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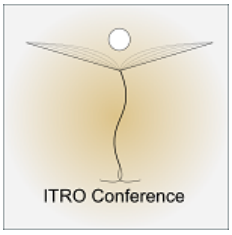

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A Review of Robotic Kits Used for Education Purposes

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Abstract – The term educational robot is usually associated with systems that can be classified as robots and that are used in the process of education with a final goal to learn with, form or about it. In the last decades, due to the technological and pedagogical advancements as well as low prices of the educational robots, their usage is dramatically increased. This is also reflected in the increasing number of articles that are published in the last decades. Various education robots have different features from architectural, structural and functional point of view. Therefore, the main goal of this paper is to present a literature review of the educational robots and their characteristics.

I. INTRODUCTION

Despite the fact that the technological solutions nowadays are omnipresent, traditional opinions that they are completely depending on us and on our commands prevails. However, in the last decade, the concept of autonomy is permanently changing with a fast pace mainly due to development of Artificial Intelligence (AI). The growing popularity of the Artificial Intelligence (AI) and its application in various fields [1], starting from tourism [2], through medicine [3-5], biology [6], education [7], robotics [8-11], and also in economy [12], is mainly due to the apparatus i.e. the models and techniques used to mimic the human reasoning, learn and improve during time.

Today we are witnesses of devices that are moving autonomously in our environment on their own but, also systems that are performing tasks and working on our behalf. We can find multiple mobile systems that have significant level of intelligence, used in our daily life. Examples include autonomous cars or unmanned aerial vehicles, various service robot systems, smart home appliances such as air-conditioning systems, automatic vacuum cleaners, search and rescue operations, rehabilitation activities and many more.

Even systems that are "fixed" can also act autonomously, take decisions and act in dynamic and cluttered environments as contrasted to being pre-programmed to a fix sequence of actions.

Many of the tasks mentioned above are performed by robots. The fact that our life is becoming more and more "robotized" as well as the possibilities to develop smart systems that may contribute to improve human live, is inspiring more and more students to gain knowledge and become robotics specialists.

Therefore, the main goal of STEM education and technical faculties should be to prepare the students for the forthcoming age. In particular, they should be prepared to:

- understand the principles of working of these devices,
- control and even program such systems in order to use their full potential,
- design and create them, as well as to provide the necessary services for their maintenance.

This is one of the main reasons why robotics education is becoming intrinsic part of the education programs in almost all technical faculties but, also in primary and secondary school. Every application of robotics in any sort of education process is very important if we like to foster the development and permanent growth, and to avoid possible stagnation and gaps.

Following this education mission, at the Faculty of Computer Science at the University Goce Delcev in Stip, the course Fundamentals of Robotics, has been introduced as a part of the bachelor's curriculum for more than 5 years.

Our previous research showed that students tend to find Robotics very attractive, but they are also aware that it is a multidisciplinary area combining elements of physics, mechanics, electronics, and mathematics.

Our classes are supported by various simulation software programs. This way the students were able to overcome various constraints such as: limited number of physical robots, capability to test and experiment for a limited and fixed number of hours and only during working days etc.

The feedback of our students regarding the simulators was very positive and they found them

very useful because they help them to gain better and faster understanding of studied theoretical concepts.

Despite the usefulness of the simulation and virtual laboratories used, the real world tends to be very complex mainly due to the noise and uncertainty of various types. Even through the control of a real robot can be very easy, the behavior of the physical (real) robot depends on the conditions in the real environment. Therefore, including real robots in the education process is very important.

As a result of miniaturization of the hardware components and decrease of the price of electronic components, educational robots are becoming very affordable even for developing economies. The number of educational robots is permanently increased. Different types of educational robots have different appearances, structures (hardware), systems (software), and functions (behavioral outcomes) [14]. These features play an important role in determining the curricula, the instructional activities, and the learning objectives.

Therefore, the main goal of this paper is to present a literature review of the educational robots and their characteristics.

II. CATEGORIES OF EDUCATIONAL ROBOTS

Educational robots can be defined as robotic systems that are supporting the process of teaching and learning. Although educational robots are robots by definition they still differ from the normal perception of state-of-the-art robots that are used in various industrial application.

Various education robots have different features from architectural, structural and functional point of view. In context of educational robotics, hardware components are representing robot body and they are usually classified into three main categories actuators, sensors, effectors. As effector can be considered any device that affects the environment. There are various types of effectors such as legs and arms, wheels, fingers, wings, flippers. The effectors are determined by the tasks the robot should perform, the type of environment in which they should operate etc. Despite everything, usually the effectors are used to move the robot around (locomotion) and to move other objects around (manipulation). Actuators are the actual mechanisms that enable the effector to execute the desired action. Actuators typically include electric motors, hydraulic or pneumatic cylinders, etc. Sensors on the other side are devices used for perceiving the environment and they are necessary in order to make the robots performing the actions autonomously. According to the type of principle of working the sensors can be classified as active or passive and they can serve to sense the internal or external processes and values.

Usually educational robotics have different technical, structural, and functional features, but they share at least one common goal that is education. As educational tools they are made in a specific way with specific materials and level of complexity suitable for laboratory usage. They also have different built-in pedagogical solutions that direct learners to certain actions and which helps them to learn different topics.

The rising popularity of educational robots and their application in all level of studies from primary schools up to university level studies is evident even from the number of scientific articles published (Figure 1).

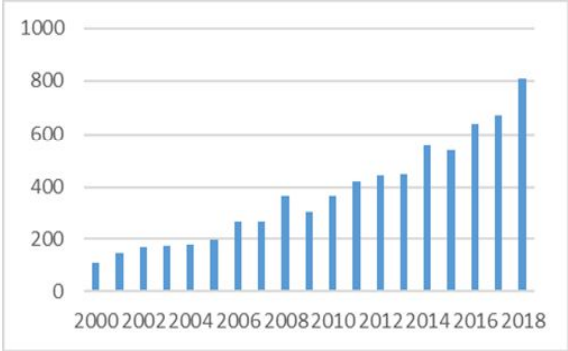

Figure 1. *Total number of articles per year retrieved from Sciencedirect web portal using the following query: "Education* AND Robot*", which retrieves articles that contains any word derived from education and robot words*

Educational robots can be categorized as robotics kits, social robots, and toy robots [15]. Robotics kits are programmable construction kits. Robotics kits allow students to create, build, and/or program robots [15]. Social robots are based on artificial intelligence and autonomous behaviors. Social robots include Socially Interactive Robots (SIR) and Socially Assistive Robots (SAR) [16]. The key feature of social robots is that they can communicate and interact with students [14]. Toy robots are ready-made commercial robots for entertainment and play [17].

III. EDUCATIONAL ROBOTS REVIEW

In this chapter we are analyzing the educational robots that fall into the robotics kits category. Robotics kits are very important because they enable morphological transformations as well as the possibility for extension of the hardware in order to cover various functions and applications. Even more, they also enable functional

transformations through software modifications. In this review we have included robotic kits that are applied in at least one curriculum at some university or high school.

Lego Mindstorm [18] is a programmable robotics kit, based on Lego building bricks with special robot parts. The kit includes: servo motors, sensors (ultrasonic, sound, touch, and light), wheels, gears, axes, connection and interface cables, the intelligent brick etc. All this parts are used for the construction of a robots or other automated systems. The intelligent brick is the "brain" of a Mindstorms system, that lets the constructed robot to autonomously perform different operations. LEGO Mindstorms kits are counted among the most widespread tools for teaching robotics and programming.

Boe-Bot [19] is a robot kit that uses a BASIC Stamp 2 programmable microcontroller. Its name (Boe-Bot), comes from the Board of Education carrier board that is mounted on its wheeled chassis. Using this robot kit, students can build several different robots using an engineering style approach.

The MiniSkybot [20] is a mobile robot aimed for educational purposes. The robot is built from 3D-printable parts, and uses a fully open-source mechanics and electronics parts, which can be modified and replaced according to needs. This robotic platform allows the students not only to learn robot programming, but also to modify easily the chassis and create new custom parts. It is also very cheap, since the price is almost exclusively determined by the cost of the servos, electronics and sensors.

VEX robotic platform [21] is designed from the ground up to encourage students' creativity in problem solving. The kit includes microcontroller that acts as the robot "brain", allowing for both autonomous and driver control of robots. The microcontroller also includes wireless communication, enabling remote control with joysticks. The programing part can be done using the VEX coding studio, which is easy to use and easy to learn. Students can learn to program with blocks, transition to text and move into C++ as their skills advance. Users can also test their coding skills with Robot Virtual Worlds, which is a high-end virtual environment.

Fable [22] is a modular construction system that can be used to create different types of robots. Students can assemble modules together in many different configurations. They can build custom robot bodies, use the inbuilt sensors and program the robot's movement. Depending on experience level, students can program using visual blocks (Blockly) or a programming language (Python). While working with Fable students are able to develop comprehensive skills in robotics, programming and innovation.

Alpha Bot2 robot [23] supports Arduino, Raspberry Pi 3 Model B, and Raspberry Pi Zero W, with different adapter boards. It features rich common robot functions including line tracking, obstacle avoiding, Bluetooth/infrared/WiFi remote control, video monitoring, etc. It has a highly integrated modular design, which make it easy to assemble by a snap, no soldering, no wiring. AlphaBot2 employs a 2-layer structure to provide excellent stability and compatibility.

Linorobot [24] is a suite of Open Source ROS compatible robots that aims to provide students, developers, and researchers a low-cost platform in creating new exciting applications on top of ROS (Robot Operating System). Students can use engineering skills to build different robots from the ground-up using easily accessible hardware.

Makeblock Ultimate Robot Kit [25] is a comprehensive robot kit for building complex robots and exploring the robotic world. It contains: metal geared motors, Arduino-compatible controller, programmable RGB LED strip, different kinds of sensors, robotic gripper and other mechanical parts. The constructed robot can be controlled using a smartphone or tablet through Bluetooth connection.

The Speechi robotics sets [26] are carefully thought tools, to learn coding, robotics, electronics, and how those are used in our everyday lives. The sets include: multidirectional building bricks, as well as sensors and actuators (servomotors, buzzer, etc). Different programming interfaces and languages are used, thus allowing a smooth learning curve: icons-based interface, Scratch, Arduino (C, Java), Python, Microsoft MakeCode.

The BIOLOID [27] is an educational robot kit which helps students to learn the basics of structures and principles of robot joints. The name BIOLOID comes from BioAllDroid (Bio + All + Droid = BIOLOID). The BIOLOID platform consists of components and small, modular servomechanisms (AX-12A Dynamixels), which can be used in a daisy-chained fashion to construct robots of various configurations, such as wheeled, legged, or humanoid robots. The Robot is programmed with RoboPlus - C language based software solution.

IV. CONCLUSION

Using robots and robotics in schools and at universities is gaining rising popularity and there is a larger and larger variety of commercial educational robots available in the market. Therefore, the educational robotics emerged as an independent scientific discipline in the last decade. It is defined as a field of study that aims to improve learning experience of people through the creation, implementation, improvement and validation of pedagogical activities, tools (e.g. guidelines and templates) and technologies. In this scientific discipline the educational robots play an active role as pedagogical tools that should facilitate the process of learning and teaching.

Considering the variety of educational robots currently used in the process of education and their constantly increasing number, as well as the permanently increasing number of the articles related to educational robotics published in the last decade or two, in this paper we presented an overview of educational robots. They were described from architectural, structural and functional point of view.

In the context of educational robotics this paper should contribute during the process of preparation of various curricula and planning the hands-on experience part of it.

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