Robotika.SK Approach to Educational Robotics from Elementary Schools to Universities

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Abstract—**The Association Robotika.SK organizes and participates in a wide range of activities, projects, contests, events, workshops, summer schools, seminars, prepares educational materials, builds educational hardware and software platforms. This article presents our viewpoint on educational robotics, the challenges, tasks, goals, and means of achieving benefits for the learners and teachers. We summarize several years of experience we collected and provide perspectives on the future development, and some of our future plans.**

Keywords - educational robotics, robotics contests, robotics summer schools

I. Introduction

In a happy society, people get the chance to work on what they believe in. We believe in robotics, and we think that we can also improve the chances of others who share our common interests. We believe that robotics technology can help humans to avoid arduous, repetitive, dangerous, and unpleasant tasks, we believe that robotics technology does and will allow us to reach beyond our current horizons, both in microscopic and macroscopic worlds, but within our environments as well. Robots may help rescue people, animals, and other living creatures in critical situations. Robotics can be applied to make our environment cleaner. Robotics technology might bring easier, cheaper, more versatile and flexible solutions to various common tasks. Moreover, we believe that robotics technology can contribute to improvement of the educational process in schools, it can provide entertainment, and for young people, it can be the reason for spending of lot of their time in a valuable and useful way. Robotics can also attract many young people to the fields of science and technology. We also honestly believe that reasonable application of robots in production process will not take the work from people and generate unemployed. On the contrary, the resources saved by cheaper production can be used to give better and more interesting work to the people, in more comfortable working conditions. We think there are not enough robots around us and large efforts are needed to bring them here. We founded the association Robotika.SK, a non-profit, non-political and non-governmental organization, and we use it as a platform for organizing cooperation of institutions of higher education, preparing seminars, talks, summer schools, competitions, initiating, coordinating and realizing various projects, supporting schools, and individuals. All activities are centered around our information website robotika.sk that always brings up-to-date news from the activities organized by us and our partners, as well as robotics news from our region, and outside. In this article, we give an overview of our past and current activities. The following sections describe our viewpoint on educational robotics, the overall structure of our activities, cooperation, individual robotics projects, student work, seminars and talks, summer schools, contests, and public presentations.

II. Educational Robotics

The omnipresence of technology today is a fact. However, a traditional view prevails, namely that technology is still completely dependent on us. Mobile phones, portable computers, digital assistants, intelligent security systems, automatic vending and money transfer machines, advanced technology in production – everything remains fixed at a single place where it was installed, or wherever we take it with us. Soon, however, the technology will start to move in our environments on its own. Automatic delivery, monitoring and service, personal assistants, cleaning, guiding, shopping, and many other tasks will be performed by autonomous mobile devices working on our behalf. And even those that will still be fixed, they will be able to act more autonomously and take smart decisions in dynamic environments as contrasted to being pre-programmed to a fixed sequence of operations.

Many of the tasks named above are performed by robots already today and we must get prepared for this forthcoming age. In particular, we must:

- make sure people will be able to understand the mode of operation of these devices;
- make sure people will be able to control, and even program such devices to utilize their potential;
- prepare enough skilled engineers, who will be able to create them, and provide the necessary service;
- keep building a sufficiently large community of professionals in all related areas, which are important for the progress of development of robots – material science, energy science, physics, electronics, mechanical engineering, communication and human interaction, computer science and technology.

This is why we need educational robotics today, to foster the progress and development, and to avoid stagnation and crises. Every meaningful application of the robotics technology in any form of educational process is a valid contribution. The following ideas have been tried and implemented:

- organizing robotics summer schools and summer camps
- organizing competitions with robots
- building hobby-robotics clubs, labs, and free-time centers
- teaching programming with robots
- using robotics to explain and elaborate on mathematics
- using robots in teaching physics and science
- setting up interdisciplinary student projects utilizing robots
- developing special courses with introduction to robotics
- implementing lectures about robotics into various courses
- building robotics hardware and software platforms
- using robots as educational toys from very early age
- developing art projects and presentations with robots

We believe all these ways are useful and important ways to increase the competence of the general population and specialized students, and we think there are large unfilled spaces in particularly in finding and developing new platforms with completely new features, approaches and ideas. We argue that even though it is important to support the main-stream product lines such as LEGO Mindstorms NXT, it is also important to search and support different systems. Still, only very little has been done on larger-scale parallelization, modular architectures, non-conventional kinematics, and other areas. We will continue our attempts to actively contribute to at least some of them.

III. Structure of Our Activities

We are a small group of scholars and students with some links with industry. We maintain a student and research robotics laboratory. In our institutions, we teach a few courses related to robotics, and outside of them, we try to maintain robotics clubs in primary or secondary schools. We participate in organizing various relevant activities that are initiated or organized by us or our partners. We mention both kinds for completeness. Our activities spread across several levels:

- events for general public, where everybody can register and visit, the aim is the popularization of science and technology;
- events for schools, where participants (i.e. teams) from schools can register, and participate, these events have a more specific target group and thus can be better tailored for their audience;
- events for selected students from technical universities, for instance organized in cooperation with student networks of technical universities;
- events for students in our institutions, these are local events, tailored for our students;
- activities focused on development of robotics platforms and projects that are made publicly available for those interested;
- student projects in a form of bachelor or master theses, or other types of student projects including students from secondary schools;
- publishing information, articles, and materials related to robotics technologies, methodologies, etc.

A description of individual activity types follow.

IV. Cooperation

Our group is built on cooperation. In the very beginning it put together people from three different institutions: two universities and one private company producing sensor technologies, Microstep-MIS. However, many of our activities would be impossible without efficient cooperation with our partners, who include student organizations (BEST), non-profit associations (e.g. InnoC from Austria, Slovak Society of Electronics, Robotika.cz), foundations (e.g. Children of Slovakia Foundation), primary and elementary schools (e.g. Spojená škola Novohradská, Spojená škola sv. Františka z Assisi, ZŠ Karloveská 61), and private companies (e.g. RLX, Microstep s r.o., AVIR, Freescale Semiconductors, and other). We also cooperate with variouis individuals, for instance, the author of the RoboSapien Dance Machine Project, local hobby photographers who needed a robot-operated camera, or artists who are exploring new art forms utilizing technology.

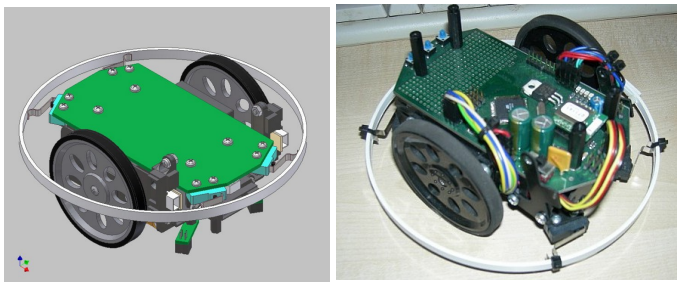

Figure.1 Sbot robot platform with BlueTooth radio communication, autonomous control, line sensors, bumpers, installable IR proximity sensors and encoders, with easily exendable circuit board.

V. Individual Robotics Projects

Various robotics projects represent the type of activities we put our emphasis on, and when also our learning is most intensive. The projects are often developed in cooperation with students, or they are student projects. Sometimes the projects overlap with the contests, when we work as team leaders, or supporters who provide the background, equipment, and guidance. Here, we would like to name a couple of example projects:

Robotnačka v.2 – the drawing robot, controlled from LOGO language

This is a hardware platform, which can be attached to a Logo turtle, which is normally only drawing on the screen. In this way, learning programming becomes much more entertaining, and the robot can also be used for new activities, utilizing its sensors, for example, teaching geometry [1,2].

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Robotnačka drawing shapes based on bitmap image

A secondary school student software project: the application received a bitmap image on its input, extracts countours from the image and generates a trajectory to be drawn by Robotnačka [3].

Remotely-Operated Robotics Laboratory

A permanent installation of robots in a laboratory that is always available on the Internet. The robots in the laboratory can be controlled the same way as locally connected Robotnačka – from Logo language, or, alternately, from a web browser, or C++, Java, or another type of application [4].

S-bot and Acrob robot platforms for education and projects

Platforms that were developed in our group for the purpose of simple robotics experiments, bachelor theses, exercises on locomotion and navigation [5, 6], see Fig. 1.

Remotely controlling WowWee family robots

A USB device for sending arbitrary IR signals that could be used to control RoboSapien and other WowWee robots [9]. We also developed a solution for controlling the robots using LEGO IR tower and directly from RCX programmable brick, see Fig. 2.

Figure 2. Controlling RoboPet from RCX using IR signals.

VI. Student Work

We use the robotics laboratory to provide the bachelor and master students with a working environment, and the required equipment. In our courses, students get hands-on experience in using robots of different types – LEGO NXT robots, BoeBot robots, Robotnacka, Acrob and Sbot robots. In these exercises, they learn basics about kinematics, signal processing, sensor types, calibration, and control. In the last two years, the following bachelor theses have been successfully completed:

Probabilistic mapping in remotely-operated robotics laboratory (2009)

Bayesian Robot Programming (2009)

SBOT Sokoban (2010)

Localization using distance sensors (2010)

Mobile robot for category line-follower (2010)

and the following diploma theses:

Representations in Evolutionary Design (2005)

Visual Programming of Control System for a Colony

of Robots (2007)

Robotic laboratory experiments for secondary school physics (2010)

Cellular Embryogenic Representations for Evolutionary Design (2010)

Didactic materials for the topic robotics construction sets and Imagine Logo (2010)

The exact references can be found at our wiki page [7]. Currently, several other bachelor and diploma theses are in progress.

VII. Seminars and Talks

Our group runs an internal seminar for students and researchers, but more importantly, we invite various speakers to give lectures on topics related to robotics. For instance, we organized a talk about chemical robots (Doc. Štěpánek from VŠCHT Praha), and a talk about Constructionism and Robotics in Schools (Prof. Alimisis from School of Pedagogical and Technological Education in Greece).

Even though our organization is not educational by the definition, one of the best results achieved in previous years is participation in the international project Centrobot, where some joint Austrian-Slovak lectures for the students of secondary schools both from Vienna and Bratislava were organized, Fig.3. There is a big potential of increased motivation of the students from different countries to work on joined robotics projects together. This allows them not only to acquire the knowledge and skills, but also to gain a different perspective, open their minds, and compare their own performance with others.

Figure 3. A joint Slovak-Austrian lecture, Vienna, February 2010.

VIII. Summer Schools

For several years, we have been organizing an event called “Robotic holidays”, a one week intensive lab work with lectures and talks. Typically in the beginning of the summer or in September, interested students and people joined us to work on several more or less challenging robotics projects. During the last three years, together with the student organization BEST (Board of European Students of Technology) and InnoC (Austrian Association for Innovative Computer Science), we organized a summer school for students from technical

universities across Europe – twice in Bratislava and one time in Vienna. This two-week course includes lectures, workshops, excursions, and leisure activities. Fig. 4 shows a group work from our robotics summer school in 2010.

Figure 4. Centrobot robotics summer school 2010.

IX. Contests

Contests are very central part of educational robotics, and they cost a lot of our time and energy. The main advantages of contests are:

- a fixed deadline – improves planning skills, makes it easier to prioritize and focus
- a clearly specified task, which was selected by experienced people in such a way to be solvable, non-trivial, and interesting
- often a standardized platform with a broad user base, which allows good access to information, saves time and efforts
- the possibility for the participants to compare their skills with their peers
- the school or club can make itself visible, this is a great motivation to produce an excellent result
- a nice possibility for building social and professional networks
- contests have a healthy competitive and sporting atmosphere, everything is subordinated to allow a perfect result of everybody

A. Istrobot

Istrobot is the primary contest of our association, where we are the main organizers. The tradition dates back to the year 2000 and a permanent quality growth can be observed. At the present time the contest consists of four different categories: The Pathfollower for linefollowing robots, Micromouse for maze solving robots, MiniSumo for fighting robots, see Fig. 5, and Freestyle for everything else, see Fig. 6. The contest is attracting approximately 100 robots each year and only our internal limits stopped its additional growth. The best experience from this contest is that it really fosters the development of the mobile robotics in our region. With a surprise, we find many research papers in local conferences inspired with robots solving the maze, or line-followers.

B. RoboTour

RoboTour is an outdoor robotics contest organized by the Czech association Robotika in Czech Republic. In the year 2010 it goes international for the first time and it takes place in Slovakia, Bratislava. Design of an autonomous intelligent vehicle appropriate for such contest inspired by the famous Grand Challenge contest is challenging for our university partners and our material support is very useful. Participants from universities and clubs in Czech Republic and Slovakia (wish one exception of a foreign team) compete in autonomous outdoor robot navigation in a leisure park. Robots are allowed to use both global navigation – such as GPS, compass, accelerometers, inclinometers, etc. and local navigation such as ultrasonic distance sensors, laser range sensors, landmarks. Vision is typically the most important component, responsible for keeping the robot on the track, which is necessary to prevent an instant "game-over". This contest serves also as a good reference testing platform for various image processing problems and generates many interesting solutions of the navigation problems. Members of our association have participated in RoboTour for about four years, and this year, our association has received an invitation to organize the contest in Bratislava.

Figure 5. MiniSumo dead-match at Istrobot 2010 contest.

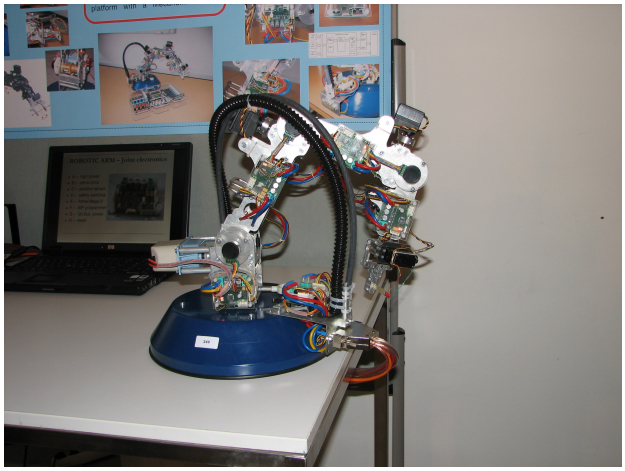

Figure 6. Robotic Arm – Freestyle competition, Istrobot 2010.

C.FIRST LEGO League (FLL)

We are actively involved in organizing regional tournament of FLL in Bratislava that is taking place for the third time this year. It is a contest for teams of 5-10 members in the age of 10-16 years. The strengths of this competition lie in the focus on creativity and team work, excellent preparation of tasks, which are solved by tens of thousands of students round the globe. It is also important that every year, a completely new challenge is to be solved, and thus it is impossible to participate with the same robot year after year. In consequence, also excellent novice teams have a high chance of succeeding. In addition to building and programming the robot, the competition requires completing a research project and preparing a presentation. In this way, the young people get a taste of what it means to be a researcher. However, here we also see some weaknesses. In particular, the research themes are too complex to comprehend for that young people. We would like to see themes that would pose challenges appropriate to their age. For instance, many interesting small research projects in physics and chemistry at the level of elementary school can be completed to demonstrate interesting phenomena. Such experiments are genuine and achieve what they claim, answer the research question completely, and understandably. This is in contrast with typical FLL research projects that, for instance, propose to build dams, reorganize city traffic system, or find cures to diseases... That type of projects resembles somewhat the concept of "Let's pretend" society, where fridges, TV sets and CD players stop to work two weeks after the expiration period. In our local contest, we try to guide the coaches to lean towards easier projects that correspond to the knowledge level of the children. Our association not only participates in organizing the contest, but also provides equipment and staff to the participating teams. Fig. 7 shows a view from our local FLL contest.

Figure 7. FIRST LEGO League regional tournament in Bratislava, 2009.

D.RoboCup Junior (RCJ)

RoboCup Junior is a world-wide educational initiative targeted at young people up to age of 19 years. There is less team work focus in RCJ, individual teams are not an exception. There are also no restrictions on the material and software used as they are in FLL. Succeeding in RCJ (except, perhaps in the RoboDance category) requires several years experience, and advanced technical skills. Access to the information and guidance is a bottleneck, teams guided by students from technical universities or skilled engineers working in relevant industry have an advantage compared to the teams from schools in the countryside. Despite these shortcomings, we feel that RCJ in Slovakia contributes greatly to the interest in science and technology, it leads hundreds of young people through the experience of larger project, and it is a popular contest with good spirit. Our association supports this contest by all means. Fig. 8 shows a scene from RCJ in Slovakia. All information can be found at [8].

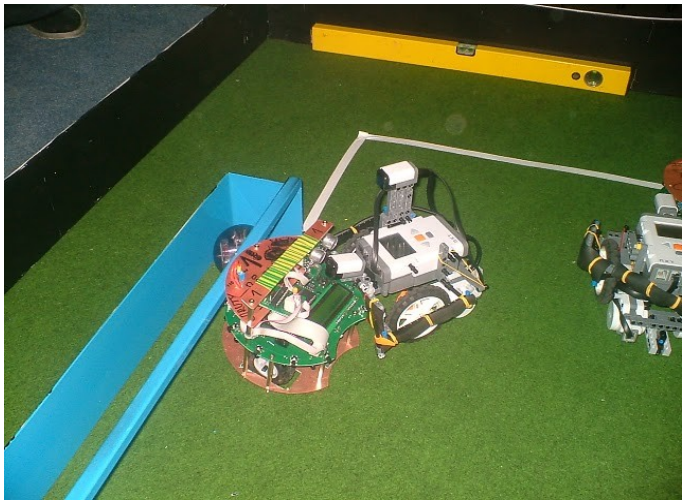

Figure 8. From RoboCup Junior Slovakia, February 2009.

E.Freescale Race Challenge (FRC)

This contest is an initiative of the Freescale Semiconductors company and its goal is to make use of the accelerometers to control the speed of the racing cars autonomously. We supported two student teams with material and advices to actively participate in this contest, see Fig. 9. Resulted autonomous cars are very good attractor also for public presentation and were used in Istrobot contest and in Elosys trade presentation. This contest is also a very good motivational tool to study embedded systems hardware and sophisticated methods of signal processing and even learning and mapping of the toy racing car track.

Figure 9. Freescale Race Challenge, Žilina, 2010, a team from STU Bratislava.

F.Robot Challenge

Robot Challenge is the World's largest contest (from the point of view of the number of registered robots). It takes place in Vienna, and it is organized by InnoC, one of our cooperating partners. Robotika.SK always both actively cooperates and

participates in the contest. We have an active exchange of participants between the Istrobot and Robot Challenge contest, which have similar categories. This exchange – best described by "a bus of Slovak participants arriving to Robot Challenge" supports Robotika.SK funding of Slovak-Austrian cooperation.

X. Public Presentations

When possible, we try to present our results to the public. We participate and support presentations of our alma maters at the annual trade show EloSys in Trencin, where we occupy a booth with robots presenting their behavior for visitors. Usually the school groups are attracted and hopefully also motivated for additional studies of technical disciplines. We also participated on the Researchers Night's – a EU coordinated science popularizing project, see Fig. 10. Our presentations were also the part of various international events as the festival of cocktail robotics in Wien Roboexotica, Eurobot national contest in Prague, etc. These are important events for creating new contacts, and attracting young people to the field, which is the aim of our activities in general. Results of the students project and our own platforms make a good jobs here. Moving and operating installations are a base of successful presentation, but the human explanation is always required for public.

Figure 10. Researchers' Night, Bratislava, 2007: vision-guided Boe-Bot that follows a ping-pong ball, and the drawing robot Robotnačka.

XI. Conclusions

Educational robotics is a young field that springs form and connects many different areas. However, it has a place of its own, and it requires separate attention. Not only to prevent repeating the same mistakes, but also to provide a place for exchanging ideas, technologies, platforms, solutions, and a discussion.

In this article, we introduce and summarize the activities and viewpoints of the non-profit association Robotika.SK. We are proud to claim that most of our activities have raised interest in robotics, science and technology among the young people and the target audience. This claim can be supported by the number of participants and students joining our activities and projects and their positive feedback. In the future, our efforts will continue according to the challenges and possibilities we will face, keeping the cooperation and team work as our main working method.

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