Transactions of the VŠB – Technical University of Ostrava, Mechanical Series
No. 1, 2011, vol. LVII
article No. 1845

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VIRTUAL ROBOTIC LABORATORY AND ITS APPLICATIONS IN INTERACTIVE TEACHING

VIRTUÁLNÍ ROBOTICKÁ LABORATOŘ A JEJÍ APLIKACE V INTERAKTIVNÍ VÝUCE

Abstract

It is important that the computer technology used in interactive teaching is independent on the platform being presented on as well as the newest ICT standards are, used. The authors consider the design of a suitable technology to implement the computer model of a virtual technological workplace in so that they are used for teaching and testing manipulation control operations.

Abstrakt

Využití výpočetní techniky V interaktivní výuce skýtá možnosti vytváření virtuálních laboratoří nezávislých na vlastní platformě S využitím nejnovějších standardů ICT. Autoři provedli návrh modelu virtuálního technologické pracoviště S možnou optimalizací včetně možnosti kontroly operací.

1 INTRODUCTION

Researchers all around the world realize that industrial processes motivated only by economic benefits began to endanger life on the planet. One of the most important recent problems is how to maintain such a quality of environment and start and continue the process of "Sustainable Development" at the same time. Bakoš et al. (2005). International scientific conferences as well as politicians deal with the issue [1, 19].

Modern world has become increasingly globalized and interconnected and the idea of sustainable development can improve the quality of life while taking the responsibility for the environmental protection. Blažej (2005) [2]. The question is, how to acquire financial means because grants and sponsoring do not represent the systematic solution of the problem.

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We see two basic resources for sustainable development:

1. Effectiveness of technology (automation and mechanization)

2. Effectiveness of human work

To solve the problem only in technological terms has both technological and economic limitations. In achieving human work effectiveness, we distinguish approach differences depending on the level of national social and economy development. In developing countries, there are efforts to maximize the profits and often include the reduced levels of occupational health care, lower salaries and higher work rates. However, in most developed countries, increased profits are often obtained by increasing the effectiveness of human work through the application of ergonomic principles and preventive programs. In any case, it is important to consider the health effects to workers to obtain the complete and true cost-benefit analysis of various working conditions. Božek et al. (2007) [3].

The privatization and transformation of industry in Slovakia and neighbouring countries of Central and Eastern Europe began as a part of the process of its integration to the European Union.

In the framework of the project solution "Transformation Industry in Slovakia through Participatory Ergonomics" 3E HCS model was proposed. Hatiar et al. (2008). The model represents an ergonomic process applied in industrial plants of developed countries and is modified to specific conditions of transformation industry in Central and Eastern European countries. We proved this model in 19 plants in Slovakia while continuing in the efforts to implement the model into practice. Hatiar et al. (2006) [6, 7].

Automation industry is an area requiring where a high level of human work effectiveness and also the application of 3E HCS model is required. The first step of the model application in the area of automation was represented within the project "Creation of virtual robotic laboratory for supporting the teaching of the subject: "Robots and manipulators" in a newly accredited study programme".

2 THE IMPLEMENTATION OF 3E HCS MODEL IN A VIRTUAL TECHNOLOGICAL WORKPLACE

Figure 1 shows the virtual 3E HCS model concept of a technological workplace. It allows to design the technology in real as well as it permits the definition of the basic principles of the technological process control system. There are three acceptable aspects (3E) of sustainable development:

1 *Environmental aspect* - all technologies carry an environmental burden. The advantage of the proposed virtual technology application means that it is not necessary to produce the model of a technological device, nor it is necessary to create the real technological workplace. By the production of the aforementioned devices, the environmental impact is minimized.

2 *Economic aspects* – can be divided into partial groups and subgroups. The most important aspects are the investment costs (the amount of finances related to the specific virtual equipment purchase) and operation costs (technological devices, electricity consumption and other related costs) which can influence also the decision making in a new technology purchase.

3 *Ergonomic aspects* of virtual technologies – working conditions, lighting, noise, protective clothing necessary for the operation of such a technology, etc.

At present the optimization is used and applied in different information systems oriented on conventional technologies where the possibilities of virtual technologies are neglected. The necessity of a computer-aided tool that will take these aspects into account is vital in national as well as in European research. Demoč et al. (2000).

Fig. 1 A

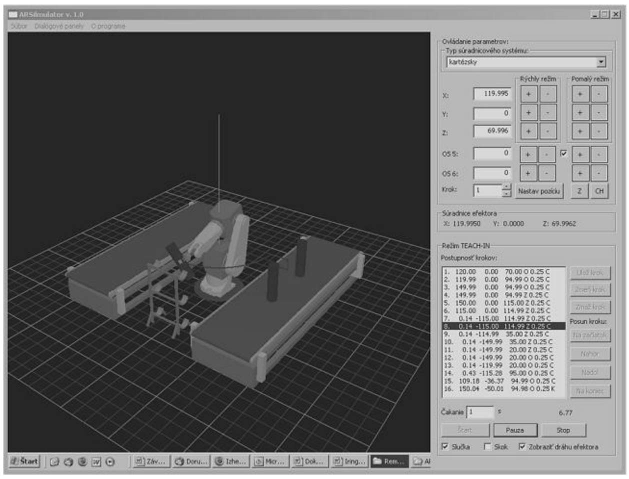

Fig. 1 B

Fig. 1 Proposed laboratory computer workplace (A) with an installed virtual robotic workplace with the control training program applying the requirements of 3E HCS model (B).

3 HCS 3E MODEL AND ITS APPLICATIONS

The HCS 3E model applies the „National strategy of sustainable development of the Slovak Republic on the macro-level while simultaneously working on the plant micro-level (3E: Environmental Health, Ergonomics, and Economy). The model is focused on the effectiveness of human work and cost benefit. We intend to use this model as a tool for both, the revitalization of plants and acquisition of financial means for sustainable development. (Fig. 2). Hatiar et al. (2003) [5, 6, 7].

The model meets the requirements both in practical and scientific areas and brings new stimuli to economic development in Slovakia and other neighbouring countries. Yakimovich et al. (2007) [17, 18].

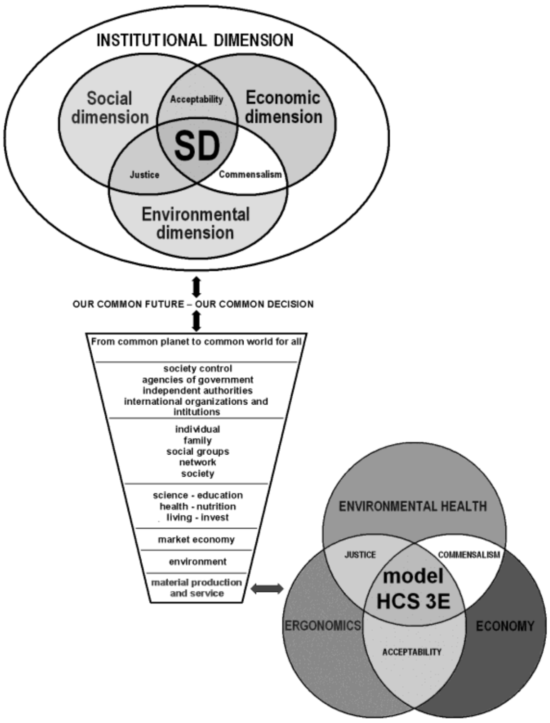

Fig. 2 The contribution of 3E HCS model to the sustainable development process, (micro-solution of macro-problems) focused on producing the necessary financial sources by human work effectiveness.

4 BOUNDARY APPLICATIONS

It is essential to define the boundary between the application itself and the application user. Barborák (2007). The ergonomics of the boundary application is an important point, i.e. the simpler the control the better. Another important condition of an application control overview is represented by the smallest possible number of control units for the user.

The control units in the simulation application of the virtual robotic workplace are arranged and implemented in such user friendly. Novotný et al. (2008) [9, 16]. The application control shall be unified as a whole and there is one control unit per function. Individual control units will be called by names or abbreviations and the control will be assisted by a helper.

At present the Institute laboratories of STU MTF in Trnava possess only a small manually controlled study robot which is able to work in an automated regime after the program runs with no simulation and in this case.

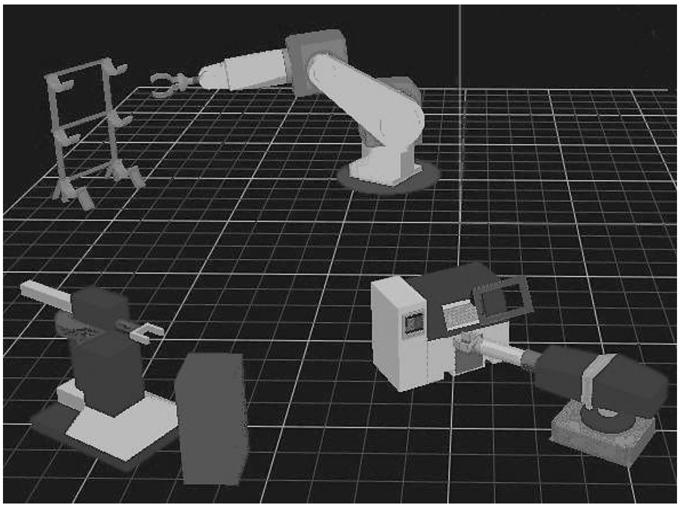

Fig. 3 An example of a virtual scene creation.

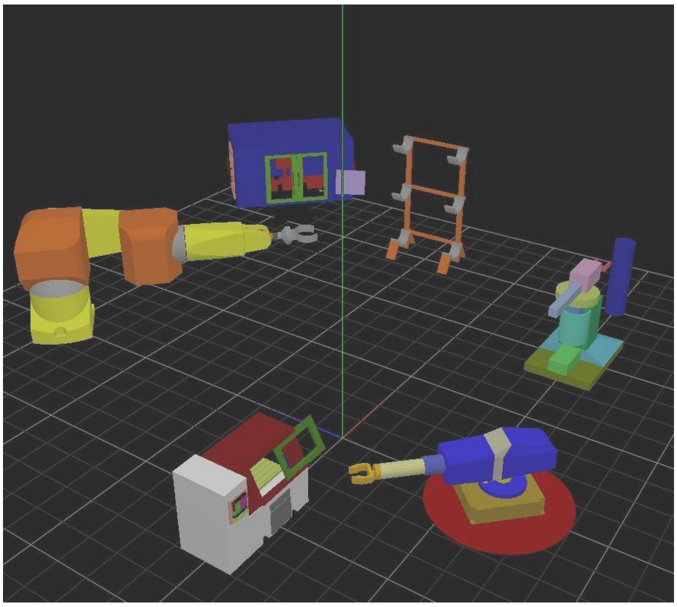

Fig. 4 An example of building the virtual scene.

The robot provides the following standard work regimes:

1 Change of constants – All specific system constants on the display are variable.

2 Automated run – The robot works automatically due to the user program

3 Individual blocks – The program runs the work process block by block together with the robot up to the testing and eventual checking

4 Start

5 Learning – The robot is operated manually, each of the points the in the current position of all axes is saved in the memory

6 Run – It is possible to turn on the run by individual steps or by using the complete program sequence

7 Input – We can program the sequence by using the coordinates of individual sequence points. The robot comes to the defined point of sequence and is saved in the memory.

8 Editing – We can check the axes positions, complementary information and individual points of the user program. From the mentioned regimes, only these ones can be used at present.

9 Automated regime run of the user program.

Figure 4 illustrates the virtual scene of a technological workplace with the possibility to generate the user program.

The aforementioned aspects of 3E HCS model play an important role in companies polluting the environment. The need of its protection increases and the conditions of the new global market call for implementing the new environment friendly and effective technologies and tools.

The project "The creation of virtual robotic laboratory for supporting the teaching the subject Robots and manipulators in a newly accredited study program", was aimed at proposing:

a general model of robotic workplace,

method to investigate the control system of a laboratory robot,

method of the effectiveness evaluation of the environment-friendly oriented workplace at universities and companies,

possibilities of using the exact methods for teaching at universities,

interface for the user program transfer and control.

Consequently, the project investigators will focus on:

verifying the related methods of individual tasks/goals at the Institute laboratory equipment,

carrying out the final corrections of the related methods,

generalizing the knowledge into final proposals of individual systems of control programming and interface,

processing the synthetic final research report.

After project completion, the programming itself was carried out with the programming of all the needed functions so that there was no duplication and the application was capable to simulate the industrial robot as well as the entire robotic workplace.

The final project phase was devoted to testing. After testing the application the virtual application were transformed into the real robotic workplace. Strnád (2007) [13, 15].

5 ANIMATION APPLICATIONS AND INTERFACE

Animation illustrates the current state of all units and parts of the robotic workplace. It is impressive not only by the manual control but also by the data processing. The animation is carried out by means of object oriented Microsoft visual C+ with the use of graphic library OpenGL, both providing wide possibilities of the use of a large number of orders and functions .

Library OpenGL is compatible with Linux operation system and represents a standard in 3D graphics. Interface has to be compatible with the data processing generated from the virtual scene, then transformed into the real environment of a robotic workplace.

Related VRML language is the most suitable for the animation of the application. It allows to define all attributes necessary for a realistic display of bodies VRML language allows the description of all bodies (including primitive), and provides reading the data on the vertex positions and count algorithms of their affiliations to object sides. This means that the algorithm of the file data reading can work only with the objects described by their form and not via primitive. Šurianský et al. (2000) [14, 9].

The virtual scene is represented by the data tree, where the scene itself is the tree top located in the uppermost point of the hierarchy. Since there only one scene, it is not represented by any data structure. The scene set up is determined by OpenGL variables, e.g. scene turn, background colour and motion, grid dimensions, light parameters, etc.

The data structures have to include also information on the machine kinematics. By the number and position analysis of these issues we can tell, that the number of characteristic points of an angular robot is identical with the number of axes, in which it carries out rotation motions. This fact is possible to generalise also for mechanism types.

The title of the part (body name) seems to be an appropriate transfer medium for determining the kinematics characteristic points of the angular robot. Then, it is necessary to determine the axis for which – following the robot kinematics – the motion is carried out.

6 FUTURE PLANS

Our research team plans to orient future activities in the next time period particularly on:

continuing in initiation of participatory ergonomics programs in as many enterprises as possible in Slovakia and in countries of Central and Eastern Europe;

analyzing the data obtained and work on disseminating those results and experience to other plants in Slovakia and abroad;

monitoring the progress of the ergonomics processes in all plants involved, conduct cost benefit analyses for the ergonomics program and process rationalization of an ergonomics process based on participatory approach 3E HCS model principles in the Slovak Republic and neighbouring countries. Landryova et al. (2006) [8, 10].

applying of ergonomics to the process of development and operation of new effective automated production systems;

implementing the virtual technologies in the increasing ergonomics, environmental and economic preventive programs effectiveness. The implementation of virtual technologies in personal management, training and education of employees seems to be very promising;

continuing the study of theoretical and practical aspects of 3E HCS model application in the ergonomics program based on participatory approach principles. We already initiated this process by running PhD programs oriented on:

1 general and enterprise specific form of Cost Benefit evaluation of ergonomics process managed by 3E HCS model by CBA,

2 3E HCS model and Balanced Score Card,

3 expression of 3E HCS model process in general and enterprise specific forms, describing its relation to enterprise processes,

4 general and specific forms of ergonomics program in a plant,

5 effectiveness of ergonomics programs based on 3E HCS model,

6 refining the epidemiological methods in the health effects evaluation of occupational disease preventive measures implemented within the framework of ergonomics program based on 3E HCS model.

7 continue in disseminating the ergonomics programs throughout Slovakia and neighbouring countries by expanding the personal and completed materials.

7 PROJECTS ACHIEVEMENTS

The projects described represent the research of two institutes: Institute of Applied Informatics, Mathematics and Automation in Industry (UAIM) and Institute of Industrial Management and Production Quality (UPMK) and they are focused on sustainable development via the application and implementation of ergonomics into practice of some Slovak plants as well as they are aimed at the proposal of various virtual robotic workplaces to promote new technologies.

Multimedia programs use text, graphics and animation to communicate with an end user - student. The Department of Industrial Engineering and Management (part of UPMK) in cooperation with the Department of Applied Informatics and Automation in Industry (part of UAIM) prepared the multimedia software to support scientific logistics subjects.

Figure 5 illustrates the introductory page of the study e-material developed within the KEGA research projects 3/3068/05 and 3/3111/05. The self-access e-study material is oriented on Building a virtual robotic workplace and represents the application of logistics in manufacturing systems [3].

Fig. 5 Introductory page of a CD on Building a virtual robotic workplace.

8 CONCLUSION

The application of information technologies should be a must in the whole educational process regardless the specialization. The university graduates should be able to utilize the majority of services offered by various information technology applications as well as the ability to understand the principle of its operation should be assumed.

Utilization of information technologies and multimedia implementation can be an excellent aid and a useful tool in hands of a professional teacher, and eliminate boring routine. Ožvoldová et al. (2001) [11]. Obviously, readiness of both teachers and students is an essential prerequisite for professional utilization of developed interactive materials.

Utilization of study materials developed internally – usually within numerous research projects are available either on the Internet or Intranet. They are not only costs friendly, they bring more or less unified standards, student-friendly environment instant distribution of the final product or feedback to the recipient. Rašner et al. (1998) [4, 12]. Modern programs for computer aided learning are not a simple duplicate of the original learning material, they are tailored to the students ‘needs on a regular basis, and moreover, they are attractive thanks to latest graphics and can be interactive. Students enjoy lessons using interactive study materials, even those „worse“ students.

ACKNOWLEDGEMENTS

The contribution was elaborated within the research of following projects:

1 KEGA No. 3/7285/09: Contents Integration and Design of University Textbook “Specialized Robotic Systems” in Print and Interactive Modules for the University Of Technology in Zvolen, Trenčín University of Alexander Dubček and Slovak University of Technology in Bratislava and project **KEGA No. 3/3111/05**: The creation of virtual robotic laboratory for supporting the teaching the subject Robots and manipulators in a newly accredited study program.

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