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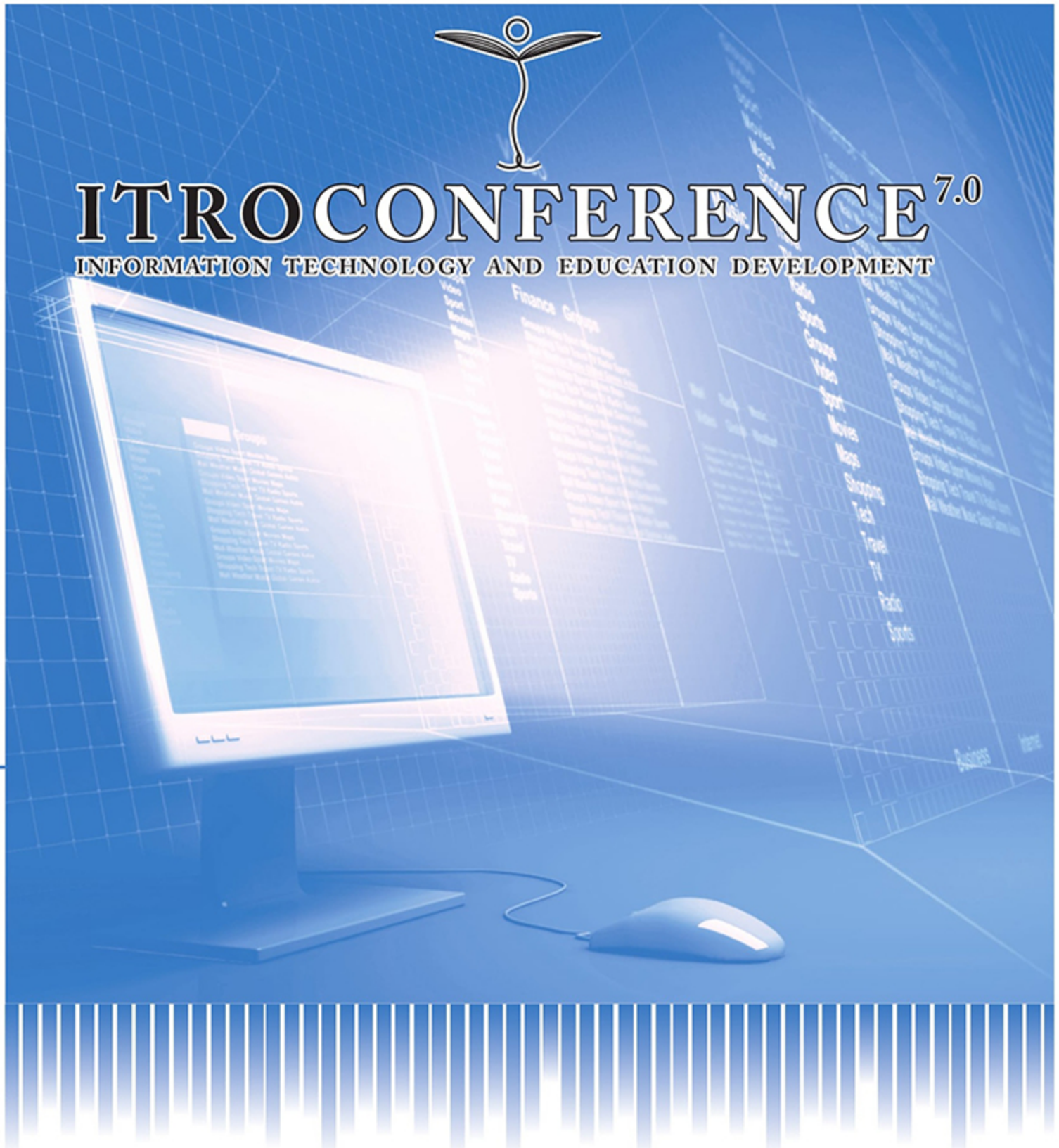


**ZRENJANIN, June 2016**

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VII INTERNATIONAL CONFERENCE ON

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PROCEEDINGS OF PAPERS


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*With this publication, the CD with all papers from the International Conference on Information Technology and Development of Education, ITRO 2016 is also published.*

# INTRODUCTION

This Proceedings of papers consists from full papers from the International conference "Information technology and development of education" - ITRO 2016, that was held at the Technical Faculty "Mihajlo Pupin" in Zrenjanin on June 10th 2016.

**The International conference on Information technology and development of education** has had a goal to contribute to the development of education in Serbia and the Region, as well as, to gather experts from natural and technical sciences' teaching fields.

The expected scientific-skilled analysis of the accomplishment in the field of the contemporary information and communication technologies, as well as analysis of state, needs and tendencies in education all around the world and in our country has been realized.

The authors and the participants of the Conference have dealt with the following thematic areas:

- Theoretical and methodological questions of contemporary pedagogy
- Personalization and learning styles
- Social networks and their influence on education
- Children security and safety on the Internet
- Curriculum of contemporary teaching
- Methodical questions of natural and technical sciences subject teaching
- Lifelong learning and teachers' professional training
- E-learning
- Education management
- Development and influence of IT on teaching
- Information communication infrastructure in teaching process

All submitted papers have been reviewed by at least two independent members of the Science Committee.

There were total of 163 authors that took part at the Conference from 15 countries, 4 continents: 96 from the Republic of Serbia and 67 from foreign countries such as: Macedonia, Bulgaria, Slovakia, Russia, Montenegro, Albania, Hungary, Italy, India, Rumania, Bosnia and Herzegovina, USA, Egypt and Nigeria. They were presented 82 scientific papers; 42 from Serbia and 40 from the above mentioned countries.

The papers presented at the Conference and published in Proceedings can be useful for teachers while learning and teaching in the fields of informatics, technics and other teaching subjects and activities. Contribution to the science and teaching development in this Region and wider has been achieved in this way.

***The Organizing Committee of the Conference***

# *CONTENTS*

## *INVITED LECTURES*



## *SCIENTIFIC PAPERS*

# Learning Software Engineering Basics Through Robotics

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**Abstract – Software engineering is a scientific discipline that deals with all phases of (requirements analysis, design and modeling, implementation, evaluation and validation, as well as maintenance). Learning various concepts of software engineering is not a trivial task, and requires more than a one semester course. LEGO MINDSTORMS NXT kit is a popular and affordable education robotic platform, used as an educational tool in various areas. This paper describes how the LEGO MINDSTORMS robots can be used for teaching the basics of software engineering. We have also evaluated the outcomes of the course in order to reveal the effects of using this off-the-shelf robot kit**.

## I. INTRODUCTION

In a world where technology leads the economic and social development of the countries, the significance of a good academic engineering training must be considered as a core aspect in every educational system. Such engineering training must cover both theoretical aspects as well as practical applications that show the students how to relate the abstract knowledge they learn in the lecture sessions with real world problems and their difficulties.

Robotics has been shown to be a superb tool for hands-on learning, not only of robotics itself, but of general topics in science, technology, engineering, and math (STEM) [1].

A broad spectrum of robot tools and platforms that can be used in educational process exists, but we will concentrate on the LEGO MINDSTORMS NXT kit, because it provides students and teachers with a user friendly environment and gives the students opportunities to engage in real world science through, design, construction, and testing of their own experiments. Additionally, many students are familiar with LEGO. Some have used them in their childhood, others use them in computer games and they even see them in films.

LEGO modular design allows for multiple solutions to a given assignment, and the sensors and motors allows students to engage in a very diverse set of engineering and science activities. By allowing those to solve problems based on real-life situations, the students can developed critical thinking and learn confidence, problem-solving and teamwork.

LEGO MINDSTORMS has been used as an educational tool in various areas. Brandt and Colton [2] have used Mindstorms to teach underground students Programming, mechanics and control. Tester [3] used Mindstorms to develop skills connected with innovation and communication management. Schumacher, Welch, Raymond [4] have used Minsdstorms to teach Programming to Electrical Engineering and Computer Science freshman students from the Military Academy in the US. Caci and D'Amico [5] used Mindstorms to develop cognitive skills in children. Fabri et all.[6] have been used Mindstorms for teaching and learning software processes and project management. Church, Ford, Perova and Rogers in [7] describe a successful use of LEGO MINDSTORMS in designing robotics-based activities for teaching physics. Cruz et all. [8] have been used LEGO Mindstorms NXT for teaching at Data Acquisition, Control Systems Engineering and Real-Time Systems undergraduate courses.

However including LEGO MINDSTORMS or other robot systems in the course syllabus does not automatically mean better results of concepts by students. In order to have a teaching value, their use must be carefully designed, which requires a higher dedication of teachers.

We have tried to use robots within the course aimed at teaching the basics of software engineering. The robots were used as tools for physical representation and visualization of object-oriented software algorithms and design patterns. Moreover, dealing with physical objects should make the learning more intuitive than just looking at in-memory object structures [9].

The main objectives of the course were to teach the students on the basics of software modeling and development starting from a set of user requirements. As a final outcome students should also have to gain practical experience of

collaborative project development in a simulated production environment.

We have evaluated the outcomes of the course in order to reveal the effects of learning software engineering in robotics environment.

The evaluation results showed that students have gained practical experience and good understanding of software engineering basics and they have appreciated the proposed methodology.

This paper is organized as follows. After a brief introduction and related work overview, the paper continues with the description of LEGO MINDSTORMS NXT kit. Next section describes the course curriculum and presents one pedagogical unit. The paper then discusses the results of the pilot study and presents the conclusions.

## II. LEGO MINDSTORM KIT V2.0

The Lego Mindstorms NXT 2.0 kit contains software and hardware to create customizable, programmable robots.

It contains three motors, one light sensor, one ultrasonic (sonar) sensor, one sound sensor, and two touch sensors. The servo motors included in the kit are equipped with rotation encoders, returning to the

NXT the position of the shaft with 1 resolution.

Rotation speed of the motors is proportional to voltage applied to them, as it can be seen on graphs in Figure 1.

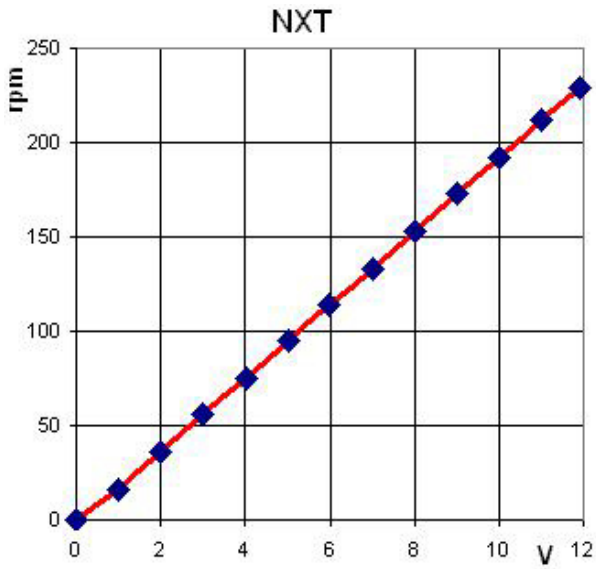


Figure 1. Dependency of the rotation speed from the applied voltage.

Two motors can be synchronized as a drive unit. Ultrasonic sensor included in the kit has accuracy up to 3 centimeters and can measure up to 255 centimeters. The light sensor can distinguish between light and dark but, in the same time can be used to recognize whether the surface color of the scanned object falls in a specific color range. Sound sensor can be programmed to give the robot the ability to hear and react. The robots can detect physical contacts with the environment and react accordingly using two touch sensors included in the kit.

The kit also contains set of 619 mechanical parts from the Technic line aimed at creating various mechanical systems and robots. The kit also includes an intelligent *brick* computer that controls the system.

The core of the ―brick‖ is the 32-bit Atmel ARM7 processor with 256 KB Flash, 64 KB RAM operating at 48 MHz. Even without its coprocessor, which is an Atmel 8-bit AVR processor, the brick is a powerful embedded platform that can be used to build variety of applications [10].

The architecture of the LEGO Mindstorms NXT Brick is presented in Figure 2.

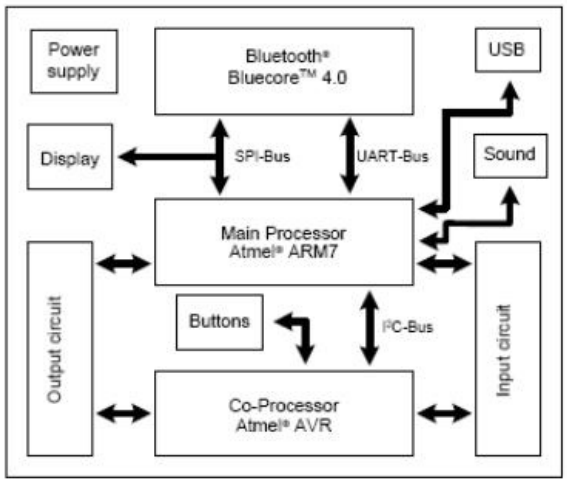


Figure 2. Architecture of the LEGO Mindstorms NXT Brick [11].

Mindstorms consists of a largely graphical interface for writing programs (Figure 3) and a flexible and simple means – the use of Lego blocks – for constructing the physical robots.

Both the programs, which can be recorded as they are constructed and edited, and the robots, which can be described in some detail; provide excellent artifacts of student critical thinking and problem solving.

There are several things of interest to educators – first, the program is completely graphical – this helps students focus more on the design rather than spend time on learning new tools and associated abstract syntaxes. Second, because the program is graphical, it lends itself naturally to parallel programming which is an inherently hard concept to teach with traditional tools. Third, the student can

configure all the parameters associated with a block at the bottom of the screen without having to navigate through multiple functions and files and finally, the software exposes key embedded concepts such as memory and resource management, helping teach the key concepts in a fun environment. For example, the student may have to, depending on the size of the program, remove some other files that were taking up memory on the brick

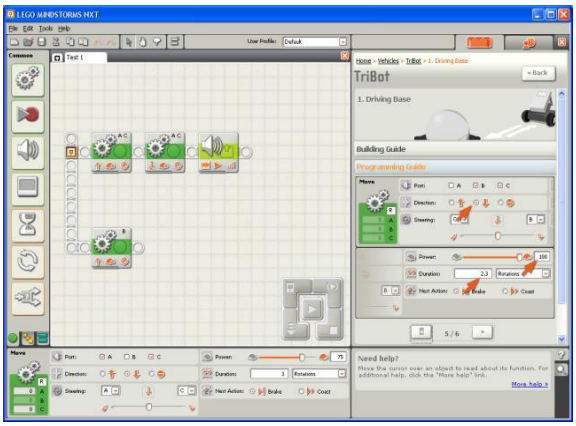


Figure 3. The Software for the LEGO MINDSTORMS NXT.

## III. COURSE DECRIPTION

Fast developing society based on technological advancements is focusing on complex hardware and software solutions. Software is becoming the main driver for growth in many fields. This is valid not only for enterprise software solutions but also for industrial embedded software, consumer products (phones, smart TV's, and robotic devices which are penetrating very fast nowadays). In order to meet the challenges of rapidly changing demands and requirements, as well as the permanent increasing of software's size and complexity, systematic approach is needed.

Software engineering is the scientific, disciplined and quantifiable approach to developing, operating and maintaining complex software systems.

Software engineering education at undergraduate level could not satisfy the specific requirements for industrial software development. Namely, in addition to requirements for embedded software development, the industry also requires the knowledge of entire software lifecycle phases (requirements analysis, design and modeling, implementation, evaluation and validation, as well as maintenance).

Therefore, we have offered a multidisciplinary course entitled Basics of robotics that teaches both software engineering and robotics aspects.

The main objectives of this course it to enable students gaining practical experience of sensing, planning and control and apply it on a small-scale educational Lego Robot. In parallel the course should provide the students with basic software engineering methodologies, design and modeling of robotics software, implementation of control software.

The course is offered as a single semester course in the 4$^{th}$ year of study (8$^{th}$ semester) and the main topics are balanced between software engineering and robotics. They are including: design patterns, modeling methods and tools, implementation patterns, localization and mapping, object recognition, path planning and robot control.

During the course four different assignments were given to the students. Through the analysis of the given assignments, the students' improvements from software engineering aspect were evaluated.

The course was attended by 35 students (22 male and 13 female). All of them were with the same software engineering and robotics knowledge gained during the previous academic years.

### *A. Description of line following assignment*

The main idea of this assignment is to understand the differences between sequential programming and state machine pattern. For this purpose the students should use the Lego Mindstorms NXT 2.0 to construct the line follower robot using two light sensors (Figure 4).

Figure 4. Line follower robot

The logic besides the control algorithm could be seen from the illustration in Figure 5.

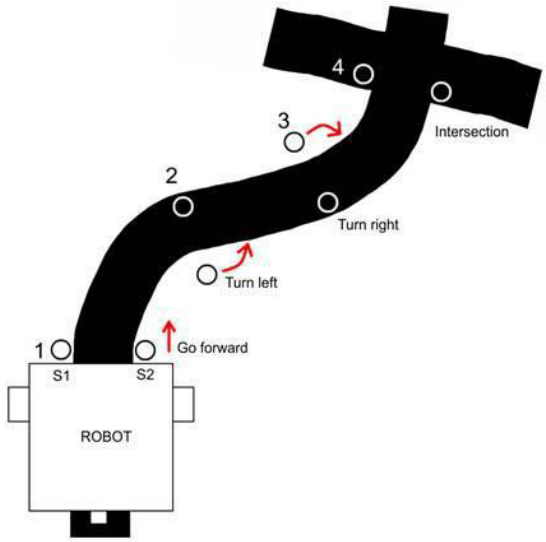


Figure 5. Control algorithm logic.

So, considering two light sensors (S1 and S2) attached on input ports 2 and 3 correspondingly we may have the following combinations: both S1 and S2 detect white background the action should be go straight, S1 detects white and S2 – black, the action should be turn right, S1-black and S2 – white, the action should be turn left, and finally both sensors detect black, the robot should stop due to crossroad.

The Lego software diagram that is solving this problem is given in Figure 6.

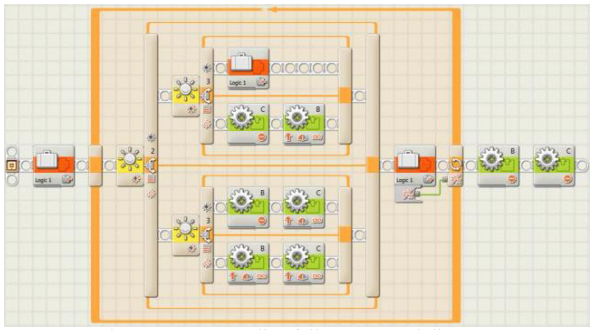

Figure 6. Four step line follower control diagram.

## IV. EVALUATION

The methodological approach was evaluated in two different ways. First of all the quality of assignments during the semester was evaluated. The qualities of assignments were evaluated by two professors, one assistant and one PhD student (employed as laboratory assistant). The results have showed that all students have presented improved qualities of their software engineering approach after the second assignment. This conclusion was made unanimously by all four teaching staff members.

Besides this evaluation, the students were interviewed at the end of the course and asked to fulfill a questionnaire composed of several questions (given in the Table 1 below). The results are also presented in the Table 1 presented below.

TABLE 1.

| N | Question | Mean | STD |
|---|---|---|---|
| 1 | Were the practical assignments interesting or motivating? (1-not interesting; 5-very interesting) | 4.32 | 0.35 |
| 2 | Usefulness of Lego NXT in learning software modeling? (1-not useful; 5-very useful) | 3.87 | 1.20 |
| 3 | Usefulness of Lego NXT in learning embedded software implementation? (1-not useful; 5-very useful) | 3.76 | 1.05 |
| 4 | Usefulness of Lego NXT in learning robotics basics? (1-not useful; 5-very useful) | 4.19 | 0.95 |

## V. CONCLUSION

We have presented in this paper a teaching innovation project devoted to the use of LEGO Mindstorms NXT robots in subjects related to software engineering.

Our experience using these robots has been really positive. Our students find the lab sessions more attractive, and they solve the proposed practical exercises more enthusiastically; this perception is statistically supported by the results of the surveys we have conducted in different subjects and, more slightly, by the scores obtained by the students, which we believe comes from a higher motivation. On our behalf, we have found that the NXT is a nearly optimal education platform in terms of cost, robustness and versatility.

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