REMOTE LABORATORIES AND METHODS OF THEIR APPLICATION IN THE STUDY PROCESS

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Abstract

Nowadays the development of distant learning methods has become one of the most advanced educational trends. Distance learning methods can be seen in their various applications in almost every educational sphere. Remote control and distance learning techniques are also of high demand in technical specialities, with the automatic control engineering field being no exception. Problems of technical realization of remote laboratories are to be considered together with the quality assessment of acquired knowledge. Obviously, such an object as the remote laboratory has to be considered from two perspectives: it is an engineering object in terms of its realization, and at the same time it is a purely scientific tool to assess the quality of education.

Key words: *distance learning, remote laboratory, automated systems, effectiveness of knowledge.*

1. INTRODUCTION

Nowadays remote laboratories are becoming the most frequently used tools for teaching and scientific research in various fields of science and technology.

Automation and robotics technology are intensively developing technical areas where methods of remote control are widely used. It is important to consider not only aspects of technical realization of virtual laboratories but also the outcomes of learning and making experiments [1]. The latter seems to present more challenges than the technical realization of such a laboratory. While developing our software environment to control remote laboratories [2] we place a special focus on the analysis of the feedback we receive from students who work and study with the help of remote and home laboratories.

All experiments are designed so that learning environment is able to detect real competencies of the student and therefore to propose proper actions. Our experience has shown that even very simple subjects may be not known, forgotten, or misunderstood by the learner. This is why the system tries to create a detailed picture of student's abilities. In our case, it is possible to conduct combined experiments where one student works at distance and another one (or a teacher) is at his/her workplace and cooperates with the first student. All actions taken by the student are logged for making a follow-up replay (for the analysis and development by the teacher) as well as for a more efficient monitoring and control of the learning process.

2. FUNDAMENTALS OF REMOTE LABORATORIES AND METHODS

The project for setting up of remote and home laboratories is based on the commonly shared integrated software environment (LoTe). The environment includes several virtual laboratories which allow students to use remote equipment. The earlier described software modules of laboratories are integrated into the common information environment. The layout of the interface of the information environment is shown in Figure 1.

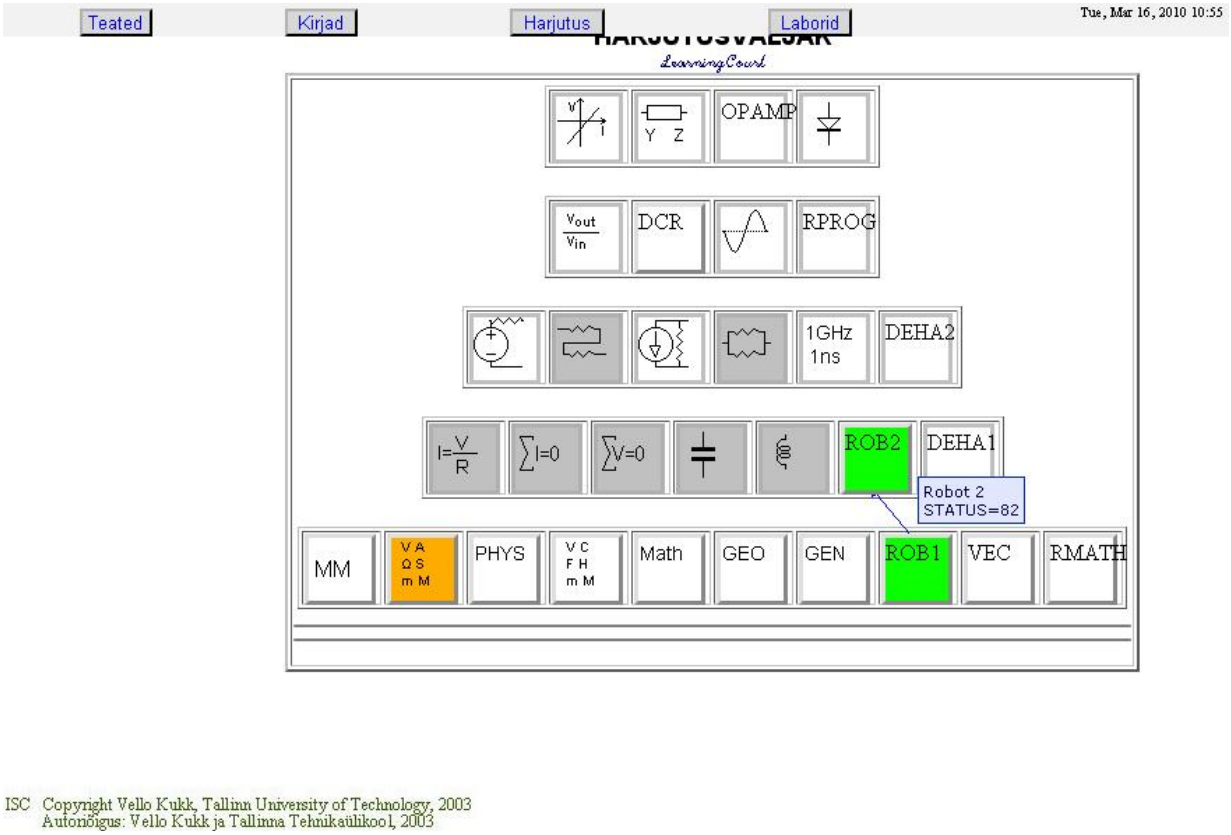


Figure 1. Start Page of the Learning Environment Interface

The student is offered several difficulty levels for the studies in the laboratory. The first difficulty level (ROB1) presupposes remote control of a robot manipulator. It requires simple manipulation techniques and knowledge of main parts of the manipulator. (Fig.2 and Fig.3)

The task completion can be controlled virtually by means of in-built WEB-cameras. The position of every arm of the manipulator can be changed with the help of special switches. The switches are built in the interface of the task window. The manipulator's working session lasts for a set period of time. Taking the manipulator into the working session is shown by a corresponding colour of windows in the view mode.

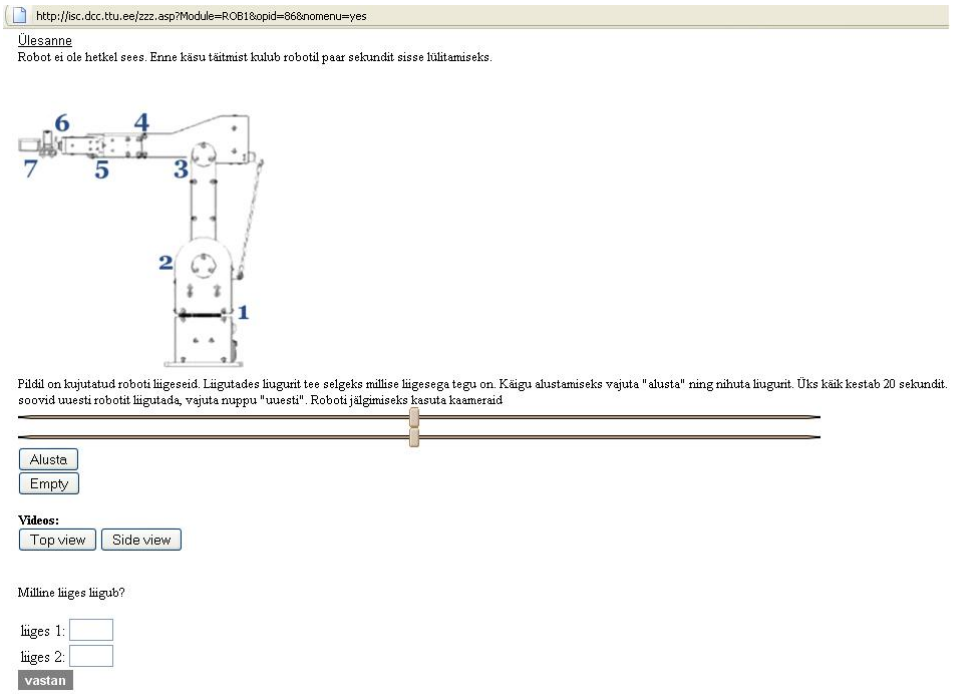
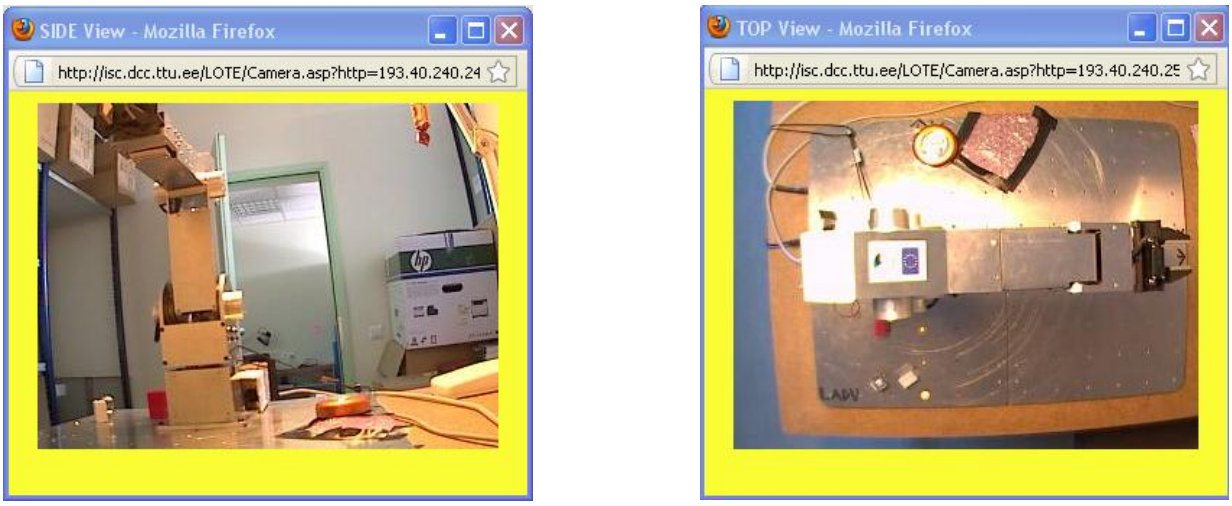


Figure 2. Sample Task of ROB1 Level



a) side view b) top view

Figure 3. View of Level ROB1 Task's Execution a) side view and b) top view

The second level (ROB2) requires from students practical skills of working with a robot manipulator. The student performs preliminary task solution (Fig.4) and can see the manipulator's response to the offered decision.

It is important that after having completed a set of tasks, the only task of the designer (= the teacher) is to process the results as a source of general information. This means to conduct a periodical statistical analysis to reset levels of tasks as usually the designer is not able to foresee what is complicated for the learner and what is not. It is enough to reconsider the levels once or twice a year. We have also to take into consideration the fact that learners are changing all the time and certain reorganization is needed just because of that.

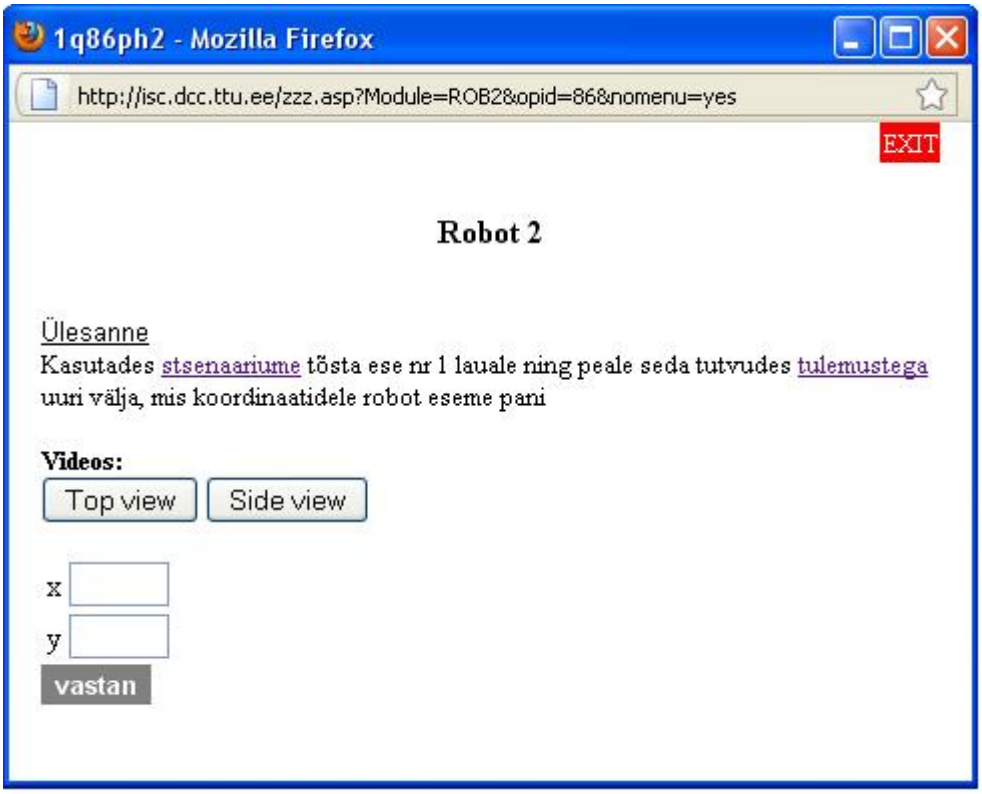


Figure 4. Sample Task of ROB2 Level

In the forthcoming time an automation laboratory is going to be integrated into the information environment. A training panel to study hydraulic devices allows to assemble and to programme a hydraulic robot manipulator remotely (Fig.5).

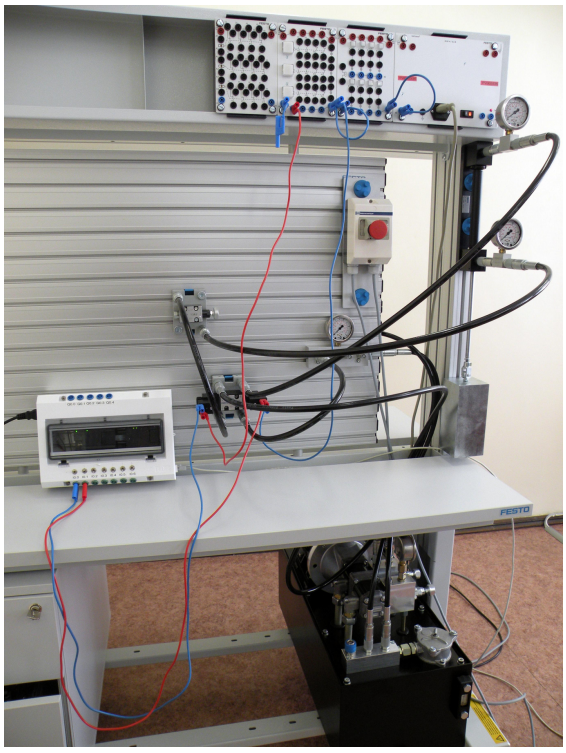


Figure 5. Training Stand for Automatics.

With the help of the information environment it is possible to receive feedback, to analyse works in progress and to assess the depth of the knowledge acquired by the student.

3. DATA ANALYSIS ISSUES

In the course of the operation of virtual laboratories there are a lot of statistical data which need processing. Alongside with standard decision making options such as the true-false technique and the method of comparison with correct answers, more precise methods and decision making procedures are requested. At present, in the project information environment there are almost 100 thousand records of statistical data. Processing of the received data and decision making procedures constitute the very part of the virtual process which requires constant work, analysis and decision making. To illustrate, one of the concepts of engineering psychology - the concept of the information model, information search and segment equivalent - can be taken as an example.

The main idea of this concept [4] is that the man is more and more being distanced from the object of control and he performs his duties remotely, which means the operator is working less and less with the object directly but operates its information model. The main requirements (rules) of the information model's construction are based on people's abilities and consist of the following: a) the model has to consider only key interconnections in the control system; b) it has to be created on the basis of the most effectively used code (language); c) the model has to be demonstrative and to be compiled with regard to particularities of people's analyzers and characteristic features, peculiarities and complexity of the performed operations. Segment equivalent of the system does not refer just to a person but it implies a whole complex which includes a man-operator, indication means (means to

display information) and control devices. The main function of the complex is to transfer and process information. The system design presupposes (in comparison with ordinary project design) the following:

- design of simple systems ('technology of operational development') is realized by gradual increase of functions and by checking efficiency on the basis of the acquired experience;
- for more advanced systems, 'the computer metaphor' approach is considered to be the most appropriate. The approach is based on the principle of dividing a whole unit into parts which still can respond to the commands of the operator (i.e. the main function is divided into sub-functions) at the stage of analysis (identification of sub-functions). The stage of synthesis (the designing stage) is aimed at application where a permanent control over efficiency of innovations is required in the form of frequent repetitions and tests ('repetition is the basis of engineering design');
- the main stages of the engineering design of complex systems are: research, analysis and planning, technical design, tests, setting into operation.

While designing various socio-technical systems it is important to take into consideration individual characteristics of an operator. Traditionally, many specialists apply Hopkin's scheme of describing individual characteristics of an operator [5].

The following 15 groups of characteristics are applied to evaluate particular qualities of an operator:

- Biographical data: age, sex, nationality, work experience, previous work.
- Physical and physiological characteristics: health, physical power, stamina, stress resistance.
- Requirements to sensor systems (including 'inter-modal interaction').
- Requirements to cognitive processes: speed, precision, recognition ability in various sensor modalities.
- Requirements to information processing.
- Requirements to psychomotor system: muscular coordination, dexterity, manipulative capability, stimuli response.
- Requirements to semantic systems: ability to speak and understand spoken speech, speech fluency and accuracy.
- Knowledge and skills: fundamental knowledge, practical skills, learning ability, ability to apply knowledge in practice, mastery at work, pragmatism.
- Requirements to education: basic and vocational education, additional training, recent achievements, attendance of retraining courses, future plans for education.
- Requirements to cognitive and mental processes: general culture; verbal, numeric, spatial, mechanical skills and abilities; the ability to learn by mistakes, the ability of not paying attention to offences.
- Requirements to the quality of performance: speed and precision of associations; perceptive, intellectual, psychomotor functions; definition of objectives.
- Individual requirements: main personality features, specific personality features, an individual profile, appearance and habits.

- Social requirements: ability to work in a team, tact, readiness for leadership, morality, attitude to superiors and juniors.
- Motivation and interest: bahaviour, need in complex tasks, readiness to apply additional efforts at work.
- Emotional requirements: emotional stability, perseverance, survivability in changing working conditions, response to stress and boredom.

To conclude, the task of designing of virtual laboratories and systems as well as of received data processing is a rather complicated multifaceted mathematic problem. The consideration of all above mentioned parameters requires complex analysis with the use of a distributed computer system. The transfer from calculations at one unit to geographically distributed systems in various fields of science (knowledge) can be mentioned here as an illustration with the example of wide-scale modeling, analysis and processing of data and making joint experiments in various fields of knowledge (chemistry, high-energy physics, thermonuclear synthesis, research of climate and life processes). In particular, the so-called grid technologies are becoming the most rapidly developing and increasingly popular areas; their appearance is connected with the increase in the efficiency of personal computers, with the appearance of cluster computing systems with massively parallel systems of functioning as well as with the creation and development of the Internet.

4. FUNCTIONING PARTICULARITIES OF THE GRID SYSTEM

The grid system is a geographically distributed infrastructure which unites a number of recourses of various types (processors, long time memory and random access memory, data storages and bases, networks) and which can be accessed by the user from any point regardless its location. Grid technologies presuppose commonly shared access to resources and their services within the system of globally distributed virtual organizations, including companies and individual specialists, who share the usage of common resources. Joint grid systems consist of extensive resources located in various research and technological centres, institutes, universities all over the world.

The resources include individual computers, clusters, local networks, supercomputers, data storages, communications, software packages and toolkits. Grid systems are efficient for solution of problems which require computing power and which can be subdivided into sub-tasks and processed in parallel, for example, the analysis of statistics while modeling complex physical systems with various random initial and final conditions; genetic algorithms, optimization methods, mass processing of huge data streams, multiparameter data analysis, modeling on remote supercomputers, realistic display of huge sets of data, etc. [6].

5. RESULTS AND CONCLUSIONS

The described learning system has been both in development and usage for about 10 years and has changed significantly. In addition to classical remote labs home lab kits have been used for almost 5 years. We can see continuous increasing of learning time at home. In some cases a student has performed almost 90% of all activities outside the school building. As a rule, only introduction is needed in laboratory, and after learning some basic principles of operation students prefer to work remotely. Of course, they have online connection all the time. However, it is surprising but the number of questions they post is rather small. Probably, it is also a result of interactive environment – they do get an instant response to all activities.

It may be surprising but learners do not like any extra details on web pages. They assume that every page is simple, consisting of only relevant information without any attractions. It seems that the student considers the learning environment as a real co-worker and does not like any disturbances.

As for remote labs, low level time sharing without any pre-registration has proved to be the right solution. It might be compared with home labs when the student is almost totally free in using his/her time.

Getting into more details about learning technologies, it becomes much clearer that considering human characteristics as a part of the process is very important for success. Processing the data collected over years shows a large variety of learner's behaviour, possible detection and usage of his/her model. Obviously, this is a more complicated and delicate problem when it is considered from the point of one's privacy. However, if it is done for the sake of a more successful learning, students will probably not argue against it. Anyway, this is one of the most important directions of further research.

REFERENCES

1. V.Kukk, "Analysis of Experience: Fully Web Based Introductory Course in Electrical Engineering". Proceedings of the 1st International Workshop on e-learning and Virtual and Remote Laboratories, Setubal, Portugal, August 24-25, 2004; 111-118
2. Oleg Shvets, Vello Kukk, Martin Jaanus, Kadri Umbleja Home and remote laboratories development of web-based practical works for higher and vocational education. // 11th International Symposium Materials, Methods & Technologies (MMT) - Sunny Beach, Bulgaria, 2009; 4-6.
3. http://www.ido.rudn.ru/psychology/labour_psychology/6.html
4. Зинченко В.П., Мунипов В.М. Эргономика. Ориентированное на человека проектирование. М.: Тривола, 1995; 480.
5. Леонова А.Б., Чернышева О.Н. Психология труда и организационная психология: современное состояние и перспективы. Хрестоматия. М.: Родикс, 1995; 55
6. Глазков В. П., Пчелинцева С. В., Егоров И. В., Лавров А. В. Решение задач робототехники с использованием распределенных grid-вычислений в автоматизированной дистанционной обучающей среде.РИЦ СГТУ: Саратов, 2007; 5-6.