



## SOME APPLICATIONS OF NEUROARM INTERACTIVE ROBOT AND WEBOTS ROBOT SIMULATION TOOL

Mihailo Lazarević<sup>1</sup>, Petar Mandić<sup>2</sup>, Vasilije Vasić<sup>3</sup>

**Summary:** *In this paper they are presented possibilities an advanced 7 DOF robotic arm research platform (NeuroArm) equipped with various sensors, and controlled by seven 16 bit processors and one 32 bit Core Embedded PC running 2.6 Linux. The NeuroArm comes with a suite of software including a MATLAB configuration and a suite of C, API libraries and low level protocols for all joint level controls and sensors. Moreover, the robot incorporates, as standard, a novel human-robot safety interaction system to facilitate robot operation in close proximity to people. Also, software tools including the Cyberbotics Webots Simulation package i.e. Webots is a development environment used to model, program and simulate robot and it is well suited for research and educational purposes related to robotics. Webots also contains a number of interfaces to real robots, so that once your simulated robot behaves as expected, you can transfer its control program to a real robot like e-puck, Khepera, Hemisson, LEGO Mindstorms, Aibo, etc. Finally, the effectiveness of webots will be illustrated on suitable model of Neuroarm and inverted pendulum.*

**Keywords:** *NeuroArm robot, Cyberbotics Webots Simulation package, properties of robot, 7dofs*

### 1. INTRODUCTION

It is well known that robotic systems are more and more ubiquitous used in industrial applications as well as in the field of direct interaction and helping people so-called *friendly home environment*. As one of these robotic systems capable of operating in such environments is NeuroArm robotic system. It is an integral part of the Laboratory of Applied Mechanics, Mechanical Engineering in Belgrade, (Fig.1) and serves the educational purposes within the course Mechanics of robots, the Master works as well as for scientific research in the field of robotics to doctoral studies.

Within NeuroArm Manipulator System - there are a rich set of options that

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<sup>1</sup> Full prof., dr Mihailo P. LAZAREVIĆ, Department of Mechanics, Faculty of Mechanical Engineering, University of Belgrade, Serbia, st. Kraljice Marije 16, Belgrade 35, SRB-11120 Belgrade, Serbia, e-mail: (mlazarevic@mas.bg.ac.rs)

<sup>2</sup> MsC student, Petar Mandić, Faculty of Mechanical Engineering, University of Belgrade, Serbia, Kraljice Marije 16, Belgrade 35, SRB-11120 Belgrade, Serbia, e-mail: (mandicpetar84@gmail.com )

<sup>3</sup> PhD student, Vasilije Vasić, Faculty of Mechanical Engineering, University of Belgrade, Serbia, Kraljice Marije 16, Belgrade 35, SRB-11120 Belgrade, Serbia, e-mail: (vvasic@mail.amis.net)

enable scientists and engineers to configure your robot that will meet the needs. From the mechanical point of view NeuroArm a robotic arm has 7 degrees of freedom (6 for rotating and translating 1), including gripper, (Fig. 2).

Mechanism of griper has the possibility of a parallel movement and control the position and speed. The maximum load that can raise the robot is up to 2-3 kg depending on the additional equipment. Control is based on the applying of robotic processors Atmega 128 with I2C or SPI high-speed highway,(Fig. 1B). Processor Atmel Atmega 128 Robot® - integrate other coprocessors that are used to control on the executive level, surveillance sensors, robot status, while for the security of the robot uses NeuroBackdrive™ & NeuroArm™ Protocol. In the main joints there are sensors for measuring position, velocity, acceleration and torque. This robot has a highly configurable advanced PID controllers, the actuator's torque high intensity, i.e. 3 Amp Maxon DC motor with planetary gearing and high-resolution encoders for each robot joint, respectively. These provide a good/smooth control in closed feedback loop in respect to position, velocity, acceleration of a given profile, as well as control which based on the torque (*torque control*). Besides, there are inertial sensors on the end-effector in the purpose of determining and taking into account the inertial effects caused by the inertial forces. Also, the part of the equipment is haptic joystick with force feedback. It allows us to control a robot remotely over the web, with the ability of the operator "fee" what the robot "feels. "

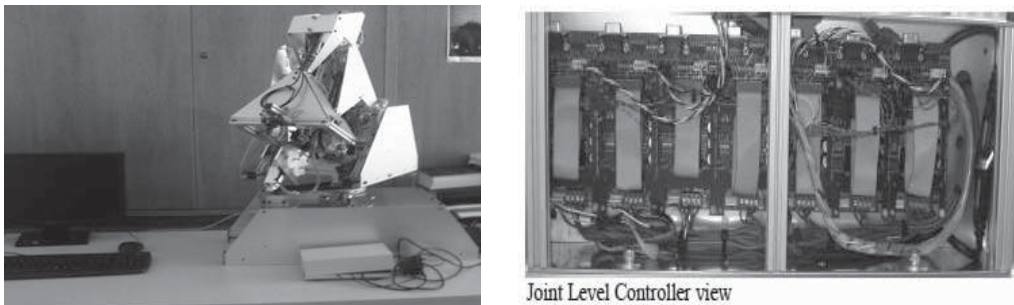


Fig. 1 A) left-Laboratory Robot - NeuroArm™, Department of Mechanics, Faculty of Mechanical Engineering, BU, Belgrade B) right - hardware structure of control system of given robot

Also, Powerful Robot Host High Level is used to sophisticated real-time control with simultaneously using of inverse kinematics, dynamics, trajectory, and control by force, adaptive control, control based on artificial intelligence, etc. In addition, it is enabled the internet connection with the accompanying web server as well as the USB host controller. Robot includes as standard equipment, the new man-robot security system in the process of interaction to facilitate the operation of robots in the vicinity of people. NeuroArm Manipulator System™ in conjunction with the Human-Robot Interaction Safety System is used to solve this problem.

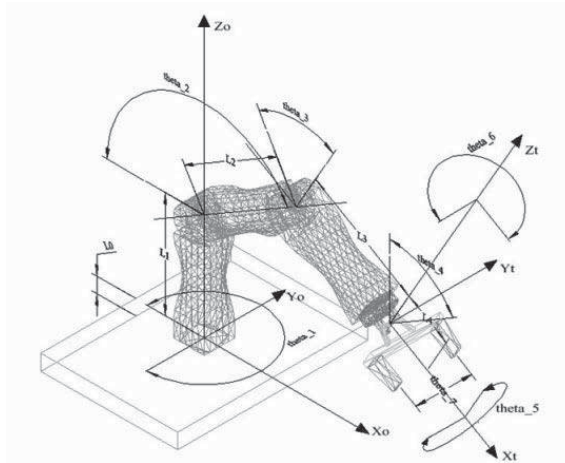


Fig. 2 Model of Neuro Arm with 7 degrees of freedom

In particular, on the top of the robotic arm, near the gripper it is built a camera, that is, computer vision sensor CMU cam3 which allow us to visually tracking given objects, or object recognition enabling the implementation of various telerobotic applications. CMUcam3 is fully programmable built-in computer vision sensor-where the processor is connected to the Philips LPC2106 OmniVision CMOS camera sensor module. Common C code can be developed for the GNU port CMUcam3 using the number of open source libraries and various ready-made programs.

## 2. CONTROL OF NEUROARM ROBOT

There are four basic methods of control given robotic system that can be used to set requirements and programmatic experience. The first of these is the use of

- Windows GUI Tool - Windows graphical interface (Fig. 3) which allows for easy use and control of robot educational purposes

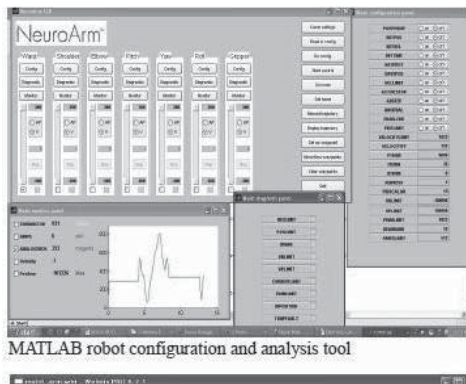


Fig. 3 Graphical Interface in Matlab environment

- Another way is the use of open source serial protocol & C library so that it can provide built-in programmable controller PC. This level requires a good knowledge of C programming language, C++, Java, Python as well as good understanding of the robotic system in real time and is intended more for scientific purposes, ie, researchers and PhD students.
- It can also be used so URBI's (universal real-time behavior interface) specially developed interface that enables control of any robot in a very short time and in any language.
- Details will be displayed here last, the fourth way, which includes the use of Webots simulation package Cyberbotics company.

### **3. SOME APPLICATIONS WEBOTS SIMULATION PACKAGE**

Webots is a professional simulation software package for robots, with emphasis on the use of mobile robots and it can be used for educational purposes and for research in robotics. It offers a rapid prototyping environment robot, which allows the user to create 3D virtual world, taking into account the real properties such as mass, the corresponding coefficients of friction, etc. The user can now add a simple way active / passive objects (stationary or mobile robots). In addition, the Webots contains a large number of robot models and examples of control programs that can help users in the initial stage. Webots also contains a large number of interfaces for real robotic systems, which enables the developed program is transferred to a real robot, such as e-puck, Khepera, Hemisson, LEGO Mindstorms, Aibo, etc.

If they are not used to use existing models of the robot one may create their own models of robots in simulated environments, using appropriate software packages for 3D modeling application with the VRML97 standard. Webots-alone application and consists of three phases. In the first phase it is formed file of Webots world which consists of one or more robots and the corresponding 3D virtual environment forming so called .wbt files. The second phase one may define the control algorithms for given robot using C, C + +, Java, Python, Matlab program, while in the third phase one can optionally use supervisor. Supervisor is a privileged driver type robot that can perform operations that are normally carried out by the operator and not a real robot. For example, this type of monitor's controller allows the robot takes a random position in space, to realize a simulation of video recording, etc.

Here are two examples of application shown Webots, i.e., a modeling, simulation and control a robotic arm that corresponds to the actual configuration NeuroArm robotic system (Fig. 4, 5), as well as an example of modeling and control of inverted pendulum, (Fig. 6). On Fig. 4a it is shown the graphical user interface under development wbt file where one can see two working windows, the left side of the window where it is defined the model while in the right window shows following code in C language. Figure 5 presents a graphical interface that also includes a mask control as a result of the second phase of the simulation within a webots. In the second example (Fig. 6) is realized as the modeling and control of inverted pendulum in a given webots environment.

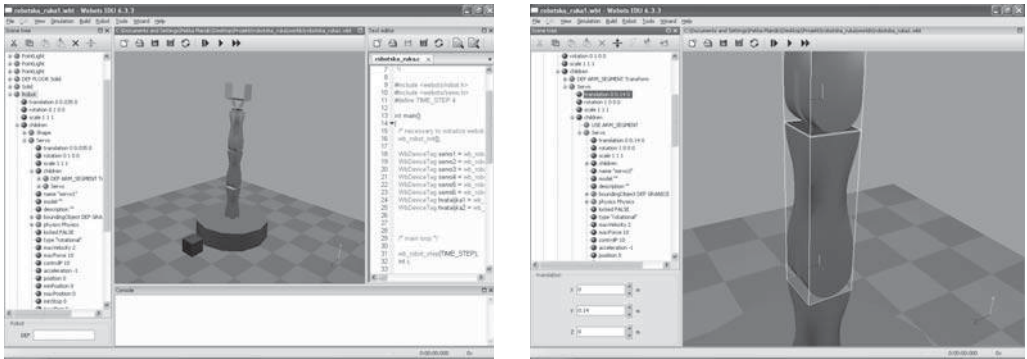


Fig. 4 A) left-user-interface of robotic arm.wbt B)right- defining the geometry of the robot segments

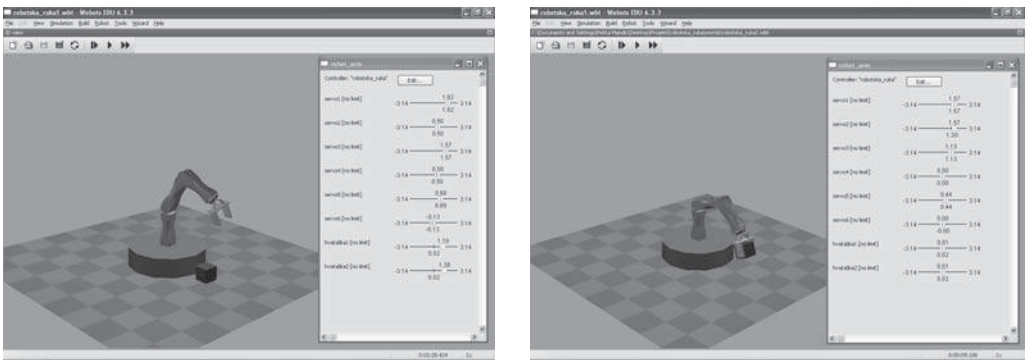


Fig. 5 Simulation of movement of robotic arms with a display driver interface A)left- initial position B) arbitrary-set position

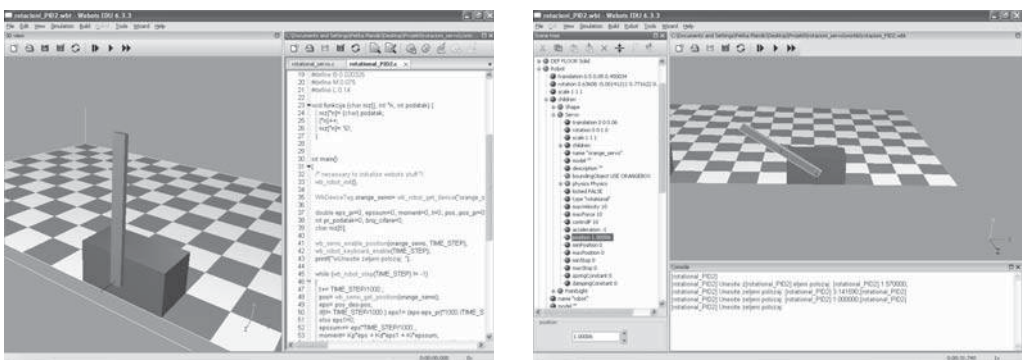


Fig. 6 Example of control of inverted pendulum in the Webots environment A) left- code in C B)right- defining the geometry of given model

#### 4. DISCUSSION

This paper presents the possibilities of advanced robotic systems (NeuroArm), which is given in the form of a robotic arm with seven degrees of freedom are equipped with various sensors, controlled by seven 16-bit processors and a 32-bit Core Embedded PC. NeuroArm robot is supported with appropriate software package that includes MATLAB and C, API library and the low level protocols for all levels of management and joint sensors. It also has a development environment - Cyberbotics Webots simulation package used for modeling, simulation and robot programming, where the application of appropriate interfaces for real robots, can be applied to give the control program to real robots. Last, two examples illustrate the application of simulation in webots environment: robot Neuroarm and inverted pendulum.

#### 5. ACKNOWLEDGEMENT

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