Design elements used in the construction of a wheeled mini-robot destined for special applications

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1. Introduction

Recent military conflicts have shown that it is absolutely necessary to reassess forces, means and the operational procedures for their use, particular focus laying on the human factor, aiming, in this sense, to limit the loss of human life among the military, as well as among civilians who are not part of the conflict. The human factor has become the central element in military confrontations, a fact which led to an unprecedented development of the means used, resulting in the exponential growth of military research spending in recent years [1]. Thus, the unmanned vehicle sector is one that has long passed the *science fiction* area and became part of military actions widely publicized in the media. In recent years, a special effort has been oriented towards unmanned aerial vehicles – UAVs, but also towards unmanned ground vehicle – UGVs used by teams of engineers to defuse improvised explosive devices or unexploded ordnance elements that led to saving countless lives among soldiers or civilians. Observation, recognition, detection systems and firearms in the endowment of unmanned ground vehicles generated the need to equip the military structures acting in theatres of operations (for example, the U.S. has already developed a number of UGVs in the Iraq and Afghanistan conflicts – The Gladiator Tactical Unmanned Ground Vehicle and The Foster Miller Talon, while Israel already uses The Guardium in the confrontations with the West Bank and Gaza) [2].

The wheeled mini-robot prototype designed, engineered and manufactured within our institution falls under the unmanned ground vehicles category having the ability to act autonomously, enabling it's endowment with means of observation, listening, tapping, relaying and jamming. The mini-robot is provided with a photo detector sensor, being able to detect and draw near sources of light, this being something that renders it extremely useful within certain physical protection systems of important military objectives, for both defensive and offensive purposes. The developed mini-robot is also used for educational purposes, being especially useful in the general military training of cadets through the use of software designed to enable access within specific applications / virtual combat scenarios conducted within applied tactical - engineering classes, conducted in specialty laboratories.

2. The integration of the hardware component in the mechanical structure of the mini-robot

In order to develop the hardware component of the prototype under study (Figure 1) a plastic platform was used equipped with four rubber wheels, metal axles and a steering system.

On the surface of the platform two DC motors were fixed together with a motherboard on which three ATMega-type chips were placed, the configuration of the prototype being ensured by means of a simple interface for bluetooth with LEDs indicating its availability, integrated circuits, as well as boards for pin adding.

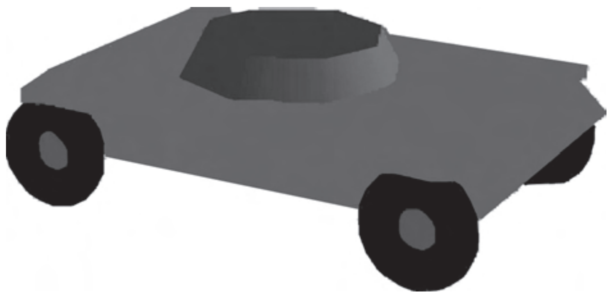

Figure1. Experimental prototype of the mobile wheeled mini-robot.

The pins have the role of making the connection both with the sensors that are used in the development of the mini-robot and the device that facilitates the modification of the program implemented within the microcontroller. The board uses a quantizer and on it a rechargeable lithium-polymer battery is connected, the mechatronics device benefiting thus also from the incorporation of a recharging system that connects the battery and the power source via a USB cable.

For the experimental prototype to move, unless it is autonomous, for control purposes a laptop or a phone connection with an implemented android system was used. The necessity for android is justified when using a special application that can only be implemented in the presence of the respective system on the mobile phone. The autonomy of the device can be established either by clearly specifying the speed, displacement distance and the moments when the wheeled mini-robot system is to turn left or right, an action pre-established by the program, or by the manipulation of sensors placed in the mechanical structure of the prototype (one for distance and another one for photo detection).

The displacement of the developed mini-robot is performed by means of the two DC motors using voltage from the rechargeable battery and through the orders received from the microcontroller for the accurate movements it performs. The rechargeable lithium-polymer battery (Figure 2) is mounted under the motherboard and insulated with a plastic-tape in order to eliminate all possibility for incidents. It is connected to ground through two connection wires.

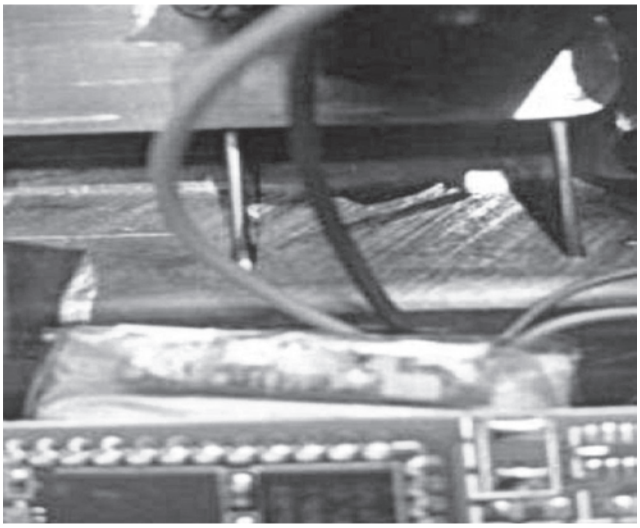

Figure 2. Battery connection within the mini-robot mechanical structure.

The motherboard (Figure 3) is also fixed on the structure of the mini-robot under study together with the auxiliary

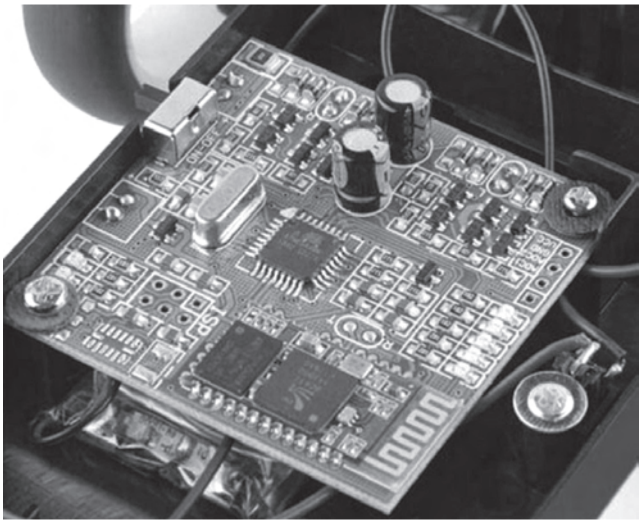

Figure 3. The motherboard attached to the mechanical structure of the mobile mini-robot.

components, and, in order to achieve conductivity between auxiliary components, pins of standardized dimensions are attached by soldering. The pins will go through the motherboard at equal distances, using, to this end, plastic spacers that provide them with stability and accuracy (Figure 4). On the back of the motherboard pin ends will be attached by soldering, operation performed using tin, which, once the soldering iron is heated, becomes liquid.

The assembly thus created is passed through a special substance with a consistency similar to wax, its use favouring the prolongation of the liquidity interval of the molten tin. In the absence of this substance, tin automatically solidifies when removed from the source that melted it. Tin becomes adhesive to the motherboard only if at the moment the liquid substance is poured at the junction of the board with the pins, and the surface of the board that the tin is applied on is heated.

On these pins sensors will be attached, used for the optimum operation of the mobile mini-robot under study, within required applications. A first sensor attached to the mechanical structure is the photo detector one, sensor that will perceive the level of lighting in the environment, but that will also take into account

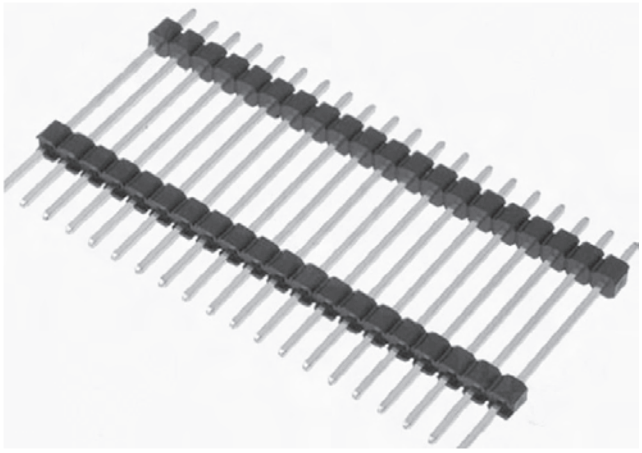

Figure 4. Pins used to facilitate the connections between the mobile mini-robot components.

the ambient light that could provide some drawbacks in its implementation. The OUT signal output pin will be coupled to an analogue pin of the motherboard noted by ADC1&2, the connection being achieved according to this notation. The third pin, a GND one, can be found on the board with the same acronym. Increased attention was paid to the operation of connecting the sensor on the board (Figure 5) as if the supply

Figure 5. Connection of the photo detector sensor in the mechanical structure of the mini-robot.

pin in the device is reversed with the ground one, it can instantly burn out, its reuse being then impossible. The second sensor attached to the mechatronics device is the distance one (average distance sensor, with a range from 10 to 80 cm), with the role of measuring the distance between the mini-robot and various surrounding objects. Similarly to the other sensor, this one also uses all three pins, and upon installation it was kept in mind that the board does not allow the implementation of both sensors in the same range as it can only benefit from one supply pin and one ground pin at a time.

There is still the possibility to connect both sensors if we perform a trick by means of connecting to the base a conducting wire to the two pins which then will be attached to the pins in a sensor slot. The third ADC pin does not create inconveniences, because on the board two such pins are connected, increased importance being given to the operation of bonding wires to the pins' basis which must not touch the second sensor connected. We underline that the distance sensor singularly used will not cause inconveniences as for large distances (e.g.: 70 ÷ 80 cm), it has a conical range with a radius large enough to detect objects of sizes similar to that of the designed mini-robot.

3. Simulation of the mechatronics device within special educational applications

The development of this experimental prototype of wheeled mini-robot can constitute an element with applicability in the field of military operations, but also in the educational field, constituting itself as an additional element of a security structure, in view of the constructive relaying and jamming of a foreign communications system threatening national security structures. In order to prove its usefulness as far as the security feature is concerned, the educational mini-robot has an embedded microphone and is controlled from an android system. Used, at the moment, for educational and scientific research purposes, the embedded microphone is built-in on a headset, this being connected directly to the computer and attached to the mini-robot. The signal received from the microphone will be sent to a file through the Matlab software by means of the data acquisition block. As a result, the volume spectrum will be automatically played simultaneously with the recording thereof.

In order to achieve the interface between the microphone and the computer using MATLAB, a GUI application with multiple windows will be used. In this context, cadets or master students will develop by means of the Graphical User Interface application, an interface that enables the user to easily handle and control interactive correlations between the windows, navigated with the help of buttons. The first window introduces us to the system and the code, written on seven lines, is easy to manipulate and understand as it uses conditional functions applicable to any programming language:

```
choices = menu('Initiate Wheeled Mini-robot, 'Initiate Program','Description');
if choices==1
  initiate2
else
  description
end.
```

Hence, this window provides us with two options: once the program starts we can either be introduced into the program or be directed towards a short description of the system. By choosing button number two, we will go through the content of the next window, the one describing the application. This window uses five code lines; the first describing what will be displayed, followed by what will be written on the back window button:

```
choices = menu('element additional to a security system, perspective must be developed,'Back);
if choices==1
Spectrum
end.
```

Through the only available option in this window, the name of the editor to be gone through is provided, in our case the *Spectrum*. Returning to the initial window and given that the second option in this window has been gone through, we will select the button suggestively called – *initiate program*. At the moment of the selection, in the Command Window of the program, an imperative will appear that initiates the session of signal capturing by displaying the command Start Speaking. Concurrently, the new window appears and the content of the editing file corresponding to this window is run. When the time allotted to the recording ends, in the same Command Window, the End of Recording imperative appears, this informing the user that the program no longer runs and that it will display a spectrum analysis of the captured signal's volume and time. For that, on the editing file's window twelve code lines will appear:

```
% Record your voice for n seconds.
recObj = audiorecorder( 40000, 16, 2); % frequency, nBits, nChannels;
disp('Start speaking.')
recordblocking(recObj, 30);  % number of seconds;
disp('End of Recording.');
% Play back the recording.
play(recObj);
% Store data in double-precision array.
myRecording = getaudiodata(recObj);
% Plot the waveform. (volume vs time)
plot(myRecording);
initiate2.
```

Hence, the first code line specifies the way the programming sequence is channelled, the following line defines a function for recording with three parameters (frequency, number of bits and number of channels), the third line is the one using a display function (the display in the Command Window of the first imperative), while the fourth line specifies the recording interval using the recordblocking function with its two parameters, followed by the display of the second imperative function. Then a comment is used to highlight the decision on the utility of the following playing function of the respective signal that will be saved in the file destined for the option of playing it. The last comment describes what the next function will do, and draws the graph of the signal in relation with its time and volume

(Figure 6). The final code line automatically transfers the user to the next window which enables us to either play what has been previously recorded or to record something new.

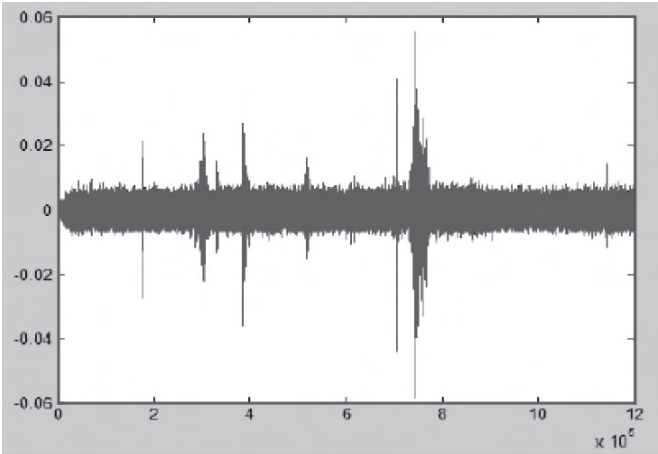

Figure 6. The spectrum analysis performed with the help of the Matlab software.

For the first option that appears in the window, automatic transfer will be performed to the previous window which records the signal, plays it and then returns to the window in question. For the second option, the code associated to the editing file will be run for the playing of the latest recording:

```
% Play back the recording.
play(recObj);
initiate2.
```

This code sequence has three lines, the first representing a comment stating what the program is running, the following line being a function with a parameter that runs the actual recording, while the last one automatically sends the user back to the previous window.

4. Conclusions

In the unmanned ground vehicles (UGVs) category, the autonomous wheeled mini-robot experimental prototype, designed and developed within the "Nicolae Bălcescu" Land Forces Academy, enabled the modelling and simulation of a means with a strong scientific and military applicative substantiation, constituting a pilot project that can be developed so that it be used in various offensive and defensive operations.

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