Development of the modular platform for educational robotics

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1. Abstract

This article presents a new concept in the application of educational robotics. At this stage, the development of a prototype of a modular mobile platform and its software is presented. The final goal of the project is the creation of a robotic stand that provides students with the ability to visualize group control algorithms, as well as a web interface for remote testing of algorithms used in group robotics. The main goal of this development is to expand the scope of training robotics and make it accessible not only for schoolchildren, but also for students.

2. Introduction

We live in a digital age, where science and technology are the two key concepts for understanding the fundamentals of the various devices that people face every day.

Robotization of various fields of science and technology is gaining momentum every year. For example, mobile robotics finds application in many areas of our life, such as medicine, military intelligence, service and so on. In addition to these areas, mobile robotics are also involved in education. Mobile robotics is an excellent area suitable for education, because it integrates mechanics, electronics, computer science and programming [1].

The trend of evolution of educational robotics increases every year. As a result, it is necessary to orient young people to study the foundations of the development of modern technologies.

There are many robotics construction kits on the market, such as Fischertechnik, Lego, Huna, MakeBlock and so on. But as statistics show, the majority of existing construction kits and teaching methods have age limits.

Educational robotics expands opportunities for teaching children by receiving practical skills. Most importantly, educational robotics provides an interesting and exciting learning environment because of its practical application and integration of various technologies.

Firstly, the usage of robotics in the educational process stimulates motivation of children to acquire knowledge.

Secondly, it is an evolvement of children's interest in technology and programming.

Thirdly, it is an amplification of programming skills, development of logical and algorithmic thinking.

In conditions of automation of education, we need to search new approaches to evolve of algorithmic abilities of children. The old approach to teach students programming uses only programming languages (Pascal, BASIC). It no longer meets the realities of today. Modern education requires a more active integration of robotics into educational processes [2].

In this article we present an innovative concept in the field of educational robotics, namely the process of creating a prototype of a modular mobile platform: its design, hardware and software.

3. Relevance

Despite all the diversity of educational robotics, existing construction kits have clear age limits, have closed and inflexible software. Extensibility of constructive capabilities of these construction kits is limited, and additional details to the basic kits are expensive. Therefore, the idea of creating a universal, flexible construction kit is very relevant nowadays.

4. Problem statement

Educational robotics is very popular in modern society. There is a great variety of construction kits, a lot of fields of robotics, more and more adolescents want to learn the fundamentals of robotics, learn electronics and design [3]. But again, there is the problem of creating a universal construction kit are not only for children but also for students. From here arise such issues as:

Construction kits age is limited. A very wide range of construction kits are represented on the market, but usually they are all intended for preschool children or teenagers.

Price. The cost of the basic set of the construction toy can be quite low, but the sets often don`t have sufficient electrical components, the purchase of which is a necessity for the possibility of working with this construction toy.

Inflexible software. If you purchase a construction kit for a child of preschool age, then for this age category it will be the most intuitive interface and fairly simple programming basics. If you want to move to a new level of programming, you will have to buy additional software or even a new construction set.

5. Conception

We propose a new approach to educational robotics, which alleviates the main shortcoming of many construction toys, namely the age limit, allowing not only schoolchildren, but also students, to use the construction kit for educational purposes. This approach solves the problem of age restrictions and helps to prepare a suitable base for further, more serious stages of education in this direction.

The developed concept provides a training base for all ages, with different levels of training activity. It allows to acquire skills in design, programming and working with electronics.

As the result of the multi-level software, the user has the opportunity to continuously improve their knowledge in programming. The flexibility of the software consists of the fact that for each age group, there is an intuitive interface and depending on the age of the user, his knowledge. If we are talking about primary school students, it should be noted, that the interface and the submission of methodological material should be given in a game form, but the programming capabilities at this level are rather limited. Obviously, when you move to the next steps, the level of programming complexity increases. One of the advantages of our concept is the presence of a camera in sets, due to which the user can work with technical vision. Another main focus is the availability of the photogrammetric system, (MS «Kinect» is currently in use). It allows to implement centralized, group control of robots, and in case of a robotic stand, it is a necessary attribute.

The main element of this concept is the modular mobile platform. The basic configuration of the platform assumes the presence of a control unit, and 2 units with motors.

The concept is described in Table 1

Table 1

Age group	Individuals	Organizations
1-4 grade	- Platform in basic set - Set of sensors - Software: work with sketches - Study guide	- A group of robots in the basic set - Cameras - Kinect - Software: work with sketches - Network connectivity of groups of robots - Study guide
5-7 grade	- Platform in basic set - Set of sensors - Software: programming in the form of algorithmic blocks, the ability to add simple blocks with elements of program code - Study guide	- A group of robots in the basic set - Cameras - Kinect - Software: programming in the form of algorithmic blocks, the ability to add simple blocks with elements of program code

		• Network connectivity of groups of robots • Study guide
8-9 grade	• Platform in basic set • Set of sensors • Software: programming on Python • Study guide	• A group of robots in the basic set • Cameras • Kinect • Software: programming on Python • network connectivity of groups of robots • Study guide
10-11 grade	• Platform in base set • Set of sensors • Camera • Software: programming on Python • Study guide	• A group of robots in the base set • Cameras • Kinect • Software: programming on Python • Network connectivity of groups of robots • Study guide
Bachelor Graduate student		• The robotic stand with the ability to visualize group control algorithms • web interface for remote work • Ability of testing algorithms of group robotics

This project considers the initial stage of the concept implementation, namely the development of the prototype of the platform and its software.

6. Mobile platform design

The concept assumes availability of a modular platform. In this context, the word "modular" means the easy interchangeability of various blocks of the platform. Depending on goals and purposes of the platform usage, you can use module with sensors, electromagnets, a module with a camera, as well as additional modules, for example, a block with a laser module for games, can be attached.

The modules are separated by means of special fasteners, which are the electrical components of the assembly too (Figure 1)

Figure 1 shows an example of a modular mobile platform model
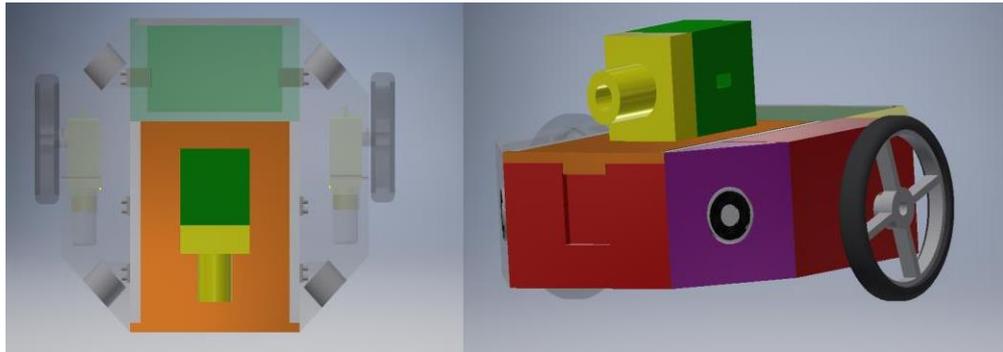
Figure 1 3D model of mobile platform

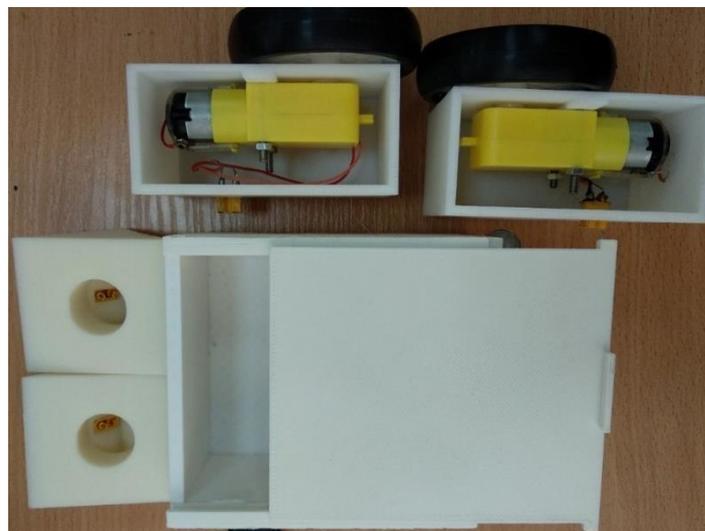The blocks printed on the 3d printer are shown in Figure 2

Figure 2 Blocks printed on the 3D printer

The next stage of the design will be the casting of parts in silicone molds.

7. Hardware implementation of the mobile platform

The hardware part of the platform includes two controllers Raspberry Pi Zero W (it has a WI-FI module) and Arduino Nano. Raspberry is the main controller that

transmits control signals to the Arduino via the I2C bus. Arduino sends control actions to other electrical components. A video camera can be also connected to Raspberry. The idea of using two boards is to reduce the load on Raspberry, which is a top-level controller of this scheme. At the moment, the Arduino Nano is used because of its availability. At further stages of work, it is planned to use self-made boards made on the AVR family controllers.
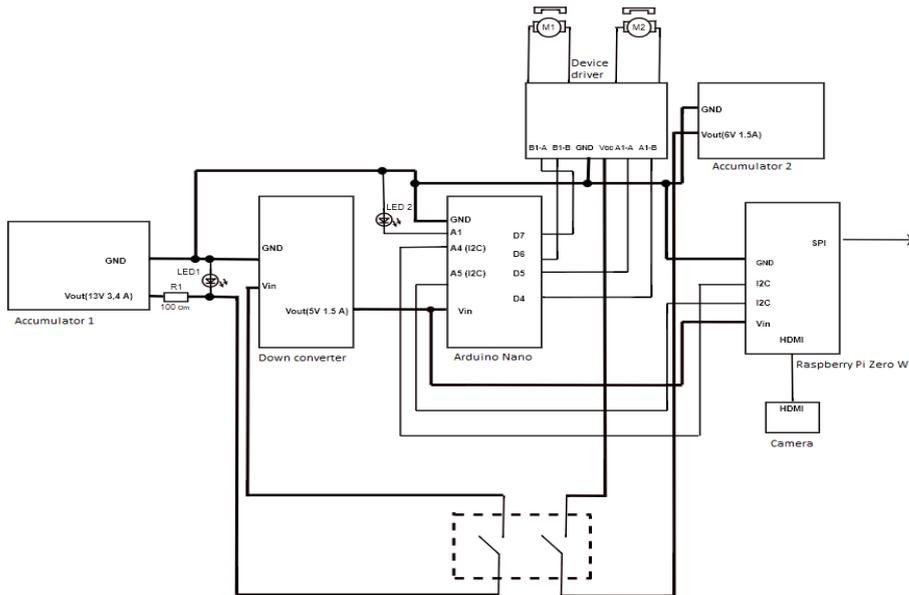
Figure 3 shows the hardware of the platform

Figure 3 the hardware of the platform

8. Software of the modular mobile platform

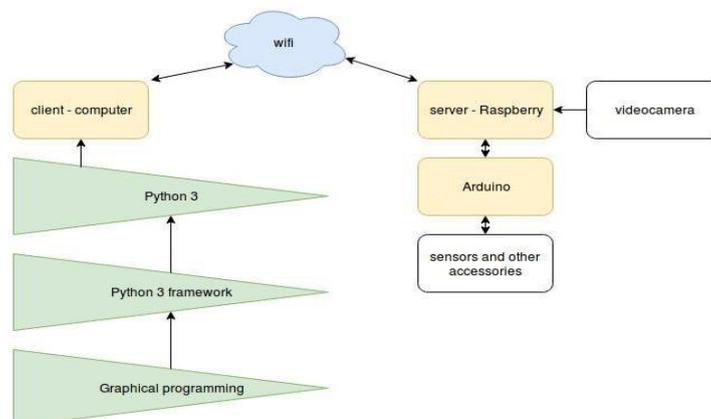The software implementation of the platform is presented in the following figure:

Figure 4 General scheme of software implementation of the platform

Client – computer implementation.

The implementation is built on three levels of complexity, depending on the knowledge of user programming skills

Level Python 3

At this stage, the user can add his code, he also has unlimited possibilities for working with software. This stage is the lowest level of software implementation. This level is built on the basis of web programming.

Python 3 framework

It is a class with a set of functions in Python 3, in which client-server communication is implemented, thus programming in Python 3 becomes very simple and convenient - all functions are similar to the Arduino language, which allows users with an average level of programming, opportunity to program the controller and the necessary electronics for the robot easily.

Graphical programming (Scetches)

This level is built on programming of the platform by using sketches. It is the simplest of the implementation of programs, but its capabilities are quite limited, hereby making this level ideal for schoolchildren in primary grades.

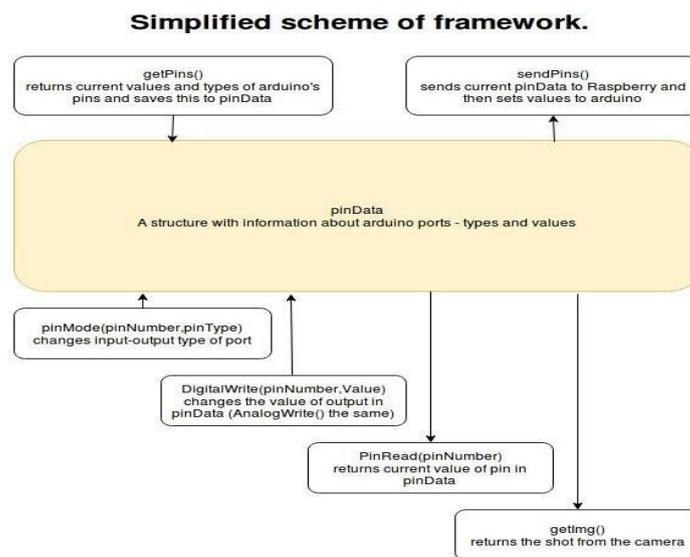The following figure shows a simplified scheme of the framework

Figure 5 Work of framework

Figure 6 shows the software interface for schoolchildren studding at 5-7 grades. This age group is the most interesting for consideration, since the environment allows to add not only algorithmic blocks, but also blocks with program code. For a more understandable interaction with these blocks, there is a color identification, which makes it easier to work with the environment.
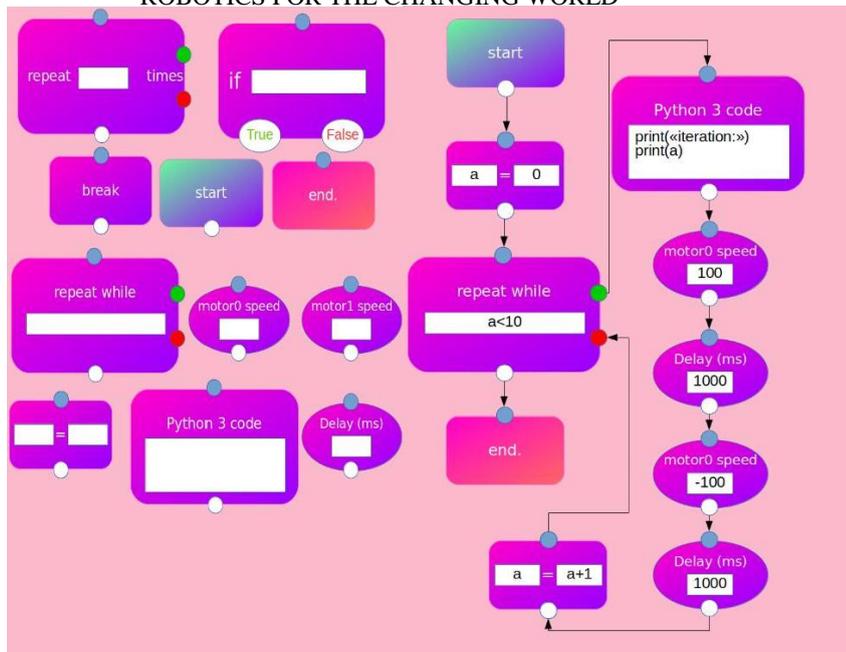
Figure 6. Example of the interface design

«Kinect» is used for the possibility of centralized management of groups of robots. To be able to register each platform as a separate device, active markers of different colors are attached to each robot. Active markers are LEDs of different colors. In future it is planned to develop its own photogrammetric system.

9. The robotic stand

The ultimate goal of the project is to create a remote, test robotic stand that will provide users with a flexible web interface for testing algorithms used in group robotics. The main focus at this development will be on supporting secure remote access to research and testing of algorithms for group robots [4]. Continuous work of the stand will be provided due to its automatic recharging of batteries of mobile robots.

The work process of the stand is planned to be realized according to the following scheme:
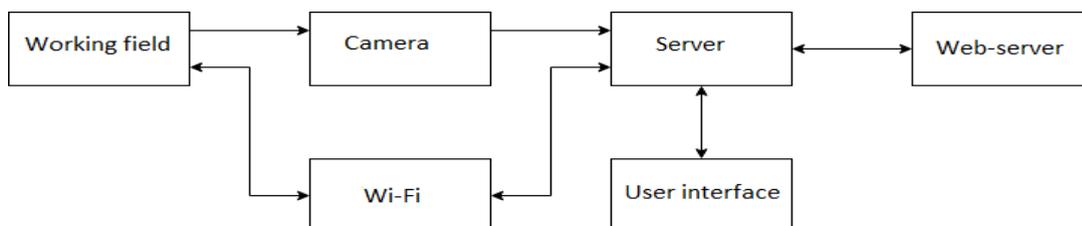

Figure 7 Structural diagram of the stand

10. Conclusion

In this project, we propose an innovative concept in the field of educational robotics. This approach to educational robotics allows students of different age categories to work with the mobile platform, to expand its functionality, depending on the training objectives. The flexibility of the software allows users with different levels of education to get programming skills. Also one of the main advantages of the platform is availability of a camera. Work with a video camera, expands the area of competence of the user, and the software allows users to learn the basics of vision systems. At the moment, the first prototype of a modular mobile platform has been produced, software is being written, teaching methods are prescribed. Monthly the project is modernized, refined and expanded.

11. REFERENCES

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[2] Yen Air Caballero González ; Ana García-Valcárcel Muñoz-Repiso «Educational robotics for the formation of programming skills and computational thinking in childish», Computers in Education (SIIE), 2017 International Symposium on

[3] Jose Etiene Bezerra Junior ; Paulo Gabriel Gadelha Queiroz ; Rommel Wladimir de Lima, «A study of the publications of educational robotics: A Systematic Review of Literature» , IEEE Latin America Transactions (Volume: 16, Issue: 4, April 2018)

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