iRobot Robots for Education

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Abstract. The paper describes iRobot offerings for education in Robotics. iRobot offers for that purpose Root Coding Robot and Create 2 Robot.
Root Coding Robot is primarily designed for learning Robotics at Primary and Secondary schools. It is packaged with iRobot Coding application. This application can be used at three learning levels with increasing coding complexity:

- Graphical coding is performed in drag-and-drop mode of graphical command blocks. It can be used to teach children to fundamental programming skills.
- Hybrid coding is a mixture of graphical coding with introduction to coding simple scripts.
- Full-text coding is a robot coding in Python.

The application can simulate the coded robot behavior and the program can be uploaded to the real Root Coding Robot. Program development and simulation can be done without any robot in presence.
Create 2 Robot is based on the vacuum cleaner robot series of the company Roomba 600. The robot communicates via USB/RS232 port. It is designed as a moving ground platform for development of more sophisticated robots.
There are many example software and libraries available for coding offered robots.

Keywords: Robotics, Robot Programming, iRobot.

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1 Introduction

In this section, a brief history of iRobot is presented collected from [1]. The history of this company is very exciting – from military and scientific contracts to mass production.

All pictures and information are taken from iRobot sites.

iRobot is founded in 1990 by Colin Angle, Helen Greiner and Rodney Brooks, roboticist educated at MIT. In 1991, the company (Rodney Brooks) develops its space exploration robot Genghis. It is now exposed in Smithsonian Air and Space Museum.

In 1996, the company develops the robot Ariel that detects and eliminates mines in the surf zone – on land or underwater. The robot development has been funded by DARPA.

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In 1998, iRobot wines a contract with DARPA for development of tactical mobile robot. The result is PackBot 510. It has been used to search debris of World Trade Center after the September 11 terrorist attacks.

In 2001, iRobot has launched its first mass home robot Roomba – floor-vacuuming robot. In this year, PackBot 510 has been deployed to the US troops, and Pyramid Rover robot has been developed with National Geographic Society for searches in the Great Pyramid in Egypt.

In 2004, iRobot wins DARPA contract to develop Small Unmanned Ground Vehicle (SUGV). The result is 310 SUGV – man-portable robot.

In 2005, iRobot launches another mass robot – the Scooba floor-washing robot. This year, iRobot stock begins trading on the NASDAQ Stock Exchange.

In 2006, iRobot launches another mass robot – the Dirt Dog shop-sweeping robot.

In 2007, the company launches its first programmable robot – Create. It is based on Roomba. This robot is intended for research and education purposes. The product offering has been influenced by the increasing hacker interest to the Roomba Series.

In the same year, two new mass robot series has been launched:

- Verro pool cleaning robot;
- Looj gutter cleaning robot.

In 2008, iRobot expands into maritime robots. The result is Seaglider. It is a deep-diving Autonomous Underwater Vehicle (AUV) designed for missions lasting many months and covering thousands of miles.

In the same year, iRobot launches the Roomba pet series and professional series vacuum cleaning robots.

In this year, iRobot wins a contract from DARPA to develop LANdroid communication robot. This is a "small mobile communications relay robot – empowering warfighters with ad-hoc communications in theater".

In 2009, iRobot launches SPARK education initiative – STEM (Science, Technology, Engineering and Mathematics) education in the classroom.

In 2010, the company co-sponsored National Robotics Week. iRobot helped to monitor Gulf of Mexico oil spill, in the same year.

In 2011, iRobot has developed 110 FirstLook – a small, light, throwable UGV (Unmanned Ground Vehicle). This is "a compact, rugged and expandable lightweight robot that provides immediate situational awareness, performs persistent observation, and investigates and manipulates dangerous and hazardous materials while keeping the operator out of harm's way".

In the same year have been launched:

- the Scooba 230 floor washing robot;
- Roomba 700 series vacuuming robots.

In 2012, iRobot 2012 acquired Evolution Robotics that had been specialized in computer vision, localization and autonomous navigation.

In 2013, Evolution Robotics Mint has been branded as iRobot Braava.

In this year, the company:

- launches Roomba 800 Series, with revolutionary AeroForce Performance Cleaning System;
- launches the Ava 500 video collaboration robot;
- launches the Mirra 530 pool cleaning robot;
- achieves more than 10 million home robots sold worldwide.

In 2014, iRobot launches the Scooba 450 floor-scrubbing robot.

In 2015, the company launches the Roomba 980 vacuuming robot, combining intelligent visual navigation, cloud connected app control and increased cleaning power on carpets.

In 2016, iRobot launches the Braava jet mopping robot, ideal for mopping kitchens, bathrooms, and other small areas.

In 2017, iRobot launches Roomba 690 and 890, extending Wi-Fi connectivity. The company achieved more than 20 million home robots sold worldwide.

In 2018, iRobot launches Roomba i7+ with Clean Base Automatic Dirt Disposal, a robot vacuum that empties itself and learns a home's floor plan, and launches Roomba e5 robot vacuum.

In 2019, iRobot launches Roomba s9+ with Clean Base Automatic Dirt Disposal, its most advanced robot vacuum to date; launches Braava jet m6, a robot mop that tackles sticky messes in multiple rooms and large spaces; and adds the Root coding robot to its product line. The last robot is the main educational robot for Primary and Secondary schools.

In 2020, more than 30 million home robots have been sold worldwide.

iRobot Education [2] is organized around its educational robots (Root and Create); private coding platform; library of programs, projects and other resources; and STEM outreach program. The intention of the last program is iRobot Education to be embedded as resource in the available STEM (Science, Technology, Engineering, and Mathematics) curricula in schools, colleges, universities and communities.

Focus of this paper is on iRobot Root and Create series – educational robots. This overview is organized around these robots and offered resources.

2 iRobot Root

2.1. Hardware

iRobot acquired education startup Root Robotics, in 2019, to enrich and boost its educational program.

Root robots are for Primary and Secondary schools.

These robots have been designed as educational robots for the above-mentioned target audience.

There are two offerings Root rt0 and Root rt1 (see Fig. 1). They are very similar in all aspects including sensors, outputs and support.

Sensors in both models are:

- Capacitive Top Touch Zones – 4
- Front Bumpers – 2
- Light-sensing Eyes – 2
- Wheel Encoders – 2
- 3D Gyroscope – 1

Fig. 1. Root rt0 and rt1.

- 3D Accelerometer – 1
- Battery Level Monitor -1
- Color sensors (only rt1) – 32

Outputs:

- Drive Motors – 2
- Large Multicolor LED Lights – 4
- Piezoelectric Speaker – 1
- Marker lift and drop – 1
- Eraser lift and drop (only rt1) – 1

Root rt0 is a home version of Root rt1. The last one is classroom oriented.

Root rt0 cover is transparent and the user can see inside its work. Root rt1 cover is not transparent.

Both models can draw with a marker put in their marker holders. When the robot moves the marker can be up or down (to draw) – it is programmatically controlled. Root rt1 can move even on vertical magnetics whiteboard and can erase the drawings on it.

Root rt1 has 32 color sensors.

2.2. Programming

iRobot Root programming can be done at three levels:

- Graphical blocks;
- Hybrid blocks;
- Full-text blocks.

All these levels are supported at one Web programming platform [3] developed by the company. It is a drag-and-drop environment.

In this platform, the user can develop its own new projects, download project from the library and share projects.

There is a set of tutorials "Getting Started with Root". Among them is a tutorial explaining how to upload a developed project into a Root robot. The project can be simulated in the platform before the upload to the robot. The project can be uploaded via Bluetooth connection.

All library projects are available as code, video clips or pdf files.

Level 1 (Graphical blocks) is intended to introduce the robot programming concepts to the kids that even still cannot read. There are four groups of graphical blocks: *events*, *commands*, *settlers* and *flow controls*.

The robot programming is event driven. When some event occurs, the corresponding "co-routine" starts its execution. The events are *robot started*, *bumper pressed* (left, right or either of them), *color detected* (black, red, and green, blue), and *capacitive top touch zone touched* (one or some combination of them).

The command blocks are *go* -16:16 cm; *turn left* -360°:+360°; *turn right* -360°:+360°; and *play a note*.

The setter blocks are:

- *switch on/off large multicolor LED lights* (in one of the eight selected colors in this mode; switch off or switch on in half/full or circular manner);
- *marker control* (on/off or clear the whiteboard); and
- *control the wheel acceleration* (left and right wheel in cm/sec, forward/backward/stop and/or left/right or in place).

There are two control flow blocks: *wait* 0:4 secs and *loop* 1:9 or to infinity. The loop block consists of two blocks: *open* and *close*. The loop "code" must be put between these two blocks.

All blocks can be selected from a stencil and arranged on the pane for execution. The block must be constructed in sequences like those that Lego puzzles. The execution starts with the event "robot started" and if during the code execution another event occurs then the control flow is transferred to the corresponding "co-routine" if available.

Example of Level 1 project is given in Fig. 2.

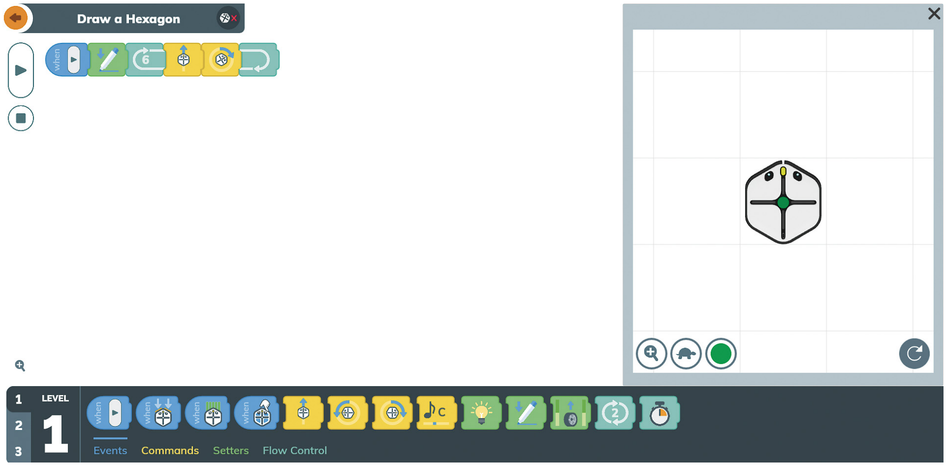

Fig. 2. Level 1 coding.

Level 2 is extended with two more groups of blocks: *math* and *logic*. All blocks are more detailed. The event blocks organize the program in "co-routines" reacting on signal events.

At this level, commands can accept calculated arguments. Commands are more detailed: *move* (as Level 1); *turn* (left/right in -360°:+360°); *arc* (left/right in -360°:+360°, -16:+16 cm); *reset navigation* (return to the previous "co-routine"); *navigate to (x, y) coordinates*, *play tone in seconds*; and *say some text*.

Setters now accepts calculated arguments. Setters are more detailed: *set lights* (in RGB values 0-255); *set marker* (as Level 1); and *set wheels speeds* (left and right in cm/sec).

Flow-control blocks accepts conditional or numeric expressions. Flow controls are *if*, *else if*, *else*, *while*, *repeat* (for loop), *wait* (as Level 1), and *comment*.

Math blocks are constant and variable definitions. The definitions are automatically generated when a "set var" block is created. All variables have to be initialized with some value – this initialization (and variable definition) is performed via the block "create var num". Variable names can be used everywhere where a number can be used. Just a same is applicable for the calculation blocks.

The numbers are integers and decimals (notes are decimals). The calculation block results are of type integers or decimals.

Finally, a random number generator generates integers or decimals in a specified range.

The logic is organized in the same manner: logic constants and variables ("create logic var"), set variable, numeric expression comparison, unary logical operations and binary logical operations.

Example of Level 2 project is given in Fig. 3.

Fig. 3. Level 2 coding.

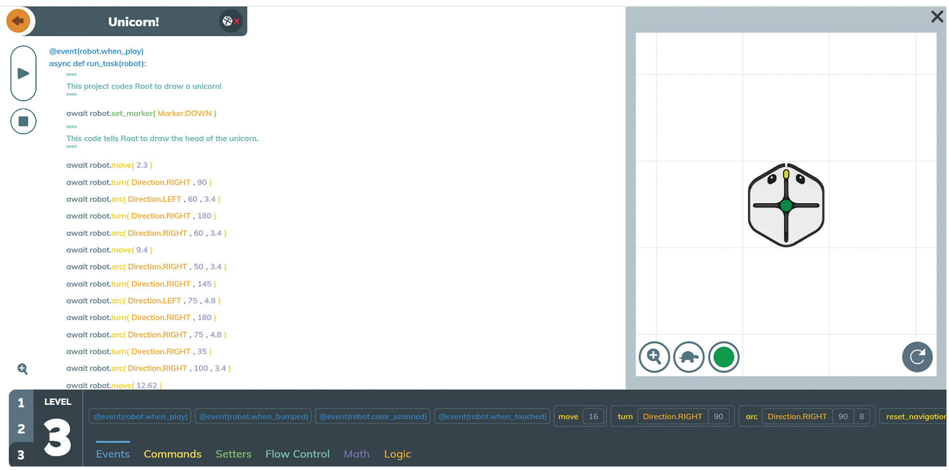

Fig. 4. Level 3 coding.

Level 3 unfolds the blocks in program scripts but still control the program structure of the script. The blocks here are as that in Level 2, but expressed as programming language constructs. Initially, Swift has been used, but now the platform has switched to Python.

Example of Level 3 project is given in Fig. 4.

2.3. The library

Root library is organized in the next sections:

1. Getting Started with Root – 7 tutorials;
2. Social Emotional Learning (SEL) – 9 projects;
3. Ready to Go: Drawing – 10 projects;
4. Ready to Go: Music – 7 projects;
5. Ready to Go: Sensors – 4 projects;
6. Root Brick Top Projects – 4 projects with Lego montages on the robot;
7. Spring Activities – 7 projects on season topics;
8. Root Costumes – 8 projects for robot dressings;
9. Finish the Story – 4 project.

Projects contain clips, solutions or instructions in pdf files.

Some projects, simply demonstrate solutions of some feature usages, other describes how to organize contests with several robots (programming to achieve peculiar robot behavior). Among the projects, there are some quests for code debugging. The simplest projects are not connected with the programming, for example, some of them are devoted to the external robot vision (dressing).

3 Create

Currently, iRobot offers Create 2 model. It is “a mobile robot platform built from remanufactured Roomba robots and designed for use by educators, developers and high-school and college-age students.”

Create 2 is Roomba 600 Series vacuum cleaner home robot. It is presented at Fig. 5.

Fig. 5. iRobot Create 2.

3.1. Hardware

Create 2 has the following controllable sensors:

bump sensor;
- wheel drop sensor;
- wall sensor;
- cliff (left, front left, front right, right) sensors;
- virtual wall sensor;
- wheel overcurrent (left wheel, right wheel, main brush, side brush) sensors;
- infrared receiver;
- buttons (clock, schedule, day, hour, minute, dock, spot, clean);
- battery (voltage, current, temperature, battery charge, battery capacity);
- motor current (left, right, main brush, side brush).

iRobot Create 2 Open Interface specification is based on the iRobot Roomba 600. There are several groups of commands:
- *Getting Started Commands*: Start, Reset, Stop, Baud;
- *Mode Commands*: Safe, Full;
- *Cleaning Commands*: Clean, Max, Spot, Seek Dock, Power, Schedule, Set Day/Time;
- *Actuator Commands*: Drive, Drive Direct, Drive PWM, Motors, LEDs, Schedule LEDs, Digit LEDs Raw, Buttons, Digit LEDs ASCII, Song, Play;
- *Input Commands*: Sensors, Query List, Stream, Pause/Resume Stream.

Create 2 accepts commands via External Serial Port Mini-DIN Connector (RS232). A communication cable USB/RS232 is available to connect Create 2 with some external controlling device (computer, tablet, computing device etc.).

Create 2 can be in one of the operational states: *Passive Mode*, *Full Mode*, and *Safe Mode*. In Passive Mode, sensors can be read, but no actuators command can be executed. In Full Mode, all commands can be executed. In Safe Mode, all commands are executed, but under some conditions (*detection of cliff*, *wheel drop* or c*harger plugged in and powered*), the robot stops and reverts to Passive Mode.

Every 15 microseconds the robot update its sensor data and internal state. This information can be read one by one or in a stream.

3.2. Programming

Python interface is available for Create 2 programming: *pycreate2 0.8.0*.

Library contents for Create 2 is:
- Getting Started with Create 2;
- Create 2 Open Interface Spec;
- Intergalactic Symphony with Create 2;

- Python Tethered Driving for Create 2;
- Battery Power from Create 2;
- Controlling Create 2 with Arduino and Android;
- MATLAB Toolbox for the iRobot Create 2;
- Command Line Interface for Create 2 Sensors.

The library contents is not reach. The first two entries are description and specification of Create 2. The other ones are projects – hardware and software ones.

4 Conclusion

iRobot Root is well designed for education solution. It can be used in Primary and Secondary schools as a tool and resource for STEM curricula, studying programing and robotics. The problem here, for no English speaking countries, is with the language: some of the materials have to be translated in Bulgarian and grouped by Bulgarian STEM curricula.

iRobot Create 2 definitely is suitable for research and education at universities. It is a smart moving platform open for control from some smart device. Translation in Bulgarian of Create 2 materials is not needed.

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References

1. iRobot, History, https://www.irobot.com/about-irobot/company-information/history, last accessed 24/04/2021.
2. iRobot, iRobot Education, https://edu.irobot.com/overview, last accessed 24/04/2021.
3. iRobot, iRobot Education, https://code.irobot.com/#/, last accessed 24/04/2021.