

# Designing a Robotic Software Application for Drilling Operations

Paul Ciprian Patric, Florin Ion Popa and Gabriela Mantescu

**Abstract**—In general, robotics research no longer deals with "low-level" issues such as motors, electrical problems, hardware construction. In the past, not only the robot's "brain" had to develop, but all its other parts of it. As such, fundamental research in robotics takes place in the area of theory and algorithms. Researchers in robotics are at the intersection of the following areas: artificial intelligence, statistics, algorithms, geometry, differential geometry, algebra, system theory. Some projects "escape" in exotic branches such as neurobiology, psychology, medicine, physics and mechanics, etc., depending on the applications of the robots. Electro-mechanical research is generally limited to the discovery of new technologies. For example robots using the magnetic field, micro-electro-mechanical devices or extreme means of locomotion Building a robot requires knowledge from very different domains. To accomplish even a very simple mission, complicated systems are needed, covering many disciplines. In the present paper one addressed aspects related to the design, construction and operation of a mechanical and operating structure of a robotic system for drilling a semi-finished product using for didactic purposes, controlled by an application made in LabVIEW, helping by NI USB 6008 Acquisition Board, supplied and connected to PC via USB port. The practical project is a part of the simple version driving through DC motors and worm gear reducers.

**Keywords**—Acquisition Board, Drilling, LabVIEW Programming, Robotic Arm, Virtual Instrument.

## I. INTRODUCTION

Generally, robots constitute a class of technical systems that imitate or substitute human or intellectual human functions. This is done by associating different types of manipulation or locomotor systems, determining the anthropomorphic character of the robot, with different types of computing or logic equipment that determine its intellectual functions. Robots perform their activity in a concrete environment, whose characteristics may remain constant or variable over time [5].

The first robotics research began in the early 1960s. After a substantial industrial robotics application, especially in the automotive industry, many applications in the non-industrial fields (non-manufacturing) have emerged in the early 1990s.

The attention of both robotics researchers and robot makers

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has focused on these applications, especially as robotics have been predicted to play a major role in restructuring the third millennium civilization [6].

The issues presented support the intention to start robotics activities, some of which can even become successful activities that can pose real challenges for robotics specialists or related fields.

In general, robotics research no longer deals with "low-level" issues such as motors, electrical problems, hardware construction. In the past, not only the robot's "brain" had to develop, but all its other "organs".

As such, fundamental research in robotics takes place in the area of theory and algorithms. Researchers in robotics are at the intersection of the following areas: artificial intelligence, statistics, algorithms, geometry, differential geometry, algebra, system theory [10].

Some projects "escape" in exotic branches such as neurobiology, psychology, medicine, physics and mechanics, etc., depending on the applications of the robots.

Electro-mechanical research is generally limited to the discovery of new technologies. Example [4]:

- Robots using the magnetic field;
- Micro-electro-mechanical devices (robots of several microns);
- Extreme means of locomotion (spider-robots, alien robots for low gravity).

Building a robot requires knowledge from very different domains. To accomplish even a very simple mission, complicated systems are needed, covering many disciplines.

One of the most important aspects in the evolution of the human being is the use of tools to simplify his physical work. Man imagined intelligent mechanized devices to take on a significant part of his physical effort. So he built automated toys and intelligent mechanisms, or imagined robots in drawings, books, SF films, and so on [2].

Since 1980 we have witnessed the expansion of industrial robots in various industries. Robots offer substantial benefits to workers, industries and, implicitly, to countries. In the case of peaceful use, industrial robots can positively influence the quality of people's lives by replacing them in hazardous areas, with environmentally harmful conditions, with unfamiliar conditions of exploitation, etc.

The scope of robotic technique is always widened, and can be used in industry, transport and agriculture, service, ocean and outer space, scientific research, etc.

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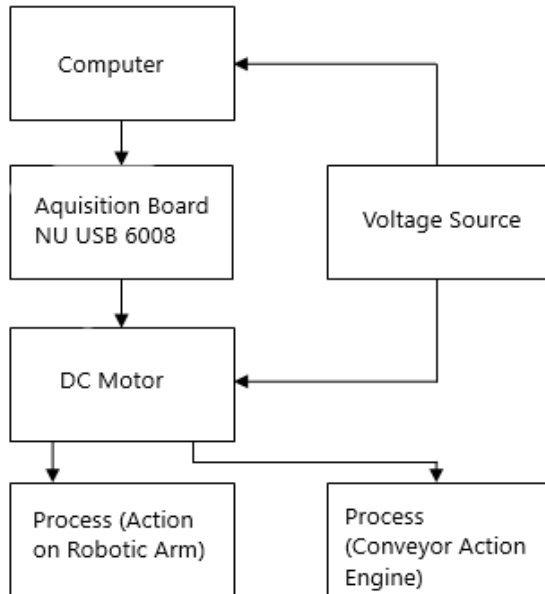


Fig. 1 Block diagram of the prototype

Thus, the present paper presents a robotic application, through which the industrial robot using a drill tool, try to manufactures a half-finished piece for its subsequent use in a technological process, as one see in Fig.1.

The practical project is part of the electric actuator variant with electric drives and mechanically spliced worm gear reducers of the transmission of the movement.

This type of reducing gear comprise a worm and wheel gear having the rotation axes crossed in space at an angle of  $90^\circ$ . These reducing are silent gears due to the relative sliding between the sides of the worm gear teeth and the worm gear.

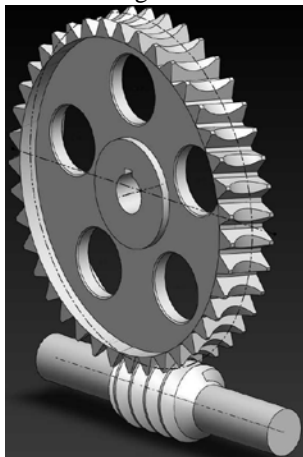


Fig. 2 Worm-gear driveshaft type

When using this type of gearbox, the following features will be taken into account:

- Simple worm gearboxes have a low efficiency;
- In order to increase the transmission ratio, reducers consist of a cylindrical gearing at the entrance and a worm gear, a construction that has a better efficiency than the simple worm gear reducer;
- Self-inflating transmissions (the leading element is the snail, itself, like in Fig. 2 and Fig. 3) [8].

The hardware platform of our project consists of the following modules:

- NI USB 6008 Acquisition Board;
- DC motor with built-in worm gear reducer for the robotic arm;
- DC motor with built-in worm gear reducer for driving a conveyor (conveyor belt) presented in Fig. 4;
- DC motor for driving the drill;
- Bridge H for bidirectional robotic arm control;
- Electronic motor for unidirectional control of the motor used to drive the drill and the motor acting on the conveyor belt;
- Power supply to power the entire system.

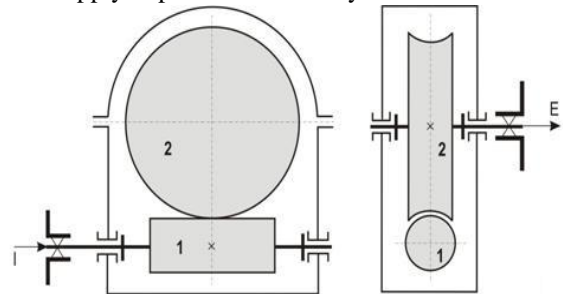


Fig. 3 The kinematic scheme of a worm gear-reducer



Fig. 4 DC motor Kit with worm gear reducer built-in

## II. BLOCK DIAGRAMS OF A ROBOT'S ELECTRICAL PART

The central element in the informational scheme is called a computer because it has all the features of an IBM PC-compatible computer. In reality, there are some differences to a classical computer structure:

- the robot's driving system can have more computers;
- the computer block also contains interface circuits, specific to robotics applications;

- an artificial vision system, which is another external camera equipped with a camera, able to collect environmental information, analyze, understand and transfer it to the central computer.

The central computer controls one or more microprocessors or microcontrollers, which will command the action system.

The drive system consists of local driving systems (LDS) made at the level of each kinematic drive coupler around an actuator motor. The LDS's are performed with an automatic regulation system structure - ARSS).

Local driving systems ensure the direct drive of the robot's axes without intermediate.

In the block diagram, presenting in Fig. 5, a local driving system with automatic control system structure is represented by the following groups:

- controls the action elements;
- action elements;
- interface;
- transducer;
- the drive element that is comprised of the engine, transmission and brakes.

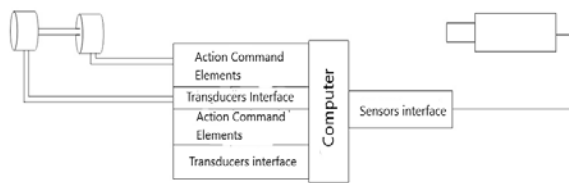


Fig. 5 The informational block diagram of the robot system

All these elements work in a closed loop and form in an automatic regulation system structure. The robot's driving system is physically implemented with electrical and electronic equipment that, for the most part, are enclosed in an electrical and electronic equipment cabinet. But not all electrical equipment is in this cabinet [9]:

- drive motors and transducers are located on the mechanical system;
- the sensors are located in the robot environment;
- the learning panel is outside the closet;
- the operator panel is on the cabinet door.

Specific for a robot's driving equipment is the learning panel, which is referred to in the literature as a training panel or training module.

#### A. Implementing the DC Motor

An electric motor is a device that converts electricity from a battery or from a voltage source into mechanical energy (rotation or linear displacement). It works on the basis of the electromagnetic forces acting on a conductive wire driven by an electric current in the magnetic field.

The elements of a DC motor are: stator, rotor, brushes and switch (collector), as one see in Fig. 6.

The stator generates the magnetic field surrounding the rotor. This field can be generated in two ways: with permanent magnets or electromagnets.

The rotor is made of one or more windings. When these windings are powered (energized), they produce magnetic fields. Magnetic poles of the rotor will be attracted by the opposed poles generated by the stator, producing rotor rotation.

As long as the motor rotates, the windings are continually energized in different sequences, so that the magnetic poles generated by the rotor will not overcome the poles generated in the stator. This field interruption (change) in the rotor windings is called switching. The winding of such an engine is mechanically controlled. A copper (semi-ring) segment called a switch (collector) makes a common body with the motor shaft. During the rotation, the graphite brushes slide over the switch, coming in contact with the different segments of the graphite. The switch segments are attached to the different windings of the rotor, so a dynamic magnetic field is generated inside the motor when the tension is applied to the brush ends [3].

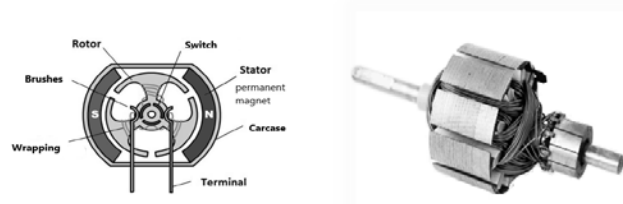


Fig. 6 The structure of a DC motor with brushes

#### B. Bidirectional control of an engine using an H bridge

To command in a two-way engine, one will use a H bridge as the driver, like in Fig. 7 and Fig. 8, from below. This is the only way to drive the engine in both directions.

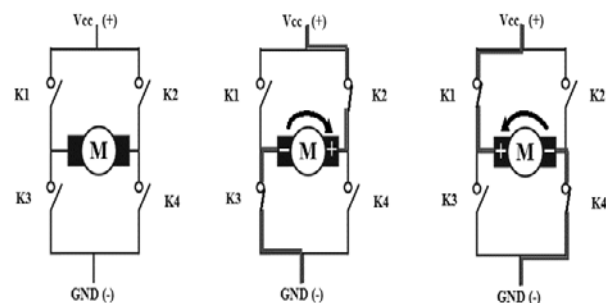


Fig. 7 H Bridge Assembly

Deck H is the name derived from the normal circuit drawing mode and is basically a four-circuit circuit-breaker, which acts twice per diagonal to change the direction of rotation of the

motor.

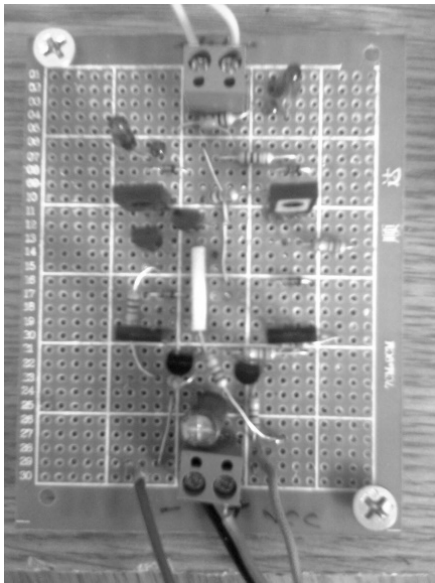


Fig. 8 H Bridge using for drilling Robot

Thus, the transistors used are PNP type and at each direction of rotation there are two of them, in conduction. The diodes have a protective or blocking role for the other two transistors. The assembly is powered at 12V and the NPN type transistor command is by 5V and comes from the acquisition board, as one presented in Fig. 9.

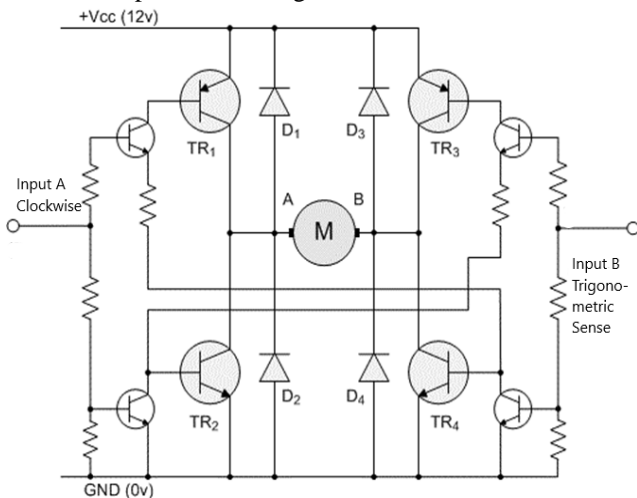


Fig. 9 Electrical diagram for a H Bridge

The unidirectional motor command that drives the drill and the motor that drives the conveyor belt is made by means of an electronic assembly in which one have used two Darlington type transistors [9].

### III. LABVIEW PROGRAMMING APPLICATION

Over the past 50 years, measuring instruments have evolved both in flexibility and in the possibility of being integrated into computers or larger complex systems. In the first generation there were predominant analog measuring instruments, manually controlled by the use of buttons on the front panel.

Measurements made with these tools are recorded manually, and the user has the ability to add new functions or modify the presentation of the results.

In principle, an VI - Virtual Instrument is a computer software that simulates the functions of a real instrument, providing comparable performance to it [7], as in Fig. 10.

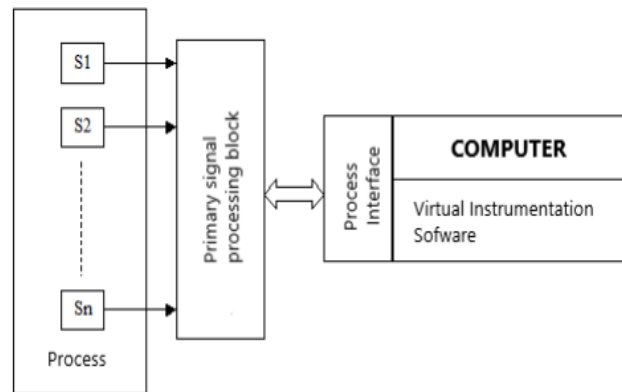


Fig. 10 The structure of a virtual instrument

Unlike real tools, virtual ones, mainly computer-based, have a high degree of flexibility, with any additional function being very easy to implement at minimal cost, with simple program changes. The basic functions that can be developed in the structure of an VI are:

- Automatic acquisition of signals obtained from sensors for measurement of electrical and non-electrical quantities in a process, according to the structure and configuration established by the beneficiary;
- Local, partial or total processing of information at the point of measurement, with dedicated microsystems;
- Transmitting processed or unmanaged raw data to a dispatcher, through a local computer network, the Internet or a wireless link (radio or mobile telephony);
- Display and display of computer monitor data on user-accessible graphical user interfaces in graphical or numerical formats;
- Automatic process control whose parameters are measured by numerical algorithms implemented on the computer (for slow processes) or digital signal processors (for fast processes);
- Organization of data, local or dispatcher, in databases or calculation tables, with their specific processing (tracking efficiency, quality, productivity etc.).

#### A. Advantages of virtual instrumentation:

- Expandability: the possibility of acquiring a large number of measurement signals by using multiplexers on analog inputs;
- Accuracy: Numerical processing of signals gives high accuracy because it is not affected by component tolerances, temperature, aging, noise etc. The only limitations of this kind are given by the analog part contained in the sensors and the primary processing block. Thus, the precision is superior to analogue apparatus and comparable to that of real numerical

instruments;

- Flexibility: adding new features, with minimal costs, through simple program changes;
- Storing information measured in large quantities on the computer memory media, organizing it in databases and statistical processing;
- Occupies a smaller workspace.

#### B. Disadvantages of virtual instrumentation:

- Limiting the frequency band of the measured signals due to limitations imposed by the measuring chain;
- Extremely high costs.

Replacing real-world measurement tools from industrial processes to virtual ones can not be done entirely at the moment, however, because the latter still have some shortcomings that will certainly be overcome in the future by advancing technology.

Labview (Laboratory Virtual Instrumentation Engineering Workbench) is a graphical programming language. It differs from other programming environments by a single difference, that is, the other languages are text-based, although Labview is a graphical programming language [1], [11].

#### IV. THE ACQUISITION BOARD NI USB 6008

After The acquisition board NI USB 6008 is used for data acquisition and control. It performs analogue-to-digital and digital-analog conversion of the information bearer, as one see in Fig. 11.

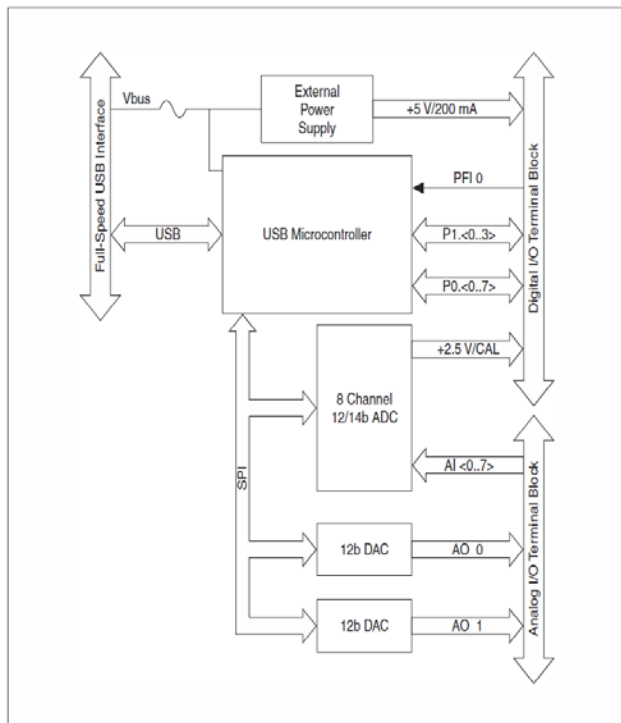


Fig. 11 Block diagram of acquisition Board NI USB 6008

The acquisition card has 32 ports of which:

- 8 analog inputs (AI - Analog Input);

- 2 analog outputs (AO - Analog Output);
- 12 digital inputs / outputs.
- 10 GND ports (Ground)

Main features of the acquisition board presented in Fig. 12:

- An analogue input can measure a signal in the form of an electrical voltage from the monitored system;
- An analogue output can generate a signal in the form of an electrical voltage that controls an actuator in the monitored system;
- Digital communications. Receiving and issuing values in binary form, representing data or codes of some commands. Digital communications can be used for measuring or generating signals if the actuator has a function described by a binary logic state (two-position switches, switches, relays etc.);
- Counting and timing; receiving pulse signals in which the information is contained in the number of pulses in the series or in their frequency [7].



Fig. 12 The acquisition Board NI USB 6008

#### V. SOFTWARE PRESENTATION OF THE ROBOT APPLICATION

The Robot application was made in LabVIEW and, below, one present the main point of interest.

The layout control panel is simple, consists of 4 buttons that control the layout and a STOP button that once is pressed, the application will stop running, as one see in Fig. 13.

The buttons are accompanied by a symbol and a text label that names the operations they perform.

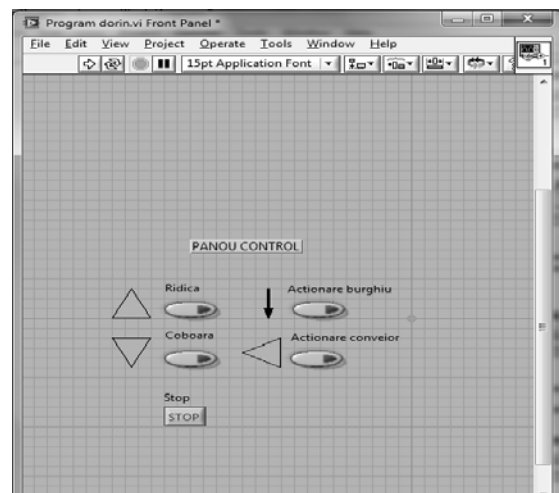


Fig. 13 Front panel of application

To drive up the boom one used the following program sequence, like in Fig. 14:

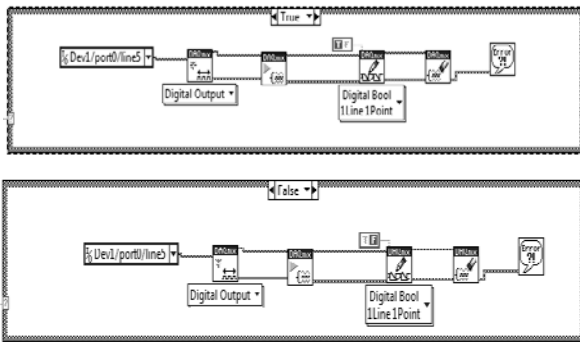


Fig. 14 Block diagram for upward operation of the robot arm

The upward button of the arm is associated with two states: TRUE and FALSE. When the button is pressed, the TRUE state is assigned and the arm will move in the specified direction. When the button is not pressed, the FALSE state is assigned and the arm will remain motionless.

To command the movement down for the arm, one used the same program structure, like above.

The button for action down of the robotic arm is associated with two states: TRUE and FALSE. When the button is pressed, the TRUE state is assigned and the arm will move in the specified direction. When the button is not pressed, the FALSE state is assigned and the arm will remain motionless.

To drive the conveyor one used the following program structure, as one see in Fig. 15:

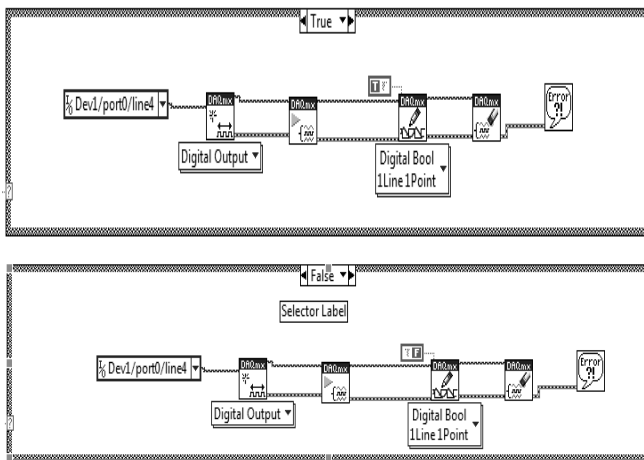


Fig. 15 Block diagram for conveyor belt drive

The conveyor belt operation button is associated with two states: TRUE and FALSE. When the button is pressed, the TRUE state is assigned and the conveyor belt will move in the specified direction. When the button is not pressed, FALSE is assigned and the conveyor belt will not move.

Note: due to electronic mounting, the conveyor belt will move in one direction.

To use the drilling operation one used the same procedure

for the program structure, such one applied above.

The drill action button is associated with two states: TRUE and FALSE. When the button is pressed, the TRUE state is assigned and the drill bit will be activated. When the button is not pressed, the FALSE state is assigned and the drill bit will not be activated.

Note: once activated, the drill will only be switched off by pressing the button by which it was activated.

The prototype of the drilling robot is presented below, in Fig. 16.

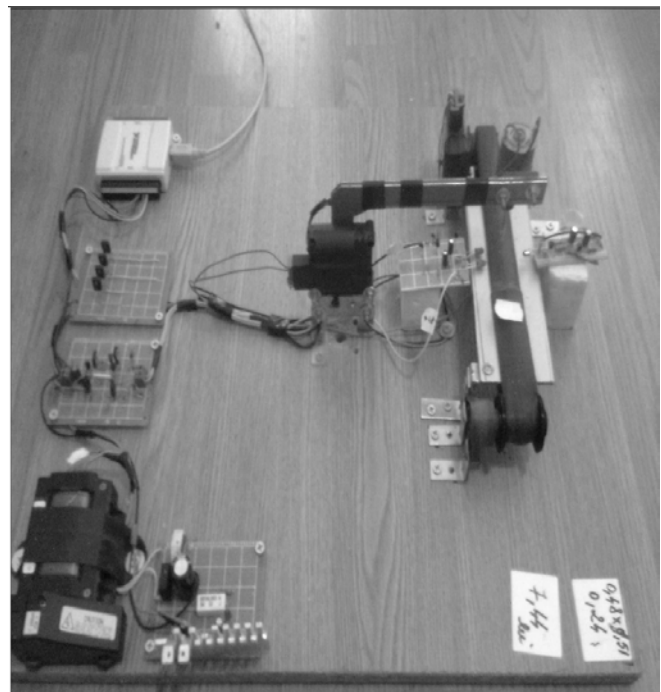


Fig. 16 Final prototype model

## VI. CONCLUSION

The project is a simple control application through the LabVIEW software and the NI USB 6008 Acquisition Board.

LabVIEW is a graphical programming language. It differs from other programming environments by a single difference, namely, the other languages are text-based, while LabVIEW is a graphical programming language.

Initially, it was desired to create a two-degree robotic arm, with two rotating movements. Due to the constructive difficulties one has encountered, one gave up, for the moment to a degree of freedom, making the application having in view just one degree of freedom.

To improve the project in the near future, one will add, certainly, a degree of freedom to the existing assembly and one will try to implement a remote control module via wireless technology.

For a future work, one thinks that a robotic approach will be better from industrial point of view. That means that industrial environment can be interested implementing this kind of project.

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