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Realization of sensory mobile platform "WEGY" and possibilities of use in education

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Abstract: *This paper discusses the design, implementation and features of simple mobile robot system, WEGY, and introduces possibilities of use in education, research and popularization of engineering. WEGY drives are in the form of WHEel+leG configuration, shorten WHEG, which gives system the ability to move easily on the open and uneven terrain. Crossing the barriers is easier than with wheels. The platform has a small mass, and compared with a caterpillar drives is much more efficient. Robots elements with a description of options will be shown. The main controller of the robot is Arduino Mega. The platform can integrate a large number of sensors and actuators so it`s suitable for different teaching modules, such as sensors, actuators, automatic control, mobile robots and others. The platform allows specific application problems to be solved, which also represents an adequate way to adopt engineering knowledge, according to the method practical-theoretical-practical (PTP).*

Keywords*: robot; wheg; sensor; arduino*

1. INTRODUCTION

For education of engineers, practice has shown that the combined method practice-theory-practice (PTP) provides the best approach [1,2]. By using this method, teacher first presents the problem to students, which needs to be solved. Students then perform an analysis of the problem, after which they learn theory that is directly related to the problem. After that, students return to a solving problem. To support this approach for students from the Faculty of technical sciences in Čačak at the Laboratory of Mechatronics and Laboratories EMPR [3,4] and in cooperation with the Laboratory of Robotics from Faculty of Electronic Engineering in Niš [5] the existing mobile robot platform is modified. Robotic platform will primary find application in education and research works of students. The name WEGY is derived from the structural solution of drive mobile robot platform. For drive is selected form WHEEL - LEG configuration - known as WHEG, which brings the benefits of both concepts. WEGY represents a very rich platform in terms of sensors and actuators, so it allows the various practical problems to be solved. Through this platform and usage of PTP method, students can get acquainted with the basic elements such as applied electric circuits, applied programming, applied modeling etc. This concept should attract students to technique and make them more interested for teaching modules which will come later during studies. The assumption is that the introduction of this optional subject with PTP access to the first year would increase the attractiveness and interest of students for the upcoming teaching modules on higher years. This is already the practice in some universities in the world [6].

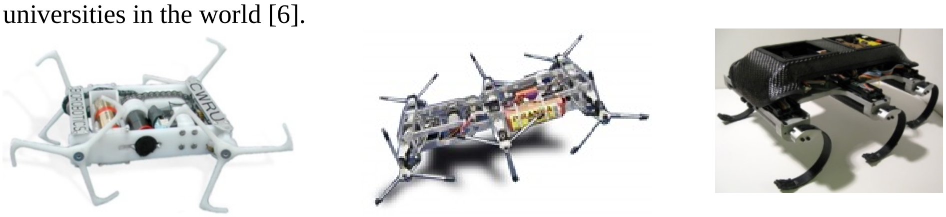

Figure 1. *Robot with wheg concept: a) Mini-Whegs b) WHEGS I [7] and c) Edubot [8,9]*

2. BASIC ELEMENTS OF ROBOT WEGY

Figure 2 presents a 3D model of a WEGY robotic platform and the appearance of the realized robot. All plastic parts are made on a 3D printer using PLA plastics. The time required to create such system is short (about 2 days). The dimensions of the robot are 50x33x18 cm and its weight is about 3 kg.

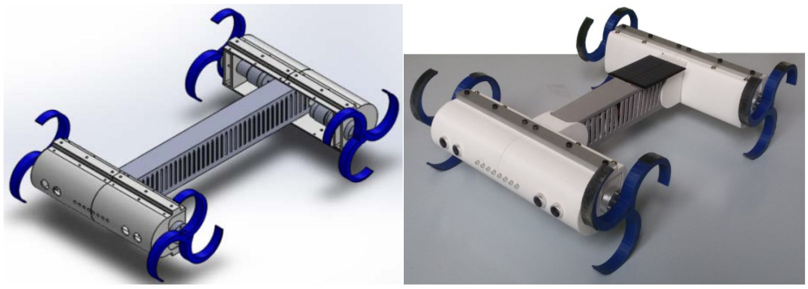

Figure 2. *3D model of the robot and realized robot*

WEGY robots block diagram is given in the following figure.

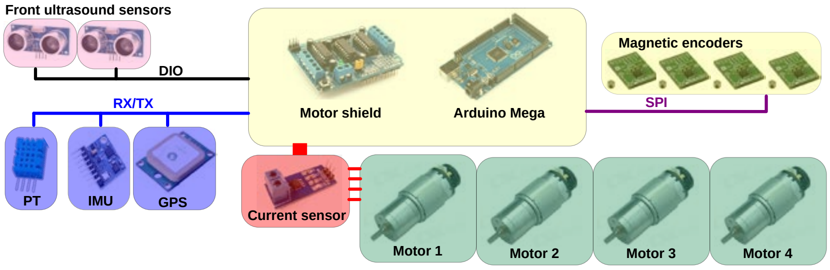

Figure 3. *Block diagram of the robot WEGY*

Each of these modules will be a briefly described with it specific purpose on the WEGY platform.

2.1. Arduino MEGA2650 controller

The microcontroller has 54 digital input/output pins (14 can be used as PWM outputs), 16 analog inputs, 4 serial ports, a 16 MHz crystal oscillator, power connector, ICSP connector. It easily connects to computer via a USB cable. There is a large number of additional modules - shields that can be added to this controller. For making of robot additional driver for motor control was used. Programming can be performed in a development environment for microcontrollers [10] and also supports the programming of the microcontroller in LabVIEW and MATLAB software.

2.2. DC motors with gearboxes and encoders

For platform drives, DC motors with brushes are chosen [11]. The appearance of the used motors is shown in figure 4.

Figure 4. *The used motor with encoder*

Table 1. *Characteristics of used motor*

Rated voltage	12	V
No load speed	4300±10%	rpm
Rated speed	3000±10%	rpm
Rated current	480	mA
Max torque	230	gcm
Gear box ratio	1:34	
Encoder resolution	41	ppr

In order to improve system performance additional magnetic encoder is added.

2.3. Module Magnetic Encoder

Magnetic rotary encoder AS5048A [12] has 14-bit resolution for angle measurement (0-360º). The sensor measures the absolute position of the rotation of the magnet. Main parts of sensor are Hall sensor, A/D converter and controller for digital signal processing. The angle is directly mapped to the PWM output of the sensor, and the angle can be read by using SPI communication. Technical characteristics of sensors are given in the table below.

Figure 5. *Sensor's plate layout*

Table 2. *Sensors characteristics*

Power supply	5 VDC or 3,3VDC
Power consumption	< 15 mA
Dimensions	5 x 2,5 x 3cm
Communication	SPI, PWM
Resolution	14-bit

2.4. The module for motor control

Module provides the necessary voltage and current levels for motor control. It amplifies pulses from microcontroller to appropriate levels. The platform uses shield with two integrated circuits L298N. Each of IC L298N on this shield is a double H-bridge, so this shield can control up to four DC motors. [13].

Figure 6. *Module for motor control*

Table 3. *Drivers characteristics*

Input voltage	7-35V
Output voltage	5-35V
Max output current per bridge	2A
Max Output Power	25W

2.5. Module with ultrasonic sensor

Module allows the detection and avoidance of obstacles. Ultrasonic sensor HC-SR04 [14] measures the distance between the sensor and the object that is in front. Distance can be measured to the objects which are static as well as the moving objects. The module is designed in the form of separate emitter and receiver on one board, and works in diffuse mode. Technical characteristics of the sensor are given in the table below. WEGY has two ultrasonic sensors placed on the front on the left and on the right side.

Figure 7. *Ultrasonic sensor HC-SR04*

Table 4. *Characteristics of ultrasonic sensor*

Power supply	5 VDC
Power consumption	< 2 mA
The angle detection	< 15º
Dimensions	4,5x2,0x1,5 cm
Measurement range	2 cm – 500 cm
Resolution	0,3cm

2.6. Module for current measurement

Module allows the measurement of the motor current. This allows calculating of consumed energy. ACS712 sensor principle of work is based on the Hall effect. [15] It allows detection of blockade of rotor in case of obstacle that cannot be overcome. Based on this measurements robot can make appropriate maneuver.

Figure 8. *Current sensor*

Table 5. *Characteristics of the current sensor*

Response	5 μs
Bandwidth	80 kHz
Error	1.5% on 25°C
Resistance	1.2 mΩ
Voltage supply	5.0 V
Sensitivity	66 do 185 mV/A

2.7. Module for measuring temperature and humidity

On the platform there is humidity and temperature sensor DHT11 [16]. The sensor is factory calibrated and does not require additional components so it can be immediately used for measurement. It consists of a capacitive humidity sensor, a thermistor for temperature measurement and electronics to communicate with the environment.

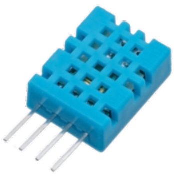

Figure 9. *The temperature and humidity senzor*

Table 6. *Characteristics of sensor*

Power supply	3-5,5VDC
Power consumption	2,5mA
Temperature range	0-50°C±2°C
Humidity range	20-90%RH±5%RH
Sampling rate	1KHz
Resolution temperature / humidity	1°C/1%
Dimensions	15.5×12×5.5mm

2.8. Module with compass, accelerometer, gyroscope

The purpose of this module is orientation and dynamics measurement of the robot. Sensor GY-87 [17] was used. The sensor unit represents IMU (inertial measurement unit), a sensor node that can detect 10 different parameters. This unit consist of three sensors HMC5883L (three-axis digital compass), MPU-6050 (three-axis gyroscope and three-axis accelerometer) and BMP085 (atmospheric pressure). Technical characteristics of the sensor are given in the table below.

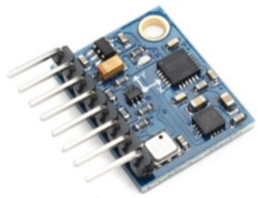

Figure 10. *IMU senzor*

Table 7. *Characteristics of IMU sensor*

Power supply	3-5VDC
Communication	I^2C
Digital compass	±8 Gauss, 12-bit
Gyroscope	±250,±500,±1000,±2000°/sec,16bit
Accelerometer	±2, ±4, ±8, ±16g, 16-bit
BMP085	300-1100hPa, 16-bit

2.9. GPS module

The module provides tracking of the geographical position of the robot. Module GY-NEO6MV2 [18] is used. This is a standard GPS module which uses serial communication for data exchange. This module can monitor a global position of the robot, speed, angle in relation to the north (compass), information of the time and date (*real time clock*).

Figure 11.*GPS module*

Table 8. *Characteristics of GPS sensor*

Power supply	2,7-5VDC
Power consumption	45mA
Communication	Serial (9600bps)
Positioning accuracy	2,5m
Velocity	0,1m/s
Precision angle	0,5°
Dimensions	25 mm x 35 mm

2.10. Power module

Power is provided with LiPo battery 5000mAh, 14.8V voltage. The platform also has a second battery to power sensors which are charged by a solar panel mounted on the upper surface of the robot so that in case of a power failure on the main battery and no possibility of movement of the robot, the sensors can continue to operate and provide necessary information.

3. CONCLUSION

The paper presents the realized WEGY robot and its possibilities for use in education. Low price of the installed components guarantees the wide availability of the robot in school environments. In further work on this robot will be tested its features. Furthermore, the aim is to create teaching material for the modules that process the components on the robot, using the PTP approach. Further steps will be to put this teaching material on the first year of studies as an elective course where students could explore one complex robotic system with top to bottom approach in fully applicative way and get familiar with the basic elements of electrical engineering, electronics, automation, drives in one interesting way. This should result in greater interest of students for items that await them in the higher years. The platform will be upgraded with additional modules, and in terms of construction, the armor will be made in the appropriate IP protection so it can be outdoor even in the case of high humidity.

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