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DEVELOPMENT OF A DIDACTIC ROBOTIC CELL FOR HANDLING BY THE ARDUINO APPLICATION

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***Abstract.** Industrial robots, during decades, have supported the companies in terms of productivity and quality assurance. Considering the high investment values involved in a robot purchase process, the universities, in majority, do not have this technology available in their field. This research project has as the subject the implementation of a robotic cell for handling, using the Arduino board as a processor, since it is cheaper and easily available in the market. The robotic structure was developed by the students who used the language C++ for programming the robot. The specifications as accuracy and repeatability were checked. This work intends to give an orientation for didactic applications for robot as a way to improve the students technical skills*

Keywords: Robotic Cell , Arduino, Programming C++, Material Handling

Introduction

The Industrial Revolution was based on production with lower cost, higher speed and, consequently, higher production volume. In order for this new manufacturing model to succeed, it was necessary to introduce automation into production processes.

Automation provides the industry with lower production costs, environmental risks and greater safety for employees, providing them with better working conditions (Barbosa, 2010).

The high degree of hazard, the precision of the activities and the production in scale, made the participation of the automated devices that present a good cost / benefit and an auto degree of adaptability and reliability become essential in the industries.

Robotics is responsible for developing such devices seeking the integration of techniques and algorithms for the creation of increasingly evolved robots (Souza, Delgado and Cruz, 2012).

The present project aims at the construction of a robotic arm manipulated through arduino. The system consists of a robotic arm articulated with three degrees of freedom, rotary joints, direct drive by dc motors with reduction, a claw with two fingers and a C ++ program, where the user will control the arm. Through a communication system, the program keeps in your memory the detail of the path that the arm will follow. When the program is running, the computer sends signals activating motors that move the arm and the actuator at the end of it.

1. TEXT FORMAT

1.1 Industrial Robots

Initially the robots were created to perform tasks difficult, dangerous and impossible to the human being, being the industries that more benefited. This development has led to increased production and elimination of hazardous tasks. In modern robotics, robots called humanoids, which have human similarities and the ability to interact with the environment, are increasingly developing (Campos, 2014).

1.2 Anatomy of industrial mechanical arms

Robots can be characterized by Cylindrical, Polar, Cartesian and Articulated Robots. The Polar Robots are formed by two rotational joints and a prismatic joint. Cylindrical Robots are formed by two perpendicular lines and a rotational base. Articulated Robots have rotational joints corresponding to the shoulder and elbow and the Cartesian Robots have their movements formed along the axis with three perpendicular lines representing the xyz axes. In Figure 1 it is possible to analyze the anatomy of each of these robots (Shheibia, 2001).

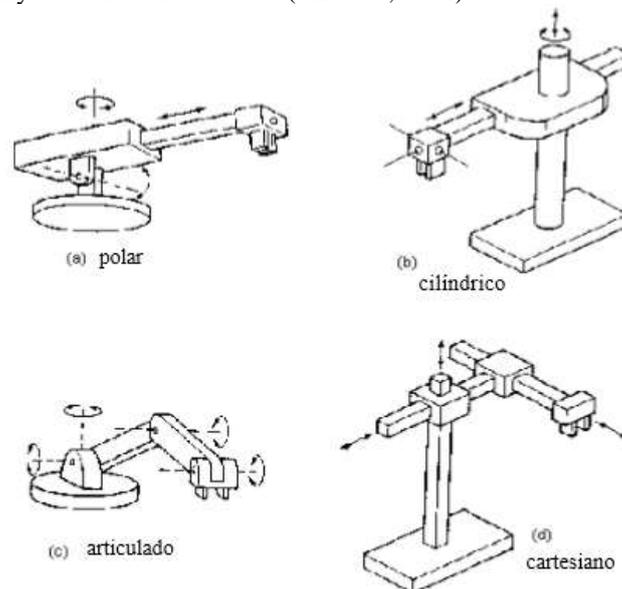


Figure 1 - The four basic anatomy of the Robot

Source:http://docs.computacao.ufcg.edu.br/posgraduacao/dissertacoes/2001/Dissertacao_TarigAliAbdurrahmanElShheibia.pdf

The model adopted for this project will be an articulated mechanical arm with three degrees of freedom, composed of elements called joints joined by joints of relative motion, where they are coupled to the actuators to realize these movements individually, endowed with sensorial capacity, and instructed by a system similar to the arm shown in Figure 2.

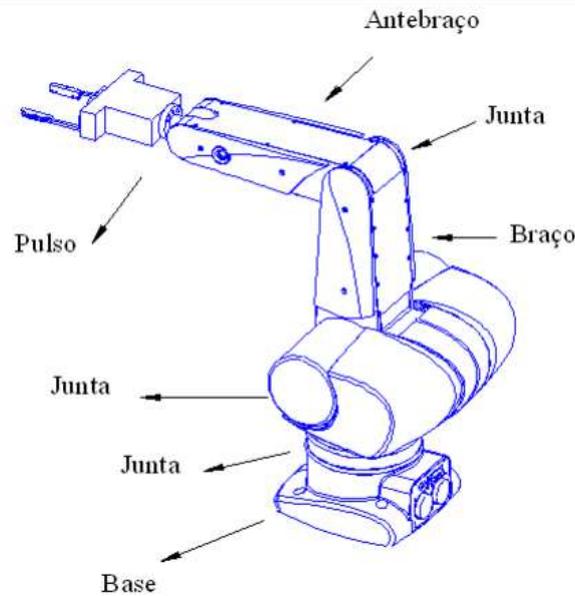


Figure 2 - Robotic Arm

Source: http://www.joinville.udesc.br/portal/professores/silas/materiais/Apostila_de_Robotica.pdf

This type of arm is widely used in the industry because it has characteristics similar to those of the human arm. The working volume of a mechanical arm is given by the space that it can position its pulse. In general, this volume is established according to the limits imposed by the structural design of the arm, the limits of joint movements, and the size of the body, arm and wrist components. In Figure 3 we can analyze the theoretical workload of an articulated mechanical arm.

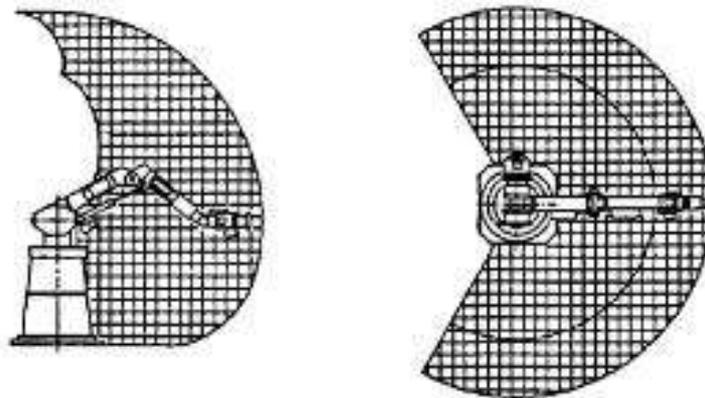


Figure 3 - Working volume of an articulated mechanical arm

Source: <http://www.ebah.com.br/content/ABAAAgx5QAB/robotica?part=2>

The mechanical arm is composed of the arm and wrist, where the arm consists of elements called links joined by joints of rotary movement, being coupled to the actuators to perform such movements individually, endowed with sensory capacity and instructed by a control system. The arm is attached to the base on one side and the handle on the other. The handle consists of a plurality of joints close to one another that allow the orientation of the end member at positions corresponding to the task to be performed, as shown in Figure 4 (Groover, 1998).

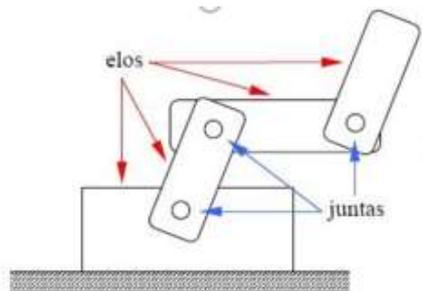


Figure 4 - Schematic notation of links and joints in an illustrative mechanical arm.

Source: http://www.joinville.udesc.br/portal/professores/silas/materiais/Apostila_de_Robotica.pdf

1.3 Mechanical Arm Composition

The mechanical arm will be actuated through a communication system, where the program stores in its memory the detail of the path that will follow and, when the program is running, the computer will send signals activating the actuators that move the mechanical arm.

The terminal organ is used to describe the hand or tool that is attached to the wrist. It is responsible for performing the manipulation of objects in different sizes, shapes and materials. The terminal organ model adopted for this project will be the two-finger claw, as shown in Figure 5 (Carrara, 2017).

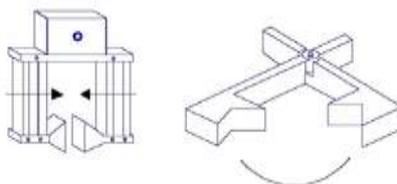


Figure 5 - Two-finger claw model

Source: http://www.joinville.udesc.br/portal/professores/silas/materiais/Apostila_de_Robotica.pdf

Servo motors consist of DC motors and a gear reducer, along with a position sensor and a feedback control system. In this project will be used 4 servo motors to perform the movement of the joints of the mechanical arm, as shown in Figure 6.



Figure 6 - Servo motors coupled to the mechanical arm

Source: http://www.joinville.udesc.br/portal/professores/silas/materiais/Apostila_de_Robotica.pdf

The arduino is used for the prototyping of electronic circuits, being composed by a board with microcontroller Atmel AVR and a programming environment based on Wiring and C ++. Both Arduino's hardware and programming environment are free, meaning anyone can modify and reproduce them. In this project will be used two arduino for programming the mechanical arm through the C ++ programming software. Its electric drive will be carried out by means of a 12 V power supply.

Conveyor belts are excellent equipment with essential functions for general industries. This product can transport, separate, assist in the loading or unloading process, production flow, identification and packaging of materials. Together with the conveyor belt, a stepper motor for rotating the conveyor roller will be used, a type plate (Drive A44 3697) for driving the motor and, in order to automatically stop the conveyor roller, it will be used a Balluf Optic sensor at the end of the conveyor belt.

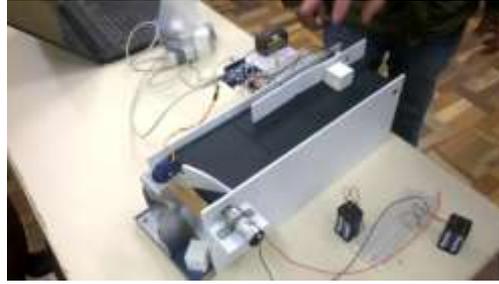


Figure 7 - Conveyor Belt

The robotic cell will be interconnected on a Protoboard. The robotic arm chosen for the project will have the following specifications:

- Material: black acrylic;
- Total height: ~ 18cm;
- Average arm width: 40mm;
- Maximum opening of the claw: 55mm;
- Thickness: ~ 3mm;
- Dimensions of arm (LxWxH): 14,5x9,5x29cm;
- 36 3mm screws (M3); The finished robotic arm can be seen in Figure 8.



Figure 8 - Finished robotic arm

1.4 Results

For the execution, programming and operation of the robotic cell, the following programming was used:

- Programming the servo motors and the mechanical arm

```
//CLR2015
#include <Servo.h>
Servo Sm; Servo Sd; Servo Se; Servo Sg;
void setup()
{ Sm.attach(11); Sd.attach(10); Se.attach(9); Sg.attach(6); }

void loop (){
{ int i; for(i=30;i<140;i++) { Sg.write(i); delay(30); } delay(3000); // Garra abre para iniciar ciclo
{ int i; for(i=90;i<110;i++){ Sm.write(i); delay(30); } delay(1000); // Mesagira em direção do
objeto
{ int i; for(i=90;i<50;i++) { Sd.write(i); delay(30); } delay(1000); // Braço posiciona na posição para
pegar objeto
{ int i; for(i=90;i<140;i++){ Se.write(i); delay(30); } delay(1000); // Braço avança para pegar objeto
{ int i; for(i=150;i>0;i--) { Sg.write(i); delay(30); } delay(500); // Garra fecha pegando objeto
{ int i; for(i=110;i>100;i--){ Se.write(i); delay(30); } delay(500); // Para evitar que objeto bata na
```

- Step motor programming:

```
void setup(){
pinMode(5,OUTPUT);
pinMode(3,OUTPUT);
digitalWrite (5,HIGH);
}

void loop ()
{
digitalWrite(5,HIGH);
delayMicroseconds(10);
digitalWrite(5,LOW);
delayMicroseconds(900);
}
```

- Programming of conveyor belt

```
{ int i; for(i=110;i>0;i ) { Sm.write(i); delay(30); } delay(1000); } // Mesa gira posicionando objeto para ser solto

{ int i; for(i=90;i<140;i++) { Se.write(i); delay(30); } delay(1000); } // Braço avança colocando objeto onde sera solto

{ int i; for(i=0;i<150;i++) { Sg.write(i); delay(30); } delay(1000); } // Garra abre soltando o objeto

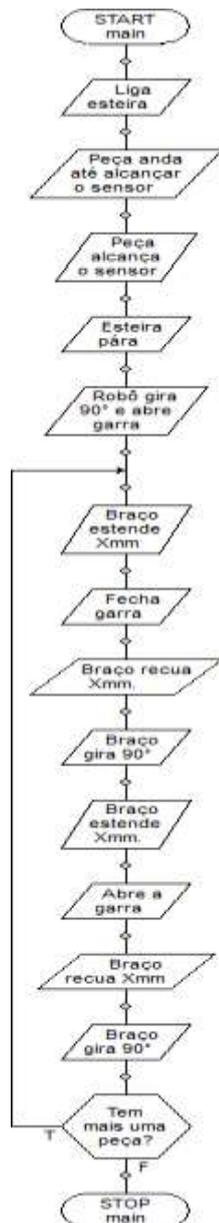
{ int i; for(i=140;i>90;i--) { Se.write(i); delay(30); } delay(1000); } // Braço recua para se dirigir a posição inicial

{ int i; for(i=30;i<90;i++) { Sm.write(i); delay(30); } delay(1000); } // Mesa gira ficando em posição inicial

while(1);

}
```

For the arm programming, the following flowchart was used:



1.5 Tests

After the operation of the project, it was necessary to perform several tests so that the mechanical arm and the conveyor belt worked in harmony. In Table 1 we can analyze the tests of the angles of movement of the mechanical arm in relation to its execution time.

TABELA DE TESTES CLR2015									
TESTES	° GARRA	° BRAÇO (esquerdo)	° BRAÇO (direito)	° GIRO	° GIRO (volta)	TEMPO C. OBJETO (s)	TEMP. S. OBJETO (s)	TEMP. ESTEIRA(s)	Situação
TESTE 1	30	70	45	90	45	5	5	2	
TESTE 2	40	50	56	90	30	7	7	4	
TESTE 3	50	70	50	90	50	6	6	3	
TESTE 4	45	65	70	90	70	8	9	3	
TESTE 5	90	45	80	90	40	9	12	4	
TESTE 6	90	(ida)140/50(volta)	(ida)30/120(volta)	160	90	3	5	3	
TESTE 7	70	180	100	90	80	7	5	4	
TESTE 8	80	120	110	90	90	6	3	4	
TESTE 9	150	(ida)150/70(volta)	(ida)50/120(volta)	170	90	10	16	4	

Table 1 - Angle tests and execution time of the mechanical arm

LEGENDA	
	Erro
	Próximo ao desejado
	Desejado

2. CONCLUSION

The developed robotic manipulator arm satisfies the initial objectives of the project: it has a compatible structure of fast movement, that allows to demonstrate the operation of an industrial robot manipulator; is easy to construct, allowing its reproduction in series; has open architecture: documented hardware and software to be used in manipulator arms research; has software available for various platforms, which allows its manipulation of different computing platforms; and is low cost.

Therefore, the robotic arm, we can say that its "structural" part will meet the desired proposal from the beginning of the work, along with the software (C++) and the control system.

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4. RESPONSIBILITY NOTICE

The authors Fernanda Rezende, Francisco Moreira, Ana Carolina Luiz, Wagner Lopes, Raphael Fornitano and Anderson Gonçalves are the only responsible for the printed material included in this paper.