

DEVELOPMENT OF MAN-MACHINE INTERFACES AND VIRTUAL REALITY MEANS FOR INTEGRATED MEDICAL SYSTEMS

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Abstract

The results of research in the field of development and intellectualization of man-machine interfaces on the basis of a virtual reality means for the integrated medical systems of a virtual reality including the medical personnel, computers and medical mechanotronic systems (robots) are discussed. It is being observed the participations of the authors in the «Intellectual and adaptive robots - 2005» International exhibition.

1. Introduction

The modern medicine desperately needs the development of new information technologies and a virtual reality means and tools for the man-machine interface and control of robots and mechanotronic systems, introducing automation into operations in surgery, and the creation of telemedical diagnostic systems, etc. The NATO-grant № PST.CLG 975579 "The man-machine interface for assisting systems in neurosurgery", executed in 1999-2000 by the partners from the St.-Petersburg Institute for Informatics and Automation of Russian Academy of Science (SPIIRAS), the State University of Aerospace Instrumentation, University of Karlsruhe (Germany) and Harvard Medical School (USA), testifies to a urgency of this problematics, in particular. This grant has been directed on development of the man-machine interface, adaptive robots and multi-agent technologies intended for use in neurosurgery [1]. Last achievements in the field of medical computer science, robotics and mechanotronics, including the results submitted in this report, have been presented at the "Intellectual and adaptive robots - 2005" International exhibition and a symposium [2].

2. Methods and means of video motion capture in a problem of translation of a sign language on a

natural language and back

Studying antropomorphous robots and their animation is very important for the solution of various problems. Innovative results in this area, based on models and means of a virtual reality, can affect essentially such spheres of human activity, as medicine, sports, systems of remote training, computer and cognitive graphics. For example, in medicine the motion analysis of the person (patient) can facilitate essentially and partially automate the diagnostics and treatment of orthopedic diseases.

The research on the motion of human or antropomorphous robot is very important in computer graphics in the task of animation of mobile virtual characters. And the important role play methods and means of video motion capture, offered in [3]. Currently these methods being adapted for the solution of problems of translation from a natural language on a sign language and back and for development of multi-modal interfaces «human – robot».

The communication for people with restrictions on hearing or reproduction of speech is taking place in completely different way, than it is for people without such restrictions. People with such restrictions cannot watch TV, listen to radio without additional means, communicate by phone as it done usually by people. So it is necessary to develop the approach to realization of a series of the specialized interfaces which could be used in any telecommunication devices. The interfaces being discussed include means of input-output of the information and data links. As for data links, it is expedient to use highly developed and reliable standard transmission interfaces.

It is offered the output of gestures to be carried out by means of animated an avatar, i.e. the simplified 3D model of the human. Avatars can reproduce gestures by two ways [3, 4]:

- Generating gestures for corresponding expressions in a natural language using script sequences from database;
- Reproducing the animation of gestures transmitted to it directly under the data link.

The subsystem of input of the information also can work by two following ways:

- Generating expressions in a natural language according to the analysis of gestures reproduced by the operator;
- Transforming gestures of the operator to script sequences of animation for an avatar.

3. Development of man-machine interfaces for the robotic systems on the basis of video motion capture

The important role in the development of robotic systems is played by the man-machine interface. The new approach in creation of such interfaces is based on technologies of video motion capture of robots and a virtual reality [5, 6].

The general structure of the man-machine interface and control system designed using means of video motion capture and technology of a virtual reality is presented on Fig. 1. It consists of two subsystems.

Subsystem 1 (a subsystem of interaction with the operator). It includes the following components:

- *System of video motion capture of the operator.*
- *Virtual control devices.*
- *Visualization procedures.*

The subsystem 2 (a subsystem of interaction with the robot) can have various structure depending on its application. However it necessary to include the following components in this subsystem:

- *Means of processing and distribution of managing signals.*
 - *Means of supervision over a condition of robots.*
- It is also expedient to develop the following components to increase the management efficiency and reliability of robotic systems [3, 4]:
- *Active multimode system of video motion capture.*
 - *Means of visual observation.*

4. The technology of management and training using multi-modal interfaces

Training of robots by showing the natural movements (gestures) of the person [7, 8] is connected to creation of natural and accessible means of communication with technical and information systems (fig. 2).

The offered technology of management and training of medical mechanotronic systems (robots) is based on the multi-modal interface, and its intellectualization [9], which provide the following to medical applications:

- Simple and correct understanding of speech commands of the doctor and the patient [10],
- The capability of teaching the system by means of movements display (without the movements programming) [8],
- A composing (mixing) of the real (for example,

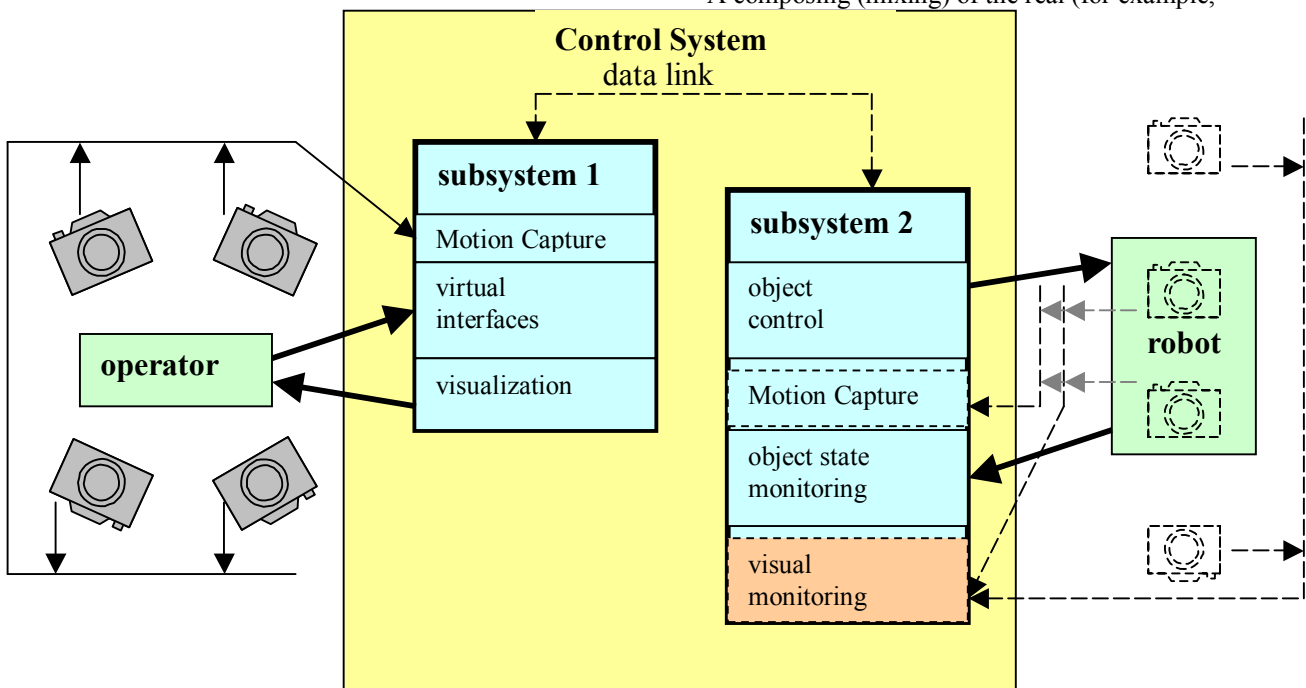


Fig. 1

- endoscopic) and virtual 3D (stereo) images,
- An interaction with computer models during diagnostics or planning of operations with tactile and force-moment sensing [6, 12],
 - The information and telecommunication support of medical equipment control systems using the virtual operating-room.

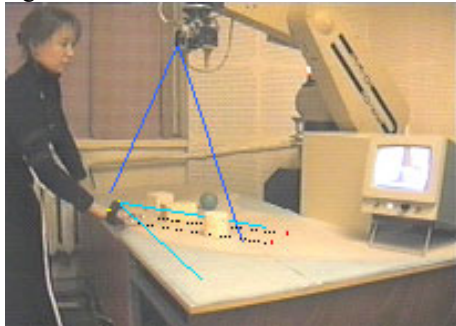


Fig. 2

The development of the multi-modal man-machine interface for a telemedicine and a medical robotics assumes the creation of highly realistic effect of presence of the person-operator in a zone of a presence of object being managed, which is on significant distance. For this purpose virtual models and manageable computer-synthesized 3D-images of virtual objects composed with the images of the real environment are used. Last years the solution of the basic problems of given technology realization is investigated, namely, a problem of exact composing of a computer-synthesized image of geometrical model of an environment with its real image and a problem of realization of a continual perception of these images in a real time mode.

It is expedient to use the following means to display of the distant environment:

- Stereo glasses for observation on the monitor of the computer (fig. 3);
- Means of composing of real and virtual images.



Fig. 3

Tactile-force interaction with virtual medical

objects is necessary when it is not only required to observe the environment, but it is also necessary to perform any actions in it. Thus manipulations in the distant environment will be more successful, if it will be possible to create realistic and adequate perception of environment surrounding the robot for the operator, to give an opportunity to feel its objects as though they have the set sizes, the form, weight, resistance of friction.

For medicine the development of so-called "haptic" interface, intended for reflection of efforts on a hand of the doctor (surgeon) or the medical robot, is especially actual. Thus the important role plays the using of this handle with reflection of efforts and storing of natural movements of the person (surgeon) facilitates the process of training of the robot's motion. The prototype of the handle with the force-moment sensor is shown on fig. 4.



Fig. 4

The offered technology of objects visualization, models of a virtual reality and means of training by displaying of movements are especially useful in applications of navigation, programming of movements and control of adaptive robots and medical mechanotronic systems [4, 11]. They are also useful in creation of highly realistic effect of presence in the distant place, where the patient is, for the doctor. For this purpose virtual models and manageable computer-synthesized 3D-images of virtual objects composed with the image of the real environment are used, it is also used the methods of exact overlapping of computer-synthesized images of geometrical model of an environment with its real images.

Using of medical robots in surgery can be dangerous to patients. Therefore it is expedient to create virtual models of robot, patient and operating-room.

5. Virtual models of a medical robot and a patient

Virtual operating-room should remind the real one as much as possible, because for the doctor work in habitual conditions would be much more effective and productive. According to this it "is filled" with familiar medical tools assisting robots in their computer representation.

In this case there is an opportunity of carrying out of trial educational operations not on the patient, but on his virtual model. Carrying out of operation on the virtual (electronic) patient can be considered as a stage of real surgical operating planning. The second important problem being solved using virtual operations is an increasing of a professionalism of the doctor and the medical personnel. The dynamic virtual model of neurosurgical operating room is presented on fig. 5.

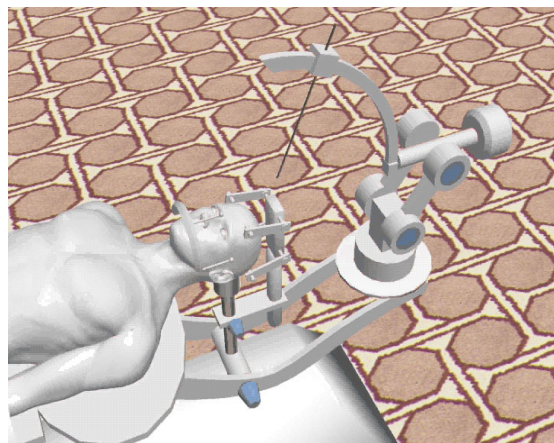


Fig. 5

The information on real and virtual operation and the subsequent information on a condition of the patient are united in a uniform picture of treatment. It is possible to return to past operations for the comparative analysis and finding-out the efficiency of different methods of treatment. Due to this not only practising doctors, but also young students and the post-graduate students training skills of work with medical robots, the man-machine interfaces and means of a virtual reality can improve their skills [3-6, 11].

During the virtual operation the surgeon can observe the trajectory of the medical tool set under tomograms of a brain of the patient. Due to this in a case when the tool gets into zones of the high risk for a life of the patient, the doctor can request the program of other variant of the tool targeting to a necessary point of a brain on a safe trajectory or draw a conclusion on impossibility of carrying out of operation.

6. The conclusion

The offered information and robotic technologies, the multimedia interface and means of a virtual reality find more and more wide applications not only in medicine, but also in other fields (space, etc.). Thus means of intellectualization of the man-machine interface, dynamic models of a virtual reality and multi-agent technologies will play especially important role [5, 6].

In 2005 at the «Intellectual and adaptive robots - 2005» International exhibition the authors of this report

have been awarded with 4 Gold medals and Diplomas «for the development and introduction of innovative technology of man-machine interaction on the basis of a virtual reality for a telemedicine and a medical robotics».

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