MECHATRONICS EDUCATIONAL ROBOTS ROBKO *PHOENIX*

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Abstract
Important of the robotics for interaction between Robots and Humans is presented. Educational robots as a good tool for learning about robotics are discussed. Statistics and Market analysis of robotics is introduced. ROBKO 01 is reminded. A developed articulated robot and its technical parameters are presented. Hardware and software systems of our articulated robot are described. Importance of educational robots is concluded.

Keywords: *Articulated robots, Educational robot, Service robot, Entertainment robot, ROBKO 01, ROBKO Phoenix*.

1 Introduction

In the beginning of the robotics, most robot applications were related to industries and manufacturing and these robots were called Industrial robots. With development of a new, more versatile robots new sensors and sensory systems, visual systems, microcontrollers, batteries etc. today robots start working in almost all fields of services too. Their application areas are from service robots for professional use to service robot for personal use including also educational, entertainment and leisure robots.
We can expect that the field of robotics will be changed dramatically in the 21st century. The number of service robot applications will grow much faster than that of the industrial robots. All this is expected because of the penetration of service robots in all spheres of human life and activities.
People perceive robots in a different way than other machines because they are performing tasks like humans who are programming them. Robots are entering more and more human homes today and are realizing often a real interaction with them (*Chivarov, N., Shivarov, N. and Kopacek, P., 2008).*
Based of those features educational robots are the best tool for learning about robotics and interaction between robots and humans.
Robotics is multidisciplinary scientific field which includes mechanics, electronic hardware, software, artificial intelligences, sensor and sensory systems etc. and is a good test-bed for educating students, young specialist and researchers (*Kopacek, P., 2007*).

2 Statistics and Market Analysis

A study made by the experts of the United Nations together with the International Federation of Robotics (IFR) is covering the statistics, market analysis, case studies and profitability of Robot investment (*IFR, 2006*).
According to these studies, Total worldwide stock of Service robots for professional use: 39,900 units installed up to the end of 2006.
Service robots for personal and private use: about 2.44 million units for domestic use and about 1.1million units for entertainment and leisure sold up to end 2006.
So far, service robots for personal and domestic use are mainly in the areas of domestic (household) robots, which include vacuum cleaning, and lawn-mowing robots, and entertainment and leisure robots, including toy robots, hobby systems and education and training robots.
Projections for the period 2007-2010: 35,500 new service robots for professional use to be installed.
Projections for the period 2007-2010: about 3.6 million units of service robots for personal use to be sold.
The market for entertainment and leisure robots, which includes toy robots, is forecast at about 2.2 million units, most of which, of course, are very low cost.

3 ROBKO 01

In the late 80's educational robot ROBCO 01 was developed (*Shivarov, N., 1987*).
It's mechanical system was simple and strings driven using stepping motors.
ROBKO 01 is six degree of freedom articulated minirobot consisting of base, three links and a gripper driven with stepper motors, gears and rollers (see fig.1). Control of the robot was realized with TTL integral schemes, transistors and diodes. Special driver language ROBASIC was created for programming ROBKO'01.

Fig. 1 Articulated Educational Robot – ROBKO 01

It was produced in a large series for domestic use and export in all former socialist countries and some west ones (small series for Argentina, France etc.). They have been produced over 18000 pieces. This robot had a great impact on introducing robotics to the young generation of that time.

4 ROBKO *Phoenix*

Having as a base ROBKO 01, developed in late 80's, we decided to redesign it and to design it's mechanical system with new links produced from aluminum and it's drives with new DC gear-motors, to apply a new hardware-control modules, new software, new graphic-user interface and new sensor system giving feedback to the control system about the exact position of the joints. As a result now we have a new modern multipurpose articulated minirobot (see fig. 2).

Fig. 2 Articulated Minirobot – ROBKO *Phoenix*

Technical parameters of the Articulated Educational Robot – ROBKO *Phoenix* are shown below (table 1).

Parameters	Link 1	Link 2	Link3	Link 4
Working range [deg]	300	110	95	185
Type of the reduction gear	WORM	WORM	WORM	WORM
Reduction rations	i=33	i=33	i=33	i=48
Actuation	Micromotos HL 149 12 V; i=10	Micromotors HL149 12 V; i=10	Micromotors HL149 12 V; i=10	Micromotors HL 149 12 V; i=10
Weight [kg]	0,500	0,250	0,250	0,250

Table 1 Technical parameters

4.1 Modular Hardware and Software systems of the articulated robot arm

The key concept of this robot will be its easy reconfigurability and intuitive user interaction. Having those requirements in mind, the design of the robot is based on modules. Different modules are chosen depending on tasks that must be performed and goals to be achieved. The electronic control blocks and software are configured accordingly.

- ***Architecture of Robot Arm controlling system***

All commands to the Robot Arm, as well as data from its sensors to the operator are passed and processed by the control module *Robot Controller.* The distribution of different queries and commands to different modules, self-test and detection of system's configuration, as well

as the whole robot intelligence at high level is performed by the embedded software of the controller using the system bus Robot System Bus. The immediate control of different mechanism types (motors, electromagnets), is implemented by separate intelligent electronic modules. Those modules care on one hand for communication with the Robot Controller using specially designed communications protocol, and on the other hand for the immediate physical control of different end mechanisms and devices. On figure 3 is shown Control System of our Educational Articulated Robot ROBKO *Phoenix*. The position of actuator mechanism can be monitored, controlled by the motor and on query – transmitted to the Robot Controller. Modules also implement basic functions for electrical overload protection and other low-level functions.

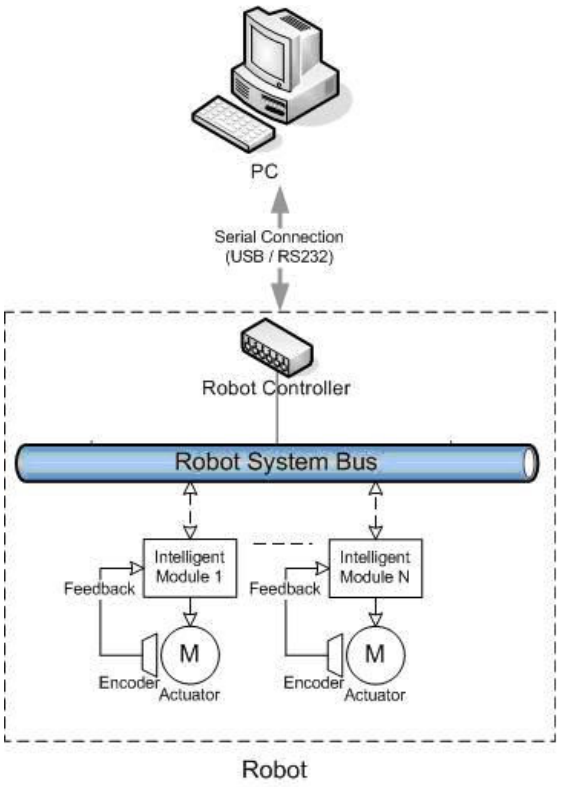

Fig. 3 Control System of the Educational Articulated Robot ROBKO *Phoenix*

- ***Intelligent modules***

The intelligent modules implement direct control of the actuators. They are built using a simple 8-bit microcontroller ATTiny26L (*Atmel, 2003*) and driver ICs that provide the necessary levels of electrical control signals for the proper actuator operation. They also have the ability to collect information from each actuator's encoder.

- ***Robot controller***

The Controller performs the following tasks:
- Communication with the host computer using a serial connection (RS232);
- Discovery and diagnostics of the system configuration – present intelligent modules;
- Control of actuators and collecting information about their state using the System Bus and a specially designed protocol.

The Robot Controller consists of three main blocks – the Control Unit CU, the Communications Controller CC and Bus Interface module BU, as shown on figure 4.

The Communications Controller implements receiving commands from the operator through a serial connection to the host PC, and sending back data for the robot status. It is implemented using MAX232 integrated circuit.
The Interface Module is responsible for connecting the Robot Controller to the System Bus. It is in fact built into the main CU microcontroller.
The Control Unit is built around an ATMega32 microcontroller from Atmel's AVR microcontroller family (*Atmel, 2002*) and contains the main software implementing the whole high-level intelligence of the Robot.

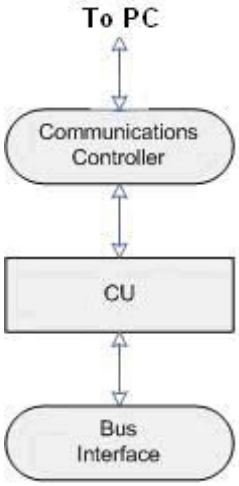

Fig. 4 Robot Controller

- ***Actuators***

The actuator mechanisms are the systems that provide immediate physical functionality and operation of the Robot Arm. All functions related to movement, rotating and catching objects are implemented by some sort of actuator – an electromotor or an electromagnet. All actuators are driven by driver control circuits contained in Intelligent Modules.Actuator's position can be monitored by the means of feedback – encoders that pass information of the Actuator's state back to the Intelligent Module that controls it.

- ***User interface***

The interaction between an operator and the Robot Arm is implemented by software on the host PC (figure 5).

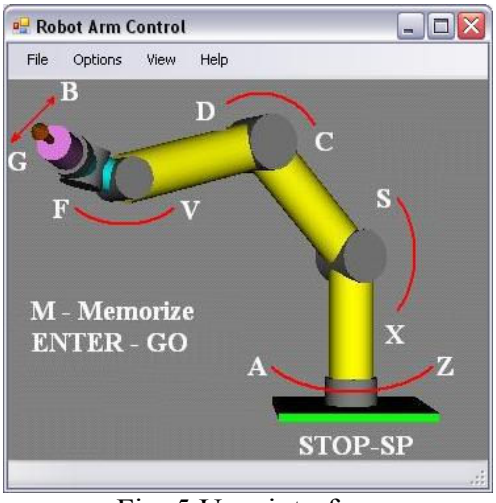

Fig. 5 User interface

The software is developed using Visual Studio Express and provides for the following functions:
- Manual control of individual joints of Robot Arm using a mouse or a key from the keyboard;
- Monitoring the state of all joints and the Robot Arm as a whole;
- Programming series of actions (scripts) that can be executed automatically later
The software has 4 items in the main menu: File, Options, View and Help.
The File option allows for saving and restoring robot positions and scripts.
The Options menu contains items for assigning and changing keys for different actions. The View menu contains options for changing Robot's image appearance in the main program's window.
Help item contains instructions of how to operate with the software.

5 Conclusion

As it was described, in the beginning of robotics development, most of the Robot applications were related to industries and manufacturing and these Robots were called Industrial Robots**.** With development of the new technologies, sensors and microprocessors, today Robots are working in many fields of Service, Starting from Service Robots for professional use to Service Robot for personal use including also educational, entertainment and leisure Robots.
Having our Robot as a good example tool for learning about robotics and interaction between robots and humans we will develop a family of Educational Robots for a variety of applications.
Educational Robotics is very good test bed for education of students, young specialist and researchers and is necessary for all technical schools, colleagues, laboratories and Universities. Our robot was called ROBCO *PHOENICS* as it is emerging from the ash of its predecessors ROBCO 01 which had a glamorous history and impact on the young people.

References:

Atmel ATMega32, 2002 & Atmel ATTiny26L, 2003; http://www.atmel.com/;

Chivarov, N., Shivarov, N. and Kopacek, P.; Educational Articulated Robot - ROBKO *PHOENIX,* Robotics and Mechatronics 2008, September 17-21, Varna, Bulgaria; p.207-p.211, ISSN1310-3946.

International Federation of Robotics (IFR); WORLD ROBOTICS MARKET 2006. http://www.ifr.org/

Kopacek, P.; "Playing with Robots - Robots for Entertainment, Leisure and Hobby - Robotsoccer"; Talk: eAROB, TU Wien, Wien, Österreich; July 13-14-2007; in: "Proceedings of the First European Workshop on Artificial Life and Robots - eAROB", (2007), 13 - 19.

Shivarov, N.; Educational robots and flexible manufacturing systems for use in training; United Nations, Economic Commission for Europe; Symposium on Management Training Programs and Methods: Implications of New Technologies. Geneva, 17-19 November 1987.