# Android Based Educational Mobile Robot Design and Pilot Evaluations

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**Abstract**

Educational robotics is a powerful tool for STEM and STEAM education. However, in practice, while trying to introduce educational robotics into a well-established educational process, a number of significant problems might arise. These include a high cost of an equipment and a lack of necessary competencies in the field of educational robotics among teachers. In this paper, we describe a concept of an inexpensive mobile robot equipped with a mobile device running Android operating system. We present sample projects that demonstrate how to extend capabilities of the educational mobile robot through the use of the mobile device. The proposed approach was preliminary evaluated in "Educational robotics" Bachelor level course and "Introduction to robotics" Master level course at Kazan Federal University.

*Keywords*: Educational robotics, Educational robot, Android based robot, Arduino based robot

## 1. Introduction

Currently, educational robotics is successfully used as an effective tool for STEM education at various educational levels[1][2][3]. Educational robotics as an interdisciplinary area within STEM and STEAM education[4] forms students' comprehensive knowledge, skills and abilities based on the integration of science, technology, engineering, art and mathematics.

Some of the technologies used in robotics and related industries are available for study as part of STEAM education[5][6][7]. Of particular interest is the implementation of elements of machine vision and artificial intelligence in robotic projects of students[8].

At the same time, in practice, when trying to introduce educational robotics into the educational process, many educational organizations face a number of problems that do not allow them to achieve the positive effects expected from the introduction. Among these problems, there is an acute shortage of specialists with the necessary knowledge in the field of educational robotics and a shortage of the necessary educational and methodological materials for the training of such specialists. In addition, in the difficult economic situation observed around the world, often educational institutions are faced with the high cost of logistics for educational robotics.

The purpose of this study is to find and test a low-cost technical solution suitable for studying the basics of educational robotics in higher educational institutions.

## 2. Project description

In order to level out the difficulties arising from the high cost of components, we use a following set of inexpensive components in the preparation of students studying educational robotics: Arduino Uno based controller or similar, DC motors, L298N motor driver module or similar, ultrasonic rangefinder HC-SR04 or similar, Bluetooth module HC-05 or similar, MPU-6050 gyroscope and accelerometer module, SG90 servo drive or similar, LEDs, RGB LED, piezo buzzer, resistors and photoresistors, optical encoders, connecting wires

accumulator batteries 18650 with the holder and power button, rubber tire wheels.

Using this kit students can build a mobile robot for robotics classes. These components are easy to find on sale and they are easily replaceable using analogues. The cost of such a set, in market prices for November 2022, is about $50.

To assemble a mobile robot from the components listed above, students will also need robot's body parts. Currently, various options for inexpensive structural elements for assembling a robot chassis are offered for sale, however, in practice, we have encountered the fact that assembling a robot from these elements takes students a lot of time. Therefore, we have developed our own model of a mobile robot, the body elements of which are easy to manufacture using a 3D printer (Fig. 1). This model is adapted to the set of parts listed above, but can be easily modified by students to fit other similar components.

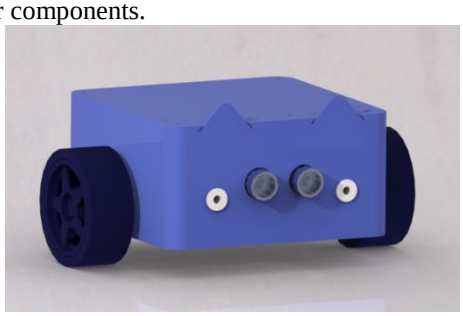

Fig. 1 The 3D-model of the robot

It should be noted that in the course of our work, we noticed that using the Arduino platform to build a robot encourages students to be creative and develop their own design of a robot body from improvised materials.

In order to expand the capabilities of a mobile robot assembled from the above components, we propose to additionally equip it with a mobile device running the Android operating system.

To solve our tasks, any device based on the Android 5 operating system and higher is suitable. We assume that these devices are accessible to many students through widespread adoption.

Thanks to mobile device an inexpensive mobile robot gets additional sensors, including cameras and microphone, additional processing power, as well as an improved human-machine interface.

Note also that additional equipment of robots with mobile devices can be used not only in educational projects, but also in scientific research[9][10].

As part of our work, we use the capabilities of smartphones or tablets based on the Android operating system to equip an educational robot with computer vision and human-machine interface elements. To exchange data between a mobile device and a mobile robot, it is convenient to use a wireless connection via Bluetooth or Wi-Fi.

Professional development tools for the Android platform, such as Android Studio, are not always suitable for use in the educational process. In practice, such tools often have a too high entry threshold for students, and their development requires a lot of time and special skills.

Therefore, to program the mobile robot we propose to use software adapted to the educational process.

For students who do not specialize in Android development, we suggest using the App Invnetor cloud platform[11]. MIT App Inventor is a handy tool for integrating a smartphone into robotics and IoT projects.

Another tool that can be used in the educational process for programming Android devices is the Processing programming language and development environment. The Android implementation of Processing[12] allows students to quickly create GUI applications.

We used the above described concept of a robot equipped with an Android mobile device to develop an "Educational Robotics" course for university students.

The proposed approach was preliminary evaluated in "Educational robotics" Bachelor level course and "Introduction to robotics" Master level course at Kazan Federal University.

Also, fragments of this course were presented as part of the advanced training program for teachers of additional general educational programs of a technical orientation in the IT-Cube digital education centers, conducted by the Academy of the Ministry of Education of the Russian Federation.

In the next section, we provide examples of educational projects implemented using the robot described above. These projects are part of the educational robotics course developed by us for students of higher educational institutions and are included in this course in the form of training assignments.

## 3. Examples of expanding the capabilities of the robot using a mobile device

### 3.1. *Mobile robot control*

This project allows to implement the control of a mobile robot in the teleoperation control mode. Students are encouraged to develop software that allows them to control the actions of a mobile robot equipped with a servo grip. Fig. 2 shows an example of an assembly scheme for such a robot from the components presented above. Fig. 3 shows an example of an application interface that allows to control the robot via a Bluetooth connection.

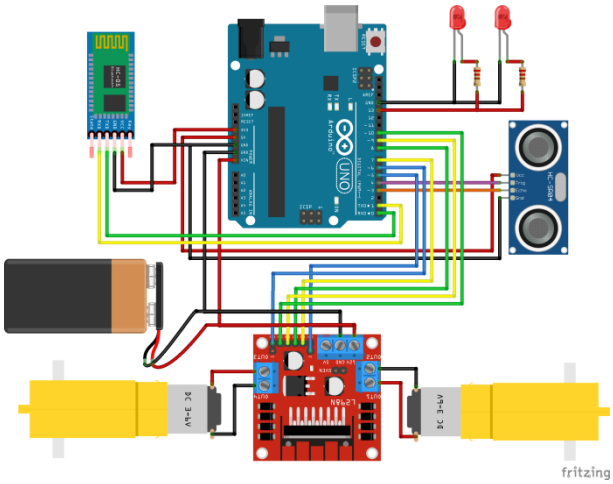


Fig. 2 Robot assembly diagram

Fig. 3 Robot control application interface

The application interface (Fig. 3) contains 8 buttons: a button to connect to the robot via Bluetooth, 4 buttons to control the movement of the robot, a button to stop the robot and 2 buttons to control the grip of the robot.

### 3.2. *Search for a specified object*

This example demonstrates how the implementation of computer vision, artificial intelligence and human-machine interface elements can be combined in a training project.

In the conditions of the task, various objects are in front of the robot. The user says a voice command indicating the object to be found (for example, "Where is the cat?"). The robot must search for this object and drive up to it, and then inform the user that the object has been found. If the object could not be found, the robot also informs the person about this in the form of a voice message.

In Fig. 4 an example of an application interface for a mobile device installed on a robot is presented. The application interface contains a button to connect to the robot chassis via Bluetooth, a voice control activation button and a camera turn button. The application screen also displays the image received from the device's camera.

Visual search for objects is based on the application of the MobileNet neural network[13], previously trained on the ImageNet dataset. This network is undemanding to resources and is suitable for devices with low performance. In Fig. 5 a fragment of an experiment with searching for an image of a cat is presented.


Fig. 4 Target object search application interface

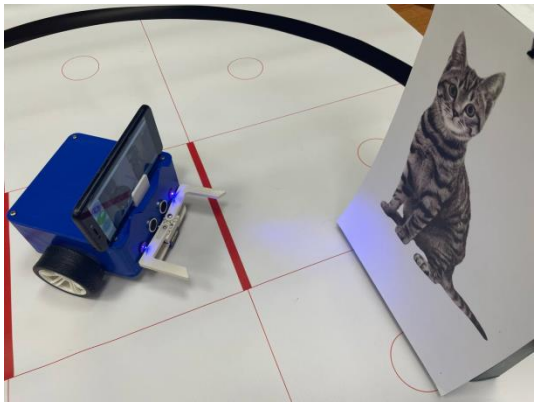

Fig. 5 Experiments with finding the cat

## 4. Conclusion

In this paper we proposed a conceptual scheme of an inexpensive mobile robot equipped with a mobile device based on the Android operating system. A feature of the proposed solution is a low cost and availability of components. Equipping the robot with a mobile device allows using additional sensors and computing resources in educational projects and expanding possibilities for a human-machine interface implementing. This concept was implemented on the model of a mobile robot developed by us and designed to study the basics of educational robotics in higher educational institutions involved in the training of teachers in the IT profile and related areas.

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## Authors Introduction

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