study of human-machine interaction in virtual reality in terms of work safety on the example of the remote control of manipulator

Author: M. Sc., Eng. Jarosław Jankowski

Supervisor: Ph.D. (Eng.) CIOP-PIB Andrzej Grabowski

Abstract:

Occupational health and safety training is a mandatory form of providing information on subjects that contribute to work in a safe manner for themselves and the environment as defined in the legal articles of the Labor Code. There are many forms of training for health care workers also regulated by the regulation but it is very important that they are conducted in an attractive way. Literature studies prove that the quality of training is correlated with the level of their effectiveness. Therefore, it is necessary to look for tools to promote knowledge of occupational safety with higher effectiveness and most of all useful. Totally new cognitive and educational opportunities in the education process technology create a virtual reality. Virtual reality is an illusory environment modeled in such a way as to give the user the impression of being able to interact in another, presented by the computer, reality. These can be synthetic environments created by computer simulations or as in the case of telepresence, real-time images captured by cameras. An important element of this technique is the way of receiving the presented world and the amount of senses involved in order to bring the participant into the virtual world as deeply as possible. The level of spatial presence felt by a participant in a virtual or remote environment is a very important condition for authenticating the content presented, e.g. training for a particular job. The increase in spatial presence can be achieved through the use of natural human-machine interaction interfaces.

In this paper we describe the activities concerning the development and evaluation of natural and intuitive interfaces used in teleoperation of inspection robot and for exploring virtual environments (of large size) improving the work and allowing the training of selected activities using developed interfaces, and so in the area of improving occupational safety and health.

The aim of this paper is to develop a model of natural human interaction with a machine using virtual reality techniques to create useful training applications in the field of improving occupational safety and health in remote-controlled virtual crane (controlled from the working level) in a large size environment and manipulator control of the mobile inspection robot.

This was achieved through research on:

- Interface of remotely controlled mobile inspection robots
- interface to control of the virtual crane (controlled from the working level) in a large size environment exceeding the size of the laboratory in which the experience took place.

Three hypotheses are presented:

1. The use of natural human - machine interface based on virtual reality technology reduces the time to perform the tasks in relation to interfaces using joysticks.
2. The use of natural human-machine interfaces based on virtual reality technology increases the level of spatial presence in relation to interfaces using joysticks.
3. The use of natural human-machine interfaces in virtual reality-based training applications enables the creation of useful training forms for occupational health and safety.

In order to prove the last hypothesis, the results of research on the training application of mining work procedures were used(co-contractor).

The dissertation described the developed individual research stand, and most importantly are:

1. Functional model of remotely controlled inspection robot equipped with a gripper-operated manipulator and a movable camera set. It allows to conduct research on remote robot control in simulated conditions. The control interface is composed of stereoscopic glasses and virtual reality glove. The whole is supplemented by the system of registration of the position of the head and the hand, the joystick and the PC with the necessary software. In order to compare different control interfaces an alternative system based on the LCD screen and joystick was prepared.
2. Interface consisting of data gloves, head mounted display along with the developed algorithm of the redirected walking ("RW" interface) and developed for comparison, the interface consisting of a set of controllers equipped with a magnetic tracking system and head mounted display ("Std" interface).

The evaluation of the interfaces was based on the analysis of objective indicators: the time required to complete the task and the accuracy of the tasks. In addition, the subjects gave a subjective assessment to each of the interfaces by completing the following questionnaires:

- MEC Spatial Presence Questionnaire,
- Group of questions about the assessment of usability, intuitiveness, and ease of use of individual interfaces,
- Survey on the best single choice of interfaces in terms of usability, intuitiveness, and ease of use.

The Usability Scale questionnaire was used to verify the last hypothesis.

Summarize the conclusions drawn from the results of the research, the use of virtual reality techniques for control method of mobile inspection robots improves operator productivity, increase spatial presence and distance estimation, Moreover, it facilitates and speeds up the execution of tasks and reduces time required to adapt the operator to the interface. On the basis of the above, it can be concluded that, by increasing the precision of tasks (small number of errors), the use of an intuitive interface for teleoperation increases the level of safety in the work area of the inspection robot. The results of subsequent studies show that, the use of the developed "RW" interface enables to work simulate such as virtual crane control, achieving a comparable "Std" performance of the operator at high spatial presence, thanks to general ease of use and intuitive movement and comfort. A general indicator of the usefulness of the system interfaces described using a virtual exploration of the environment ranks among the standard at the level of average and above average. This means that the participants of the simulation consider the produced system using virtual reality techniques to be useful.

To summarize, in the case of the teleoperation interface, hypothesis 1 is assumed to be true, but in the case of the crane control interface, hypothesis 1 should be rejected. For discussed interfaces, second hypothesis is true. According to the research, the use of natural interfaces to interact in immersive virtual reality techniques used in training applications provides the creation of useful forms of training, same the third hypothesis is true.