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Performance and Workload of Operators in a Human - Telerebot System

Editorial

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Introduction

In recent times, the area of human - robot interaction increasingly occupies the attention of researchers. This is understandable, given that robots have a more frequent usage, both in production and in everyday life. Teleoperators are a type of robotic systems where the human - robot interaction is especially pronounced. In teleoperation, a human operator interacts with the environment via a telerobot. In general, in a teleoperation system a man uses the system consisting of displays and the command organs for the purpose of control of a robot from a certain distance. This distance can be from a few meters to several thousands or millions of kilometers, depending on the need.

Teleoperators are used primarily for operations that are risky to the health and safety of people. One of the first use of the teleoperators was for activities related to the manipulation of nuclear waste. However, teleoperators also found wide use for some specific tasks that are not comfortable for the implementation or requiring additional skills that go beyond the possibilities and capabilities of a man. For example, teleoperators are used for realization of specific tasks on other celestial bodies, repairing satellites, performing the tasks under the ground, under the sea, at high altitudes, realization of search and rescue activities, as well as in various fields of medicine.

Effects on performances of operators

The performances of human operators in a man - robot system depend on several factors. It can be distinguished the following factors of which depend the overall performance of operators during the execution of the given task: design of the teleoperator system (both the robot and the workplace in which the operator executes the task, including equipment used in the workplace), the technological procedure used for the realization of the working task, factors of the environment in which the robot performs a task, interaction of the operator with other people from his environment (eg. communication with the other operator who can control certain functions of the same robot), as well as the level of workload.

Previous researches of performances of operators in robotic systems generally have involved only two of the aforementioned factors. These are the effect of the design of individual elements of a teleoperation system and the effect of workload. In general, in the studies as performance measures of work of operators were considered variables such are: the efficiency of the work (ie, the time it takes to complete a task), errors of operators, usability, response time, situational awareness and operators' well-being.

The total efficiency of a human-telerobot system depends on the success of the design solutions of a robot, as well as of the overall performances of an operator. For this reason, of great importance is the study of performances of operators, so as to be possible the optimization of those factors that affect their work. For this purpose, below will be given a brief overview of researches related to the performances of operators in robotized systems.

Effects of design of the system on performance of operators

In connection with the previously mentioned, it is important to consider the effects of different design and socio-technical solutions of teleoperator systems on the behavior and responses of operators. The main way of control of a telerobot is based on the use of the sense of sight. Visual information are presented to the operator by using different types of visual displays. However, due to various reasons (eg. because of the great distance from which the transfer of execution of a telerobot task is done) may occur a delay in the presentation of the current state of the operation that has been started (response latency). In connection with this phenomenon, a number of studies were conducted, with the aim to investigate its effect on the performance of operators. It has been shown that response latency increased the overall time to complete the task [1], can decrease the efficiency [1-3], and manifests in increased number of errors [1, 3].

Frame rate determines the number of screen shots that are presented over time, or the refresh rate of an image. This factor of a visual display can also affect the performance of an operator. Generally, better performances are connected with the higher frame rate [4]. The increase in frame rate can bring to the better efficiency [5]. However, the decrease in frame rate can cause a decrease of usability [6, 7], decrease in efficiency [7, 8], as well as an increase in a number of errors and task difficulty [8].

In a teleoperator system, a camera that records in the real time the telerobot activity is almost unavoidable part of the equipment. Manipulation with the camera is an important factor that determines what the human operator will see on its display. With the mentioned manipulation, several issues are connected. One of these factors is the camera perspective (orientation), which refers to the immersion level of a camera in relation to the target object. Generally, the researches have shown that when the camera perspective is either an exocentric (ie. third-person view of the surrounding) or "gravity-referenced", the overall performance of operators was maximized [9].

In papers that deal with this topic, the field of view refers to the dimensions of a visual screen. This factor also can affect operators work. The research results of the effect of the field of view are mixed, but they suggest the higher level of performance with wide to a moderate field of view [9]. Additionally, the amount of environmental details that are presented in the field of view also has an effect on performance of operators. In some cases, too much of environmental details that are in the area of visual control can affect situational awareness. Research results have shown that an increase of environmental details has an effect on the efficiency of operators (visual search time is prolonged), but it does not decrease the level of detected targets [9].

Monoscopic or stereoscopic types of displays are also design factors, which can influence the performance of operators. Stereoscopic type of a display gives 3D image of a telerobot environment. Researches have shown that usage of the stereoscopic type of a display leads to fewer errors, in comparison with the monoscopic type of a display. At the same time, it was shown that the work with the stereoscopic display is more efficient [9].

There are also certain design factors that can have the influence on performances of operators. The modality of the feedback that differs from the visual often has a significant effect on performance. The proper combination of visual, haptic and auditory feedback can achieve the positive effect on performances of operators. However, it should be emphasized that design solution that consists of the application of more than one telerobot for whose control is planned one operator can cause degradation in performance of that operator. Also, degradation of the performance of an operator can appear if telerobot is not reliable in performing its part of the task. This usually affects attention of an operator, who should direct attention to different aspects of the task, which are not the primary goal of the operator. In such a case, in addition to his primary task, he should perform an additional control and to try to stabilize the work of the system. Due to that, the performance of his primary task becomes reduced.

Effects of workload on performances of operators

The inadequate workload of the operator can deteriorate his performance. If the workload of the operator is not carefully determined, due to the overloading his efficiency can be reduced, and the rate of the errors can be increased. From the other side, if the operator is underloaded, due to the monotony and lessening of the attention, errors in the system are also possible.

In connection with the previously mentioned, the level of control of a telerobot is also an important issue. If the responsibilities in performing the task between a human operator and a telerobot are not designed in accordance with human capabilities and limitations, then certain errors in the work of the system are possible. In the literature [10-19] were considered different factors that can potentially have an influence on the workload of operators, such are: subjective perception of telepresence, different states of the system (including qualitative and quantitative information about the states), types of controls, interface design, latency, different types of tasks and levels of control, visual feedback, screen types, depth perception, frequency of teleoperation. Levels of the effects of these factors on the workload were different.

Conclusion

It can be noted that some of the factors that reflect negatively on the performance of operators also have a negative impact on the level of perceived workload. From the standpoint of the achievement of the goal of the system, lower level of performance can be considered in a part as a consequence of inadequate workload of the operator. However, it should be emphasized that certainly exist factors that can have the negative effect on the performance of operators, but not directly or not at all on the level of the workload.

On the basis of the conducted review and analysis, it can be noted that previous studies have not covered all the factors that may affect the performance of operators in the human - telerobot system. In this regard, in studies have not involved in proper way the factors relating to the selection of technological procedures relating to the execution of a task (for this purpose, for example, can be used HTA analysis), then factors that originate from the environment (in which the robot is positioned, as well as in which the operator is located), and factors that represent the influence of other people who are in contact with the operator (in connection with the execution of the task). The complete analysis of a human - telerobot system also should include the aforementioned factors, for the purpose of designing of the system that will have the optimal performances.

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