

# Cisco Systems concepts implementation for studying complex mechatronic system via Internet

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**Abstract** — There is significant number of software systems offering solutions for distance education (so-called e-Learning). The developed laboratory distinguishes itself from other known ones. Here students can do laboratory works with real object and strengthen the knowledge with practical work via Internet. Description of a complex mechatronic system from this laboratory is given.

**Keywords** — Cisco, concepts, studying, mechatronic, system, Internet.

## I. INTRODUCTION

Distance education is a consuming of educational service without attending educational institution using modern information technologies and telecommunication systems like E-mail, television and Internet [1].

There is significant number of software systems offering solutions for distance education (so-called e-Learning).

Common name “e-Learning” describes wide range of software products which work according to client-server architecture and use Internet or other network based on TCP/IP protocol stack.

The structure of linear distance education organization is the most widespread these days. It supposes that properly structured information is located on server while distance learning applications include tools to view and search information and control the acquired knowledge quality.

Joint research is made to create virtual laboratory “Verbund Virtuelles Labor (VVL)” for distance study via Internet in the context of cooperation between National

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Mining University (Dnipropetrovs’k, Ukraine) and Reutlingen University (Reutlingen, Germany) [1, 2].

Laboratory VVL distinguishes itself from other known ones in that students except receiving learning materials can do laboratory works with real equipment and strengthen the knowledge with practical work staying at home. The place to do the laboratory work can be as well university which doesn’t have such an equipment, in different city and even in different country.

Student doesn’t need to download any special application for this. It’s enough to have browser application and Internet access. He observes all processes running on equipment in the laboratory via webcam.

Laboratory workbench with unstable dynamic object from the VVL laboratory is described in this work.

## II. STRUCTURAL SCHEMA MECHATRONIC SYSTEM

Developed system consists of a wheel with driving gear, a ball which is located on the wheel and control system connected to the Internet.

This mechatronic system demonstrates automatic control principles of the complex moving object (ball on the wheel) position. The main aim of the control is to constantly balance the ball on the wheel and not to let the ball fall down from it (Figure 1).

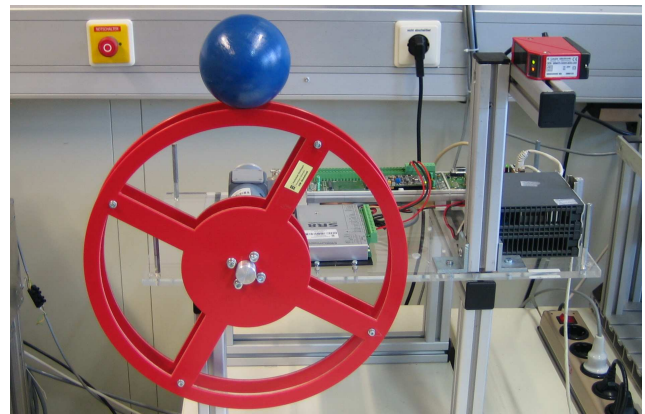


Figure 1. Balanced ball on wheel system outlook

The control is performed by a real-time embedded system Sitek/Ultimodule SCM-220 and is based on feedback from the distance measurement sensor. All control logic is performed by the program executed by the controller according to the schema shown in Figure 2.

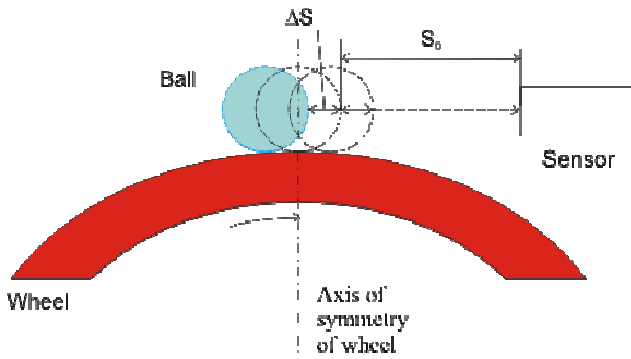


Figure 2. Functioning principle of the system

Each sample from the sensor provides the control unit with the actual distance to the ball. The control program analyzes the actual distance value and reacts to the ball movements by recalculating and adjusting the drive signal. This signal is transmitted to a servo amplifier and specifies the motor rotational rate. The wheel is linked by a gearbox to the motor axle (Figure 3).

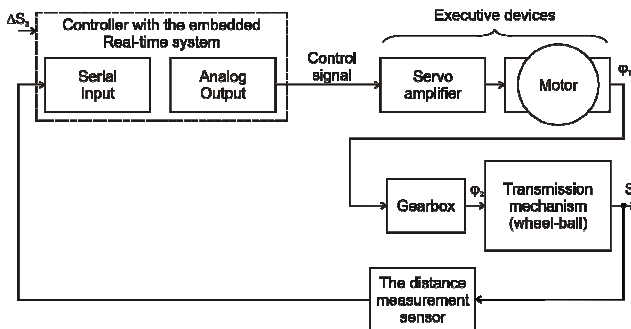


Figure 3. Structural schema of the mechatronic balancing system

Wheel rotation causes the ball to make complex rotating forward movement towards the desired position. This movement changes the distance from the ball to the sensor. The sensor measures the new distance and sends the value to the control unit and the control cycle repeats (Figure 3). The cycle time is currently set to 22ms.

With this experiment user has an opportunity to learn principle of a complex object control system operation on the real example remotely from any point of Internet using this service and observing it with webcam.

Besides observing the system the user is allowed to change a parameter of the system changing its behavior. And once again, a user can see with webcam in real time the result of own influence to the system, investigate an impact of parameter changes on the control way.

It's important to ensure trouble-free round-the-clock system operation and its availability for users. The system is programmed and adjusted so that the ball falling due to influence of a remote user would be excluded. Otherwise it would be possible to restore system operation only by local assistance of laboratory staff to put the ball on the wheel. Stability of the system operation is ensured by limiting

offset value in range from -3.5 to 3.5 mm from central position of the ball on the wheel.

User can learn technical details of the system implementation and its operating principle on the web page. It's possible to observe the system's operation in real time with web camera installed in the laboratory. User opens the camera applet window clicking on the corresponding button on the laboratory web page and selects in camera settings the Balanced Ball-on-Wheel system to observe. The camera automatically focuses on the most convenient angle and zoom preset in advance for this system (Figure 4).



Figure 4. Observing the work of the system with webcam.

User can change the behavior of the system. Following the link for setting offset parameter a dialog window opens allowing changing the parameter (Figure. 5).

For example the wheel is constantly rotating now. If this doesn't satisfy us we open the change parameter window, see that the offset is not zero and change it. Setting the parameter to zero we stop constant wheel rotation. Except the possibility to observe moving system control itself, it demonstrates possibility to remotely control such a system what is very important feature for modern industry.

### III. SOFTWARE OF THE MECHATRONIC SYSTEM

Software was developed in C++ programming language to provide the laboratory work. The control cycle implements a PID(proportional-integral-derivative)-controller in main() method (main.cpp file).

In order to abstract from the details of hardware communication three classes were created: CSerialConnection, CDistanceSensor and CMotor. To apply parameters which user can set on web page CAppearance was also created.

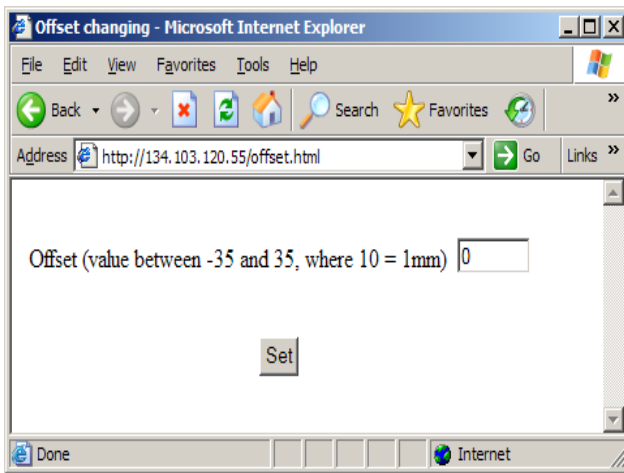


Figure 5. Browser window for changing balancing offset parameter.

Instances of these four classes are created and used in main() method.

Class CDistanceSensor – is intended to get distance value from ODS 96 sensor. To communicate via serial port this class uses CSerialConnection class.

Class CMotor is used to output the velocity value to the motor via analogue output module USMCA8CO.

Class CAppearance was created for data exchange with HTTP response handlers which provide the system with web interface.

The application is built on eCos component framework (real-time operating system). This application also includes an embedded HTTP-server that provides the system with a web-interface. Using simple web-forms, the user can change control parameters at run-time. For instance, this demonstration allows you to set an offset of the ball's balancing position relatively to the base position. Base position is on the very top of the wheel, when ball's and wheel's vertical axes of symmetry coincide. With zero offset the ball balances near the base position and the wheel almost doesn't rotate but by hardly visible movements balances the ball not letting it to fall down. To balance the ball in position relatively far from base when user sets non-zero offset values the wheel should constantly rotate (Figure 2). Dependent on the offset value sign the wheel rotates clock- (positive offset value) or counterclockwise (negative offset parameter value). Under these circumstances the ball rotates on the wheel balancing near defined position but doesn't fall down. User can change the offset parameter  $\Delta S_M$  in range from -3.5 to +3.5 mm.

#### IV. LABORATORY WORK GOAL

Laboratory work goal: study an example of complex mechatronic system.

To perform this laboratory work it's necessary to learn via Internet next topics:

- a) structure of the complex mechatronic system;
- б) characteristics of the position control system of complex moving object in the form of a ball on a wheel.
- b) software of the laboratory work WEB BALL;
- г) execution order of the laboratory work WEB BALL.

#### V. CARRY OUT NEXT ACTIONS

Carry out next actions:

- a) type in a virtual laboratory HTTP address in a browser window (browser should support Java: IE4.0 and newer, Mozilla, etc.), select Demonstrations section and follow the link Balanced Ball-on-Wheel;
- б) study general WEB BALL laboratory work description and task execution order on the web page;
- в) start webcam program (applet) clicking correspondent button on the laboratory web page and wait till the camera automatically focuses on the most convenient view angle and zoom preset in advance and applet with picture of WEB BALL demonstration appears on the screen;
- г) investigate behavior of the mechatronic system at the initial state;
- д) open a window for offset parameter change;
- ж) according to the task given by the teacher change offset parameter  $\Delta S_M$  and investigate the mechatronic system behavior under this parameter value;
- з) perform one more offset parameter change and investigate system behavior;
- і) compare results of these experiments;
- д) close webcam applet after finishing work with it.

#### VI. CONCLUSIONS

The underlying notions of the virtual laboratory aren't limited only by educational area. Research into application of the VVL concept in real industrial control systems and in social life is conducted on the Automation and Computer Systems sub-faculty.

#### REFERENCES

- [1] Цвіркун Л.І., Бічерова Л.В., Білоус А.І., Gruhler G. Розробка віртуальної лабораторії для дистанційного навчання через мережу Internet в рамках кооперації з Ройтлінгенським університетом. Перспективи вищої освіти: роль міжуніверситетських консорціумів: Матеріали міжнародної науково-практичної конференції. Миколаїв: Атол, 2004. с. 121-123.
- [2] Цвіркун Л.І., Гончарук С.О., Кмітіна І.В., Gruhler G. Віртуальна лабораторія для дистанційного навчання через мережу Internet. Матеріали междунар. научн. - техн. конф. г. Севастополь, 12-17 сентября 2006 г. с.194-195. Севастополь, 2006.