Distance Engineering System for Robotic Applications

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Abstract
The paper deals with innovative system providing a distance and online engineering functionality for students and practicing engineers. Purpose of this study and development is to provide internet based system for operating and controlling actively remote devices over the internet. Remote devices are currently mobile robots, small manipulators and profibus controllers. On the future development production machines in the factories will be included into the system.

Introduction

On the frame of economical drop the efficency and optimization of using resources have been now got much more in focus, including in field of engineering and education. The enineering education hasn't been very popular in recent decade where the economic rise has taken place. Most new students were interested to study economics and management as it seemed to be a fast way to make money. Now, on the turning point, it is very important to take actions for engineering studies to make it more attractive for young people and feasible for practicing engineers. Serious problems exist on the continuous and vocational education with the practical study process. In continuous education the main problem is the lack of time of practicing engineers to participate in lectures or labs and the common problem is to exploit new Internet technology for practical studies in engineering field. The current paper describes the joint actions [1, 2] together with Estonian, German, French and Finnish universities to contribute to solve these issues.

Distance labs, home labs and every kind of remote controlling is not very new technology. It has been done before and some successful results are received [3, 4]. However the problem seems to be the lack of 'big picture' as most of these kind of projects are single tries where only one functionality or type of experiment is provided. Lots of distance lab projects are after the initialization and some running time offline and not included into study process. In our case we try to provide integrated approach to study engineering fields (mechatronics, robotics and microcontroller programming) remotely but without losing the practical hands-on experience in the same time.

Distance engineering study concept

Our ongoing joint action can be applied into engineering course as described with mechatronic learning concept shown in Fig. 1, by the support of online controlling and management system and mobile mechatronic lab kit. The whole concept is developed in co-operation of 5 European universities (Tallinn University of Technology, Kaunas University of Technology, Royal Institute of Technology, Bochum University of Applied Sciences and Helsinki University of Technology) and is applied into practice in Germany, Estonia, Sweden and Finland. The further development has involved also French university - Université de Technologie de Belfort-Montbéliard. New target sectors are also included in the new project like system engineering and automotive industry.

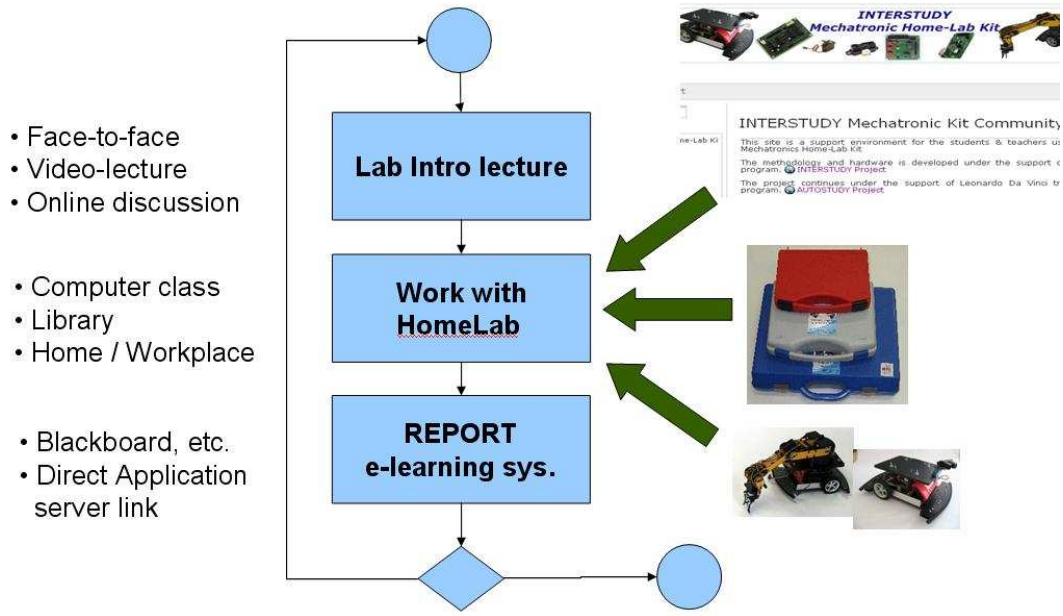

Fig. 1 Mechatronic Learning Concept and tools

The learning concept shown in above figure is a proposed methodology and set of supportive materials and hardware to carry out distance learning in mechatronics. The concept is relaying on the mechatronic curriculum combining different modules. The study modules are supported by the different tools i.e.:

1. Traditional textbook - "Integrated Systems and Design" [5]
2. Hands-On exercise book with examples [6]
3. Home Lab hardware packed into mobile suitcase
4. Distance Lab environment and learning path management
5. Mechatronics Home Lab Community website

These tools enable to study mechatronics and related fields efficiently and breaking the limits of location and time. The e-learning support is strongly built-in into all tools and strong integration offers the interesting learning process. On the side of traditional teaching and learning aids an innovative *Home Lab* and D*istance Lab* solutions are developed and put into practice.

Home Lab

All together the *Home Lab Kit* is a mobile ready to use a small test stand, which can be connected to PC and operated in home or working place. The aim of lab toolkit is to provide a practical and effective hands-on training. Students can combine various solutions on different levels of complexity and functionality, based on modules in the kit. The Home Lab Kit main feature is mobility - toolboxes are small and compact and all modules with necessary tools are seated into box. Toolkit has a USB connection to PC (for example student home computer). Simple and easy to install software is used to connect main controller to computer. This is particularly important because the student can start his/her experiment in school then continues in home or even in his/her workplace. The Home Lab toolkit includes all pedagogical materials, lab exercises and source code examples. In addition practical questions and advanced exercises are given in the end of every lab. Solutions are also given as a HEX files on the disc.

Fig. 2 Home Lab Kits

The Home Lab is provided in different Kits presented in Fig. 2, including different functionality and modules. Four standard Kits includes following components:

- Home Lab Basic Kit
  - Microcontroller (ATMega128) with motherboard
  - Study Board (Digital I/O), LCD display
  - JTAG-USB programmer
  - Measurement device
  - Software, examples, exercises & videos
  - Power supply, cables
- Sensor& Actuator Add-On Kit
  - Sensor module (LDR, NTC, Pote)
  - Distance sensors (ultrasonic, infrared)
  - Actuator module with encoder support
  - Electrical motors (DC, RC Servo, Stepper)
  - Cables
- Automotive Add-On Kit
  - Microcontroller (AVR vs ARM)
  - CAN/USB nodes
  - Cables
- Home Lab Advanced Kit
  - Home Lab Basic + Sensor & Actuator Add-On Kit
  - RFID module & tags
  - Communication module (Bluetooth, Ethernet, SPI)
  - Machine Vision module (CMUCam3)

Distance Lab

On recent years the remotely controlled and virtual labs are increased rapidly. The labs have very different interfaces and technical realizations. Some have integrated into general study environment, some has just separate web interface to program the device. Already now one university may have several virtual labs controlled over the Internet. This has bring on the fore the new issue - how to manage these Internet connected labs and devices on the particular lab. Different issues like

booking the device; managing the rights; controlling and validating the user inputs; etc. have to be solved. One possible solution for all this kind of problems is the portal type remote lab management environment. On the support of EU project a complete distance lab management and programming environment is developed. The functionality connected with remote lab is as following:

- user and group management,
- location, lab and device management,
- source code validation and version management,
- wireless device communication, including external reset and programming,
- device booking and booking rights.

Having a broad view in mind the system supports three levels of grouping:

- Location – this is organizational level where different type of devices and labs can exist,
- Lab – the virtual room where physically or virtually different devices can be located,
- Device – a set of same type devices in one location.

Devices have additionally grouped into several sub-groups according their type, e.g. mobile robots, manipulators, PLC-s, etc. The example list of available units from different labs are shown in Fig. 3.

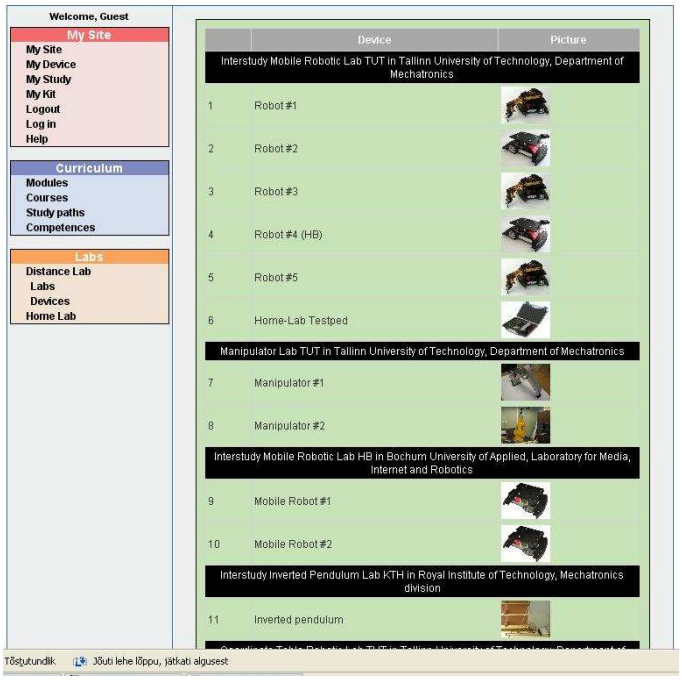

Fig. 3 The list of available devices in remote labs

The remote lab management website (see Fig. 4) is an interface to access different (e.g. mobile robotic) distance labs. The multi-robot environment is developed as a pilot and is located in the university, consisting number of similar robots equipped with short range wireless communication module. The site is fitted with web camera and server which communicates with the robots. Server has a master communication unit which can be contact with any robot on the field and reprogram it at any time when needed. The site server is connected with the portal server passing and validating the communication between the robot and user input.

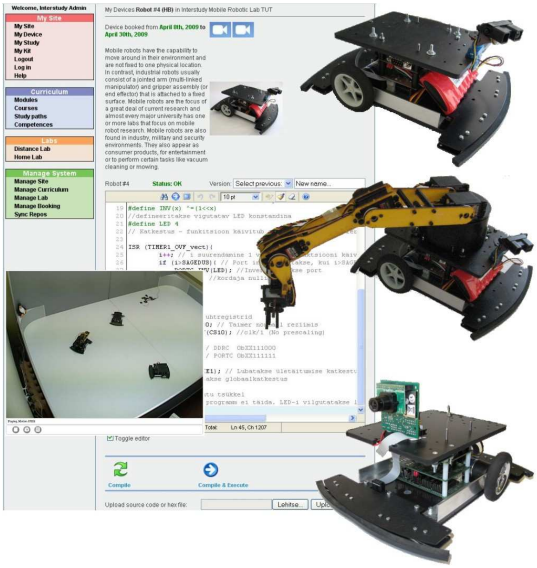

Fig. 4 Distance Lab programming environment and devices

The robotic distance lab is a multi-robot environment which is remotely controlled by the user. Robots can be either conventional industrial manipulators including conveyors and rotating tables, or autonomous mobile units without any wired connection. The device has an on-board intelligence and user uploaded functionality program. The system development theoretical background is studied on the related parallel researches: “Mechatronic and Production Systems Proactivity and Behavioural Models” [7] and “Development and Integration of Mechatronics Modeling Methodology” [8]. Another type of remotely controlled lab is an interface of Profibus programmable logic controller (PLC). An example simple system is set up by the students where profibus controller is controlling pneumatic system. Pneumo actuators are simulating the pipe play. Simple demo application is set up where toy monkey is put to play the pipe. The hardware includes: E1061 LCD TFT operator panel, FX3U-16MT-DSS main module, FX3U-64DP-M, Ethernet module and PROFICON-PLUS. The interfaces with two video windows are shown in Fig. 5. In addition to existing Home Lab Kits and Distance Lab Kits the current focus is to build up the automotive industry oriented modules for both systems. Modules will help to build up the vehicle device network where information exchange over the CAN and USB interfaces can be practiced. With Home Lab automotive module user can simulate the real car information system and explore the problems and issues related to develop automotive intelligent systems. According to our study concept the homework is supported by the distance lab where the real equipment is in university and users can actively control and program the system over the internet. The system is expected to be in action in TUT (Estonia), HB (Germany) and UTBM (France) universities on the next year.

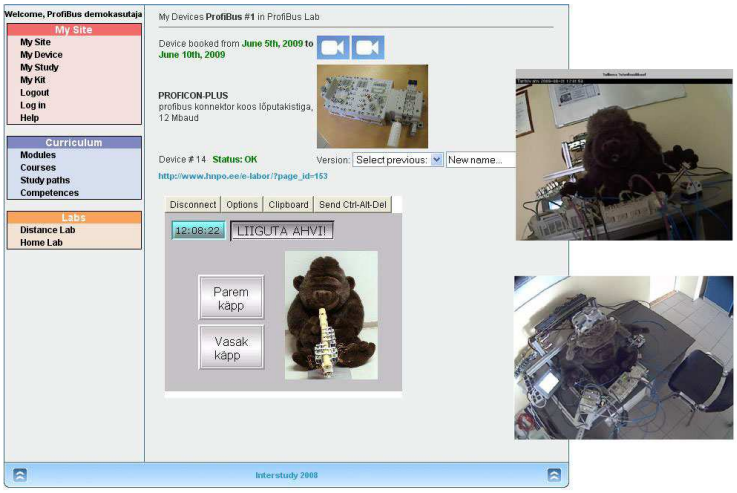

Fig. 5 Distance Lab ProfiBus controlling interface

Summary and further work

The described system has many innovative solutions and combines the theoretical e-content with hands-on tools and distance labs. The technical solution includes novel communication technologies and innovative software solution. The system is developed in open manner and the base system can be applied in several other fields. In a way it enhances university networks cooperation and gives students equal possibilities for top level education.
The further research step is to implement the base technology behind the distance lab system into industrial e-Manufacturing field. To realise it a common framework should be developed to plan and control manufacturing in a cluster of enterprises. Information exchange is performed on web-base. This includes the wireless monitoring of production lines and intelligent self-communicating sensor system. Booking of industrial device as CNC machine tool or robot welding system is thus a scenario for factories of the future. If a company buys expensive machinery it is interested to fully implement it and is eager to sell available machining time. This in turn will speed up SME-s development as manufacturing can be redistributed between smaller units. The implementation elaborated remotely controlled laboratory environment will have positive effect for society as students are expected to realise experience from academies in the real manufacturing.

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