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BRONTES - LIGHTWEIGHT EXPLORATION MOBILE ROBOT

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Abstract: *This article describes the conversion of the commercionally sold kit of a remote-controlled car model into the small and lightweight exploration mobile robot. It also describes the usage of the individual sensors which were added to the robot and the usage of the control media which transfers the data to the operator. The robot will serve as a member of the team of robots that will be remote-controlled and the aim of which will be the searching of the unknown environment or the looking for the disaster-wounded. For this purposes every robot will have the different equipment, the carriage unit and qualities so that the whole team was capable of hard ground survey.*
Key words: *mobile robot, accelerometre, GPS, wifi*

1. THE AIM OF THE PROJECT

The aim of this project is to create the lightweight wheel robot (Wise, 1990) named Brontes, which will be a part of the team consisting of several different types of robots. This team will be particularly targeted at reconnaisance and rescue operations and the individual robots will be designed so that they appropriately complemented each other and were capable of survey in whatever terrain. Brontes stems from the commercial kid of the NODE company, which is primarily aimed at the event called "crawling" (rock and obstacle climbing, extreme terrain riding). Its specialization are large and soft wheels which can cling to an obstacle and enable the ride even through very broken terrain. From the original concept we retained only the skelet and the engines, all the other components we changed for more suitable (the regulators, servomotors, accumulators) and added (the battery for the electronics, communication and control units, camera, sensors and illumination). The contemporary parameters of Brontes robot are presented in the following chart.

length	645 mm
width	379 mm
height	410 mm (including the camera)
weight	5.3 kg
battery for motors	Li-Pol, 7.4 V, 5,000 mAh
battery for electronics	Li-Pol, 11.1 V, 2,600 mAh
communication	wifi, 2.4 GHz
sensors	LED, GPS module, accelerometer, ultrasonic range finder, camera

Tab. 1. Parameters of Brontes robot

2. PROPER WORK

2.1 The Camera Tower

The camera tower was constructed by the joining of the two servomotors so that we reached the 90 degree rotation angle in both horizontal and vertical axis in every direction from the centre position. The camera was complemented by the high luminous LED diode for the illuminating of the area in front of the camera and by the ultrasonic range detector.

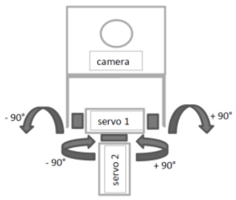

Fig. 1. The Camera Tower

2.2 The Control Units

Our team developed two units for the robot control. The first unit concerns with the control of motor regulators, servomotors and LED diodes and the second one is used for the data collection and communication transfer among the individual peripherals, which are connected to it.

2.3.1 The Unit for the Control of the Servomotors

This unit has 6 ports alltogether. They can be controlled independently. The unit is occupied by the ATmega8 microcontroller by ATMEL company and the convertor on the RS-485 bus. Through the change of the software we can set the unit so that it could control up to two LED diodes by means of the Pulse Width Modulation and the remaining units could be used for the control of the servomotors. The unit has a fail-safe function (500 ms) which protects the robot in case of the signal loss with the operator station. Unique address (ID) is alocated to every port. It identifies it within the protocol (every unit has 6 addresses). For communication we used the protocol, which is being used for the control of the servomotors by Dynamixel company and uses the RS-485 bus (RX64 datasheet). The example of assembling of commands for the setting of the position (from the whole protocol only this command is implemented for the unit):

0xFF, 0xFF, ID, 0x05, 0x03, 0x1E, val1, val2, chcksum (1)

The range of values is within the range from 0x000 till 0x3FF, the centre is in value of 0x200. Into **val1** the lower and into **val2** the higher byte position is saved. For the calculation of the check summation the following equation is used:

$$chcksum = \sim(ID + 0x05 + 0x03 + 0x1E + val1 + val2) \quad (2)$$

2.3.2 The Communication Unit

The unit is occupied by MCF52235 microcontroller by Freescale company and serves at the same time as the four-port switch. Into the switch is connected AXIS M7001 video encoder, which digitalises the image from the camera of the robot and the wireles unit for wi-fi. The communication unit is occupied by RS-485, RS-232, RS-232 in TTL logic, CAN, SPI and I2C buses. Further we have at disposal 8 ports of A/D convertor and a power supply for 5 V a 3.3 V.

SRF10 ultrasonic range finder (the restoring frequency is 10 Hz)is connected to the unit through I2C bus. The first sensor is placed above the camera, the second one on the back axle for the indication of the obstacle in case of backing.

By means of SPI bus we retain the data from three-axis SCA3000 accelerometer, which is placed on the front axle (the restoring frequency is 20 Hz). This data is further processed and analysed in the control program.

Two A/D convertors are used for the measurement of the voltage on the batteries of engines and electronics. The first unit, which was produced by our team, is connected by means of RS-485 bus.

3. THE CONTROL SOFTWARE

The control software is written in MS Visual Studio 2008 in C# language (Virius, 2002; Liberty, J. & MacDonald, B. (2008)).

To enable to switch among the individual robots by means of one operate station, the whole system must be based on the components and classes which can be connected to each other and activated as neccessary. Each unit has its class (accelerometer, GPS, the map for GPS, Dynamixel protocol, etc.) and these classes are joined by Robot (Brontes) component, which has unified inputs and outputs so that the operator software had the same data from all the components and could it interpret simply.

3.1 The Description of the Control Enviroment

The aim of the control program is to provide the operator sufficient data for the motion of the robot in the surveyed area (Zalud, 2001). The largest part of the board is occupied by the video from the main camera and can be switched into full screen mode.

3.1.1 The Drawing of the Map and Zoom Function

The second large block is a board which informs about the route driven through drawn in by means of GPS unit (Everett, 1995). This map is complemented by the data about the number of satellites, the speed, the coordinates and the altitude, the distance among the spots and ratio scale, that can be arbitrarily changed in defined steps. The data about position on the Earth and the altitude is saved each second into the amount field. At the present time the drawing of the map is created only in 2D environment. 3D visualisation is the matter of further effort. Zoom function is abode by the following equation:

$$zoom = E^{(16-val)*1.2-1} \qquad (3)$$

The parametres of the equation are set so that we could have on the eleven-step degree scale (zero to ten) the ratio scale of depiction from 0.1 m to 20 km.

3.1.2 The Control Modes

The robot can be controlled in four modes.

1. *The camera* – here we set the position of the camera by means of joysticks with the possibility of saving for the ride.
2. *The engines and wheels in tandem* – by means of the first joystick we control the rotation speed of both engines and by means of the second one we control the turning of both axles (this is the most frequently used mode).
3. *All separately* – on each joystick we control the whole axle (in one direction the engines, in the second direction the turning of the wheels). This is the mode for the special motions of the robot.
4. *Rotation* – here we do not have the possibility to change the turning of the wheels. We can adjust only the direction and the rotation speed and the robot rotates into one or the other direction.

Each of the above mentioned modes has three speeds of the control which we can switch arbitrarily. In the robot there is only one-speed gear box so the speeds are created by means of the limiting of the maximum value, which we send into the engines. In the fastest mode the maximum deflection of the turning of the wheels decreases commensurably to the speed according to the following equation:

$$turn = turn * \left(1 - \frac{|speed - 0x200| * 2}{3 * 0x2FF}\right) \qquad (4)$$

3.1.3 The Accelerometre

Another important unit is the three-axis accelerometre, which provides the data about the slope of the robot in the horizontal and vertical axis. The data from the unit are analyzed and the pieces if information serve for the protection and support of the motion in the terrain. In case if the robot stops in the aslope terrain, the engines work the counteracting force so that they prevent the robot from the motion (active brake). The protection is conditioned by the static position of the joystick for the engine control. When the robot drives onto high obstacles and is in danger of the falling upon over the front or back axle onto the top, the protection is activated and the commands for the full speed reverse motion are sent into the engines. Moreover, the accelerometre provides the data about the surrounding temperature.

3.1.4 Further Data for the Operator

The data for the operator is further complemented by the distances from the supersonic range finder and the state of batteries with the eventual warning that they are discharged and it is necessary to finish the exploration. Optionally we can switch on the monitoring of the strength and quality of the signal of the wireless unit or regulate its transmitting load and thus increase its scope.

4. CONCLUSION

At present time we produced the prototype of Brontes robot and one slightly upgraded version of it. Both robots are occupied by the same sensors and are entirely workable. We are working on the correction of algorithms, testing in the terrain and considering which further sensors and functions to add to the robots.

Further step of the project is the sharing and complementing of the map among the individual robots and marking the important pieces of information for the operator. The final aim of the project is the team of robots that are capable of independent searching of the target area and devolving of the important data on the operator.

5. ACKNOWLEDGEMENTS

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