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EDUCATIONAL TWO WHEELED MOBILE ROBOT

The article deals with the design of a mobile two wheeled robot, which is intended for educational purposes. The robot is designed as a kit with the possibility of modification and innovation. This robot gives students a chance to develop their creativity and skills. The remote control system was designed with the possibility of using a mobile phone. A mobile phone software application has also been developed.

***Keywords:** mobile robot; remote control; Arduino.*

Fig.: 13. References: 4.

Urgency of the research. The topic of the article is the development of a didactic model of a wheeled robot for the educational process of high school and university students, in the study programs Mechatronics and Robotics, where practical education is needed and this didactic model must be used.

Target setting. There are currently no cheap modular mobile robot kits available on the market that could be used for didactic purposes. The developed didactic model is conceived as a kit and so the student must build the whole model and create an electronic and software part. The robot model also creates the possibility of further creative activity of students in its further development and addition of other modules and devices. The aim is to support students' creativity and to support their experience and skills in this area.

Analysis of existing research and publications. A six-wheel version of the didactic model of the robot was developed in [1]. This robot uses a teleoperator control system. However, the developed model does not allow to modify the connection of electrical parts but contains a fixed printed circuit board PCB. Two-wheeled inverted pendulum type mobile robot for educational purposes has been developed in work [2]. Educational mobile wheeled robot with a smartphone attached was developed for practical experiments of students [3]. Work [4] introduces design of ball collecting robot.

Uninvestigated parts of general matters defining. The algorithm of autonomous navigation of a mobile robot and the algorithm of mapping the workspace of a mobile robot were not solved in this work. This issue is planned to be addressed in the future.

Article objective. In this work, the creation of a chassis is addressed and the possibility of control by a teleoperator system is also addressed, which creates space for the use of the robot and for promotional purposes for the use of the robot as a game application. This robot can also be used as an inspection robot and can add other service tasks after adding other modules.

General overview of the system. The chassis (Fig. 1) consists of two round plastic transparent plates, which are connected by spacers and screws. There are many holes and cutouts in the boards, for better handling of the cabling and also for easy attachment of components. Engines with gearboxes, which are constructed with a gearbox, are attached to the lower base. The movement of the robot is enabled by the wheels connected to the output shaft of the gearbox. The stabilization of the robot is ensured by two more rotating wheels, which are also mounted on the lower base in the front and rear of the robot. The chassis allows the placement of sensors for tracking the navigation line, so the robot can be used as a linefollower. In the upper part of the robot there is space for the location of the ultrasonic and infrared obstacle sensor for the navigation of the mobile robot (Fig. 1).

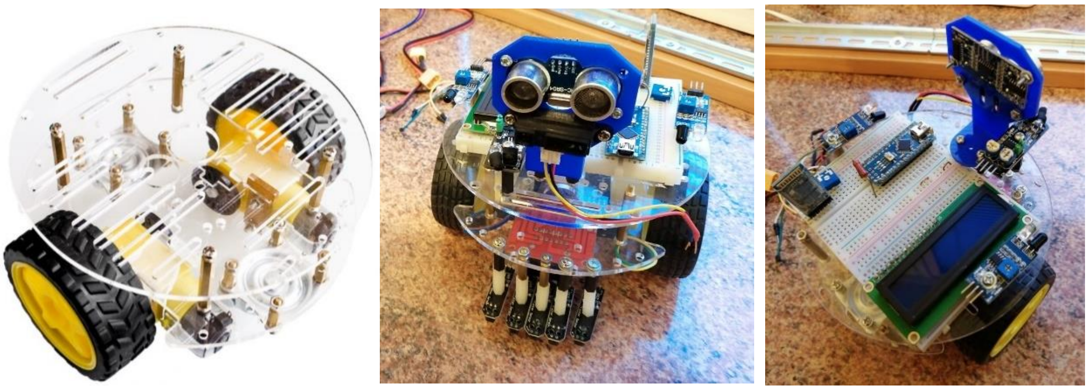

Fig. 1. Mobile robot chassis and location of sensor modules

The robot is driven by two DC motors with a gearbox with a gear ratio of 1:48 and an encoder rotating disk with grooves for measuring the speed of rotation of the wheels. The direction and speed of movement of the mobile robot is given by the difference between the speeds of the left v_L and the right wheel v_R (Fig. 2).

The instantaneous radius of rotation of the mobile robot can then be determined from the relation:

$$R = \frac{L}{2} \cdot \frac{v_R + v_L}{v_R - v_L} \tag{1}$$

The instantaneous translation speed of the center point P of the robot chassis can also be determined as a dependence on the angular speeds of the wheels ω_R and ω_L from the relation (Fig. 2):

$$v_P = \frac{v_R + v_L}{2} = R \cdot \frac{\omega_R + \omega_L}{2} \tag{2}$$

The position of the robot (fig. 2) can be described using the coordinates x_P and y_P and the direction angle φ_P:

$$\dot{x}_P = v_P \cdot \cos\varphi_P;\ \dot{y}_P = v_P \cdot \sin\varphi_P;\ \dot{\varphi}_P = \omega_P \tag{3}$$

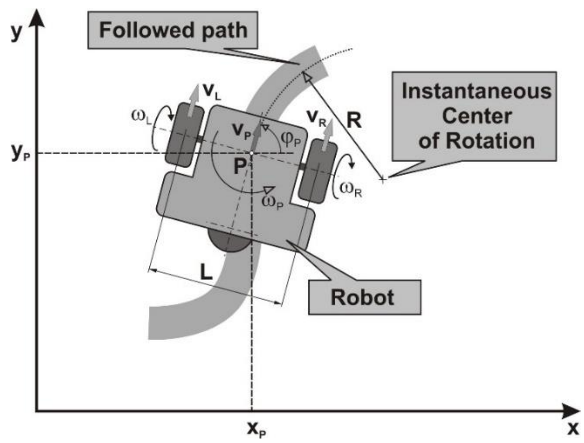

Fig. 2. The principle of robot control in a coordinate system

A dual motor driver L298N connected to an Arduino controller is used to control the motors. It is an integrated double H-bridge with protective elements for controlling DC motors. The display of information messages is solved using the LCD display LCD1602, which has 16 characters in two lines with color LED backlight (Fig. 3).

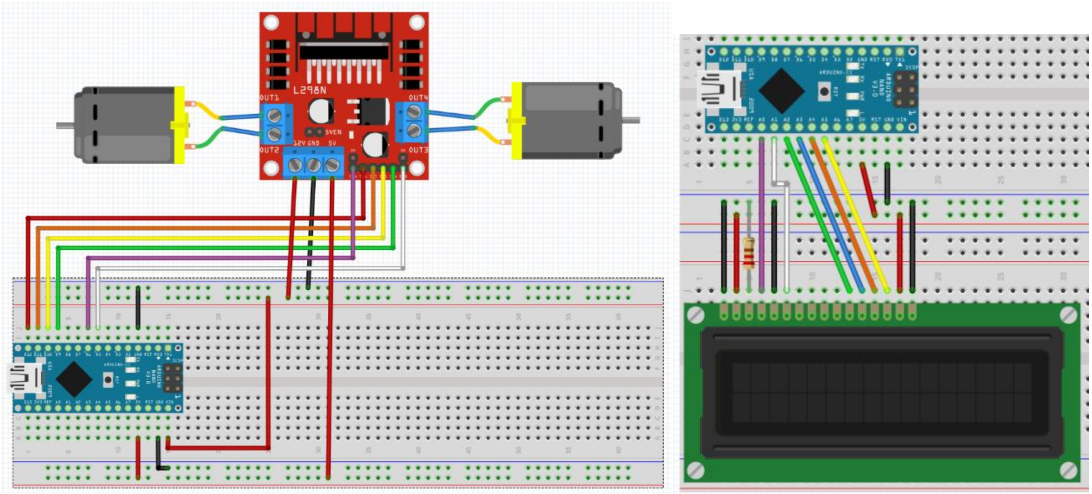

Fig. 3. DC motor driver and LCD display

For communication with a mobile robot, a Bluetooth module HC-05 and an infrared receiver VS1838 are connected, which also contains a noise filter (Fig. 4). The Bluetooth module is connected to the Arduino controller via a serial interface and allows the robot to be controlled via a mobile phone. The infrared receiver is designed to receive information from standard infrared controllers for home devices, so they can be used to control this mobile robot.

The power supply of the mobile robot is solved by means of a two-cell LiPo battery with an alarm for signaling the decrease of the electric voltage of the accumulator below the critical value on any cell of the accumulator. A drop in the voltage of a battery cell is indicated by an audible and visual signal.

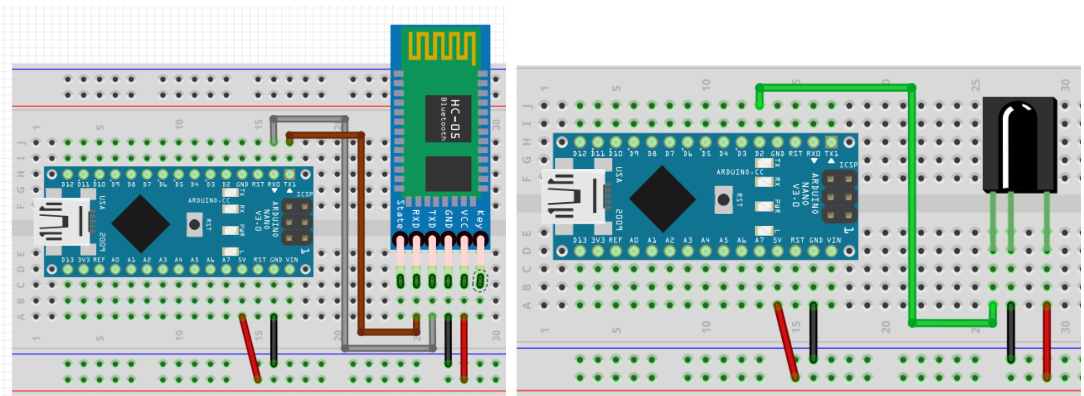

Fig. 4. Connection of Bluetooth module and infrared communication module

The final connection of the modules is realized on a solderless breadboard, so that students can adjust and modify the connection as needed. It will be possible to add other modules later and expand the functionality of the mobile robot (Fig. 5).

For safety and against damage to individual electronic or supporting components and parts of the robot, a protective frame was designed (Fig. 6). The protective frame consists of the main part and two beams, by means of which the frame is attached to the chassis of the mobile robot. The protective frame is made by FDM 3D printing technology from SPLA material, which has good print quality even at high print speeds and low shrinkage when the material cools.

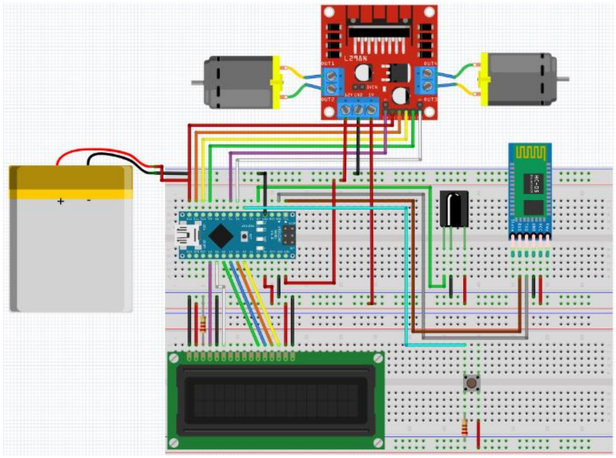

Fig. 5. The overall implementation of the electrical part of the robot control unit

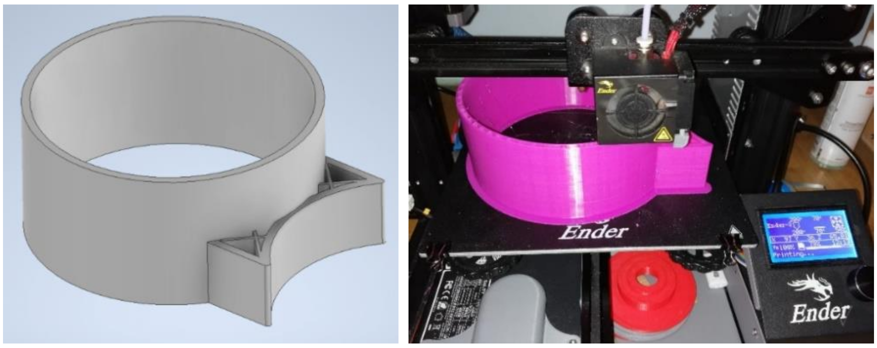

Fig. 6. Protective frame of the robot

The main part of the frame is a round base and is connected together with the beams by means of screws and nuts (Fig. 7). This protective frame is attached to the lower base of the robot. The frame also includes a blade with reinforcement in the front part for better handling of the ball or other objects.

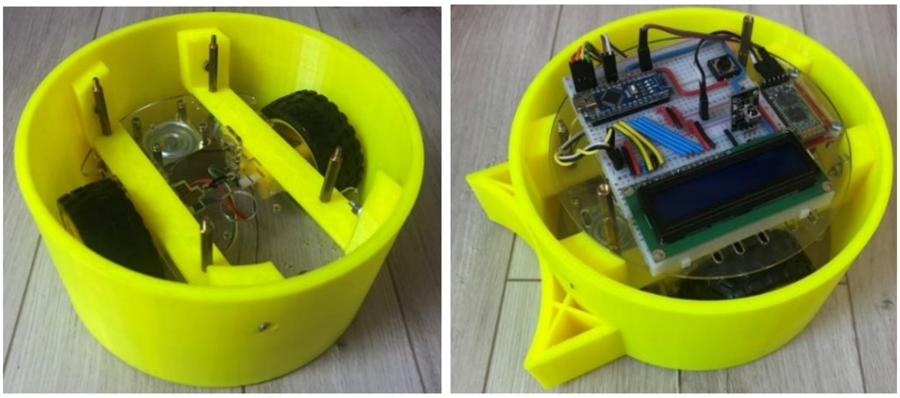

Fig. 7. Connection of the protective frame and the chassis of the robot and the overall implementation of the mechanical part of the robot

To control using bluetooth technology, it was necessary to create an application on the controller itself. Any smartphone with the Android operating system can be used as a wireless remote control, as it is compatible with the bluetooth module HC-05. We decided to program the mentioned application in an internet application called MIT App Inventor, developed by Google, which is available to everyone registered in this company. MIT App Inventor is a graphical programming language for mobile devices, in which it is possible to develop quality applications, but it is only supported for Android operating systems. This development program creates the graphical appearance of the application as well as its algorithmic part.

The first step was to create a graphic design (Fig. 8), where the landscape orientation of the screen was chosen, for better handling of the phone. We divided the basic screen into horizontal, vertical and tabular lines, in which we inserted buttons for all possible directions of robot movement. Through the user interface, we have created a list with a bluetooth icon, where all active bluetooth devices will be displayed after clicking. When you turn on the application, Not connected appears on the screen, which means that no device is connected to the application. When you open the list, select and connect the given active device, the mentioned inscription will change to Connented. In case of disconnection or connection failure of the device, the text Not connected will be displayed on the screen again. For a more beautiful visualization of the application, we assigned a background to the application, on which we placed our own author's mark. We have assigned images of arrows to the buttons of the direction of movement of the robot, which show the direction of movement of the robot (Fig. 8).

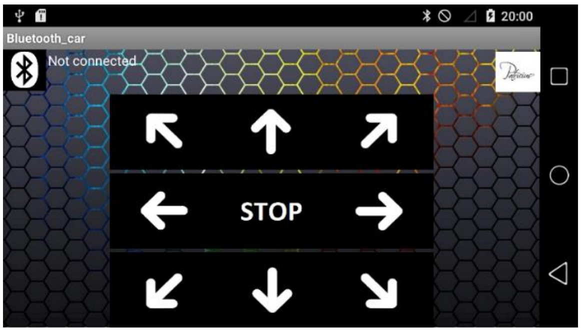

Fig. 8. Operator panel of a mobile application for robot control

The next step was to program the application, create the source code of the application. In the MIT App Inventor application, the algorithmic part of the application is created very easily using blocks, where we combine the given blocks into the program functions. In (Fig. 9) we can see that in the block before selecting the device, the application will list the address and name of all active bluetooth devices. After selecting a specific device, the application will automatically connect us to the device. The following are commands for Not connected and Connected to appear on the screen.

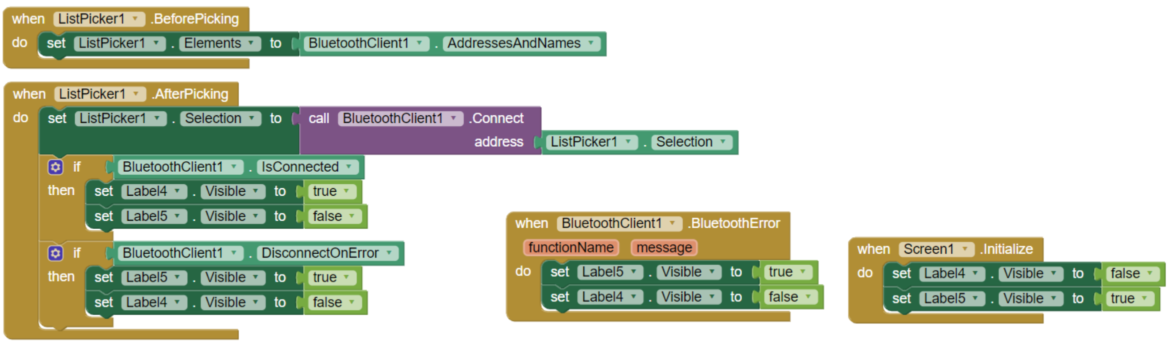

Fig. 9. The source code of the application for connecting the device

Furthermore, separate blocks have been created for each direction button (Fig. 10). If the button is pressed, then the application sends a specific associated text to the Arduino. When any button is released, the text S is sent, which means that the robot stops immediately. In the last step, an application was generated that can be downloaded and installed on a smartphone.

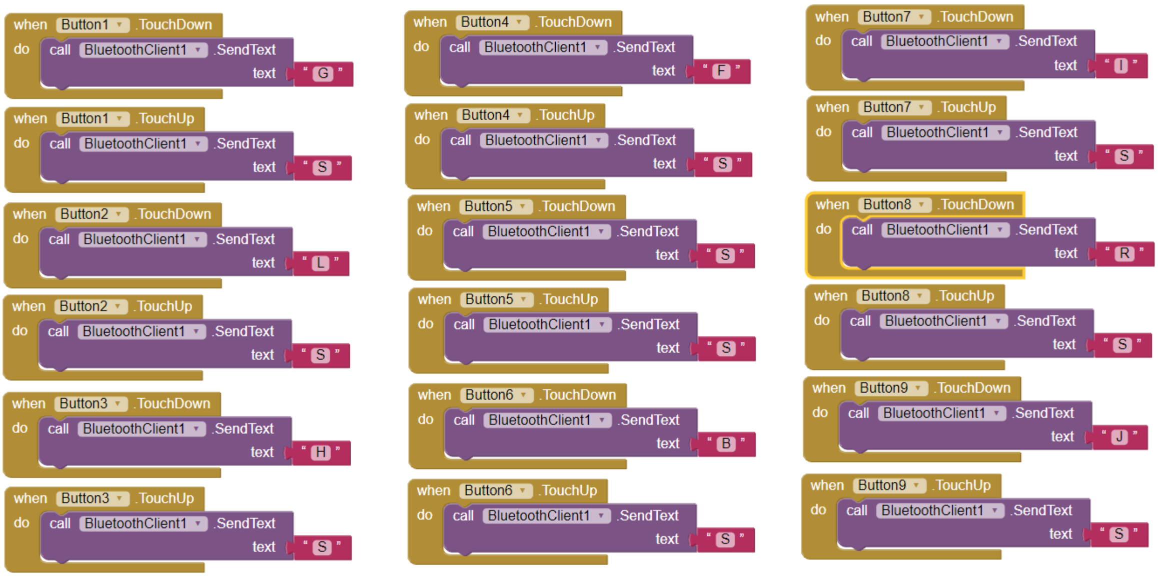

Fig. 10. Application source code for buttons

The MIT App Inventor application also allows you to create a QR code for immediate download of the application to a smartphone. A QR code is textual information that consists of white and black square modules assembled into a square matrix. Most smartphones with a built-in camera can decode this text information contained in this code. We can download our application using the generated two-dimensional barcode, which we can see in (Fig. 11).

Fig. 11. QR code to download the application

To make the connection between the wireless remote control and the robot work, a source code or program was also created for the Arduino installed in the mobile robot (Fig. 12). For programming with the HC-05 module, the library was imported with the command #include with the header file SoftwareSerial.h. Subsequently, a value named "value" was defined using the char data type. This character value serves as a variable that will change according to the commands that the HC-05 module receives. The data flow was set in bits per second (baud) for serial data transmission using the Serial.begin command. The specific baud rate for the HC-05 bluetooth module is 9600 bits per second. The if condition was placed in the program to move the robot, because it is necessary that this part of the program be executed only when something is valid. This means that if the read value sent by the bluetooth module application is equal to a value greater than zero, then the given condition is executed. After pressing the application button, the assigned text of the pressed button will be equal to the character value in the Arduino program. The exact subroutine is called according to the read value. If the subroutine was executed, we used the break statement to end the cycle, which ended the condition, which in turn will wait for the assigned value, and this cycle will be repeated again and again. The subroutines called are located below the void loop () in the program (Fig. 12).

```
#include <SoftwareSerial.h>              //knižnica pre bletooth
#include <AFMotor.h>                     //knižnica pre modul L298N
char hodnota;                            //definovanie znakovej hodnoty
int pravymotordopredu = 12;              //definovanie polohy pinov
int pravymotordozadu = 11;
int ENA = 6;
int lavymotordopredu = 10;
int lavymotordozadu = 9;
int ENB = 5;
void setup()
{ pinMode(pravymotordopredu,OUTPUT);     //definovanie výstupných pinov
  pinMode(pravymotordozadu,OUTPUT);
  pinMode(ENA,OUTPUT);
  pinMode(lavymotordopredu,OUTPUT);
  pinMode(lavymotordozadu,OUTPUT);
  pinMode(ENB,OUTPUT);
  Serial.begin(9600);          }         //nastavenie sériového prenosu dát
void loop()
{  if(Serial.available() > 0){           //vykonanie podmienky ak hodnota > 0
      hodnota = Serial.read();           //načítaná hodnota sa uloží do znakovej hodnoty
      Stop();                            //zastavenie robota
      switch(hodnota){                   //podľa načítanej hodnoty sa zvolí podprogram
      case 'F':        Dopredu();
      break;                             //ukončíme cyklus
      case 'B':        Dozadu();
      break;
      case 'L':        Dolava();
      break;
      case 'R':        Doprava();
      break;
      case 'S':        Stop();
      break;
      case 'G':        Dopredu_dolava();
      break;
      case 'I':        Dopredu_doprava();
      break;
      case 'H':        Dozadu_dolava();
      break;
      case 'J':        Dozadu_doprava();
      break;      }
}
```

Fig. 12. Bluetooth control software

The proposed mobile robot is created in two pieces (Fig. 13) so far and it is possible to assemble a team of robots to create an application for robotic football. This application is intended for didactic purposes for practical exercises of students and also for promotional purposes for initiating children's interest in studying technical fields of secondary schools and technical universities. The created robot is an open platform with the possibility of modification and further addition by students in practical training.

Fig. 13. Use of didactic models of robots for game purposes

Conclusions. The mechanical and electronic part of the mobile robot is completely demountable, and the building of the robot is left entirely for students, who thus train their creativity and innovation in the construction of the robot. Thus, the theoretical knowledge that students have acquired, and they have the opportunity to be supported by practical experience and skills. The development of practical skills and experience is very important for the application of students in practice. The development of these competencies is key to the development of students' creative personalities and means improving the level of graduates.

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ОСВІТНІЙ ДВОКОЛІСНИЙ МОБІЛЬНИЙ РОБОТ

Тема статті – розробка дидактичної моделі колісного робота для навчального процесу старшокласників і студентів ЗВО, де необхідно практичне навчання.

Нині на ринку немає дешевих модульних комплектів мобільних роботів, які можна було б використовувати в дидактичних цілях.

Дидактичні моделі роботів розроблені в [1-4]. Ці роботи використовують систему управління телеоператора. Однак розроблена модель не дозволяє змінювати підключення електричних частин, але містить фіксовану друковану плату.

Алгоритм автономної навігації мобільного робота й алгоритм відображення робочого простору мобільного робота в цій роботі не наважувалися.

Вирішується питання про створення шасі, а також розглядається можливість управління системою телеоператора, що створює простір для використання робота та в рекламних цілях для використання робота як ігрового додатка.

Модель робота також створює можливість подальшої творчої діяльності студентів у її подальшому розвитку та додаванні інших модулів та пристроїв. Метою є підтримка творчості учнів та підтримка їхнього досвіду та навичок у цій галузі.

Механічна та електронна частини мобільного робота є повністю розбірними, і створення робота повністю надається студентам, які, таким чином, тренують свої творчі здібності та інновації в конструкції робота. Таким чином, теоретичні знання, які придбали студенти, і вони мають можливість підкріплюватися практичним досвідом і навичками.

Ключові слова: *мобільний робот; пульт дистанційного управління; Ардуіно.*

Рис.: 13. Бібл.: 4.