PAPER NUMBER

RoboCup Humanoid League 2006

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Abstract. Here we describe the design and realization of Charrobot , a humanoid robot that plays soccer manufactured by students, able to make several tasks, as walking, identifies objects like a soccer ball and approaches to it and kicks it. Also there will be described not only its primary functions, but all the constraints presented along and characteristics of our design like sizes, components, specifications and design of the structure and electronic system. Because we are presenting two robots, we will specified the two different program codes, one for the player and the other for the goal keeper.
This is the first time we participate in this League and the design we are presenting is totally new.

1 Introduction

From the beginnings of robotic we have been trying to emulate the movements of human beings initiating with some insects movements because of their great functionality and adaptability in certain lands and conditions. The actual challenge of robotic is to equal the mobility of the human being to make movements of great complexity and precision.

With this project we pretend to develop an adaptable prothesis to the legs of a person, with the objective and possibility that an invalid person could walk again and recover great part of he's activities.
We do not have already the design of the prothesis, because this project just begins, in fact the RoboCup competitions will be an opportunity to prove our designs and prototype.

Because of the necessity of automatization, technology and control has been developing because lots of tasks or processes are performed via robots, replacing men and keeping always the simplest and most comfortable way to do things, many ideas can be achieved thanks to these machines.
As robots are flexible enough to develop many or specific challenges, it's design, manufacturing and testing are important points to take care of.

2 Image of the robot

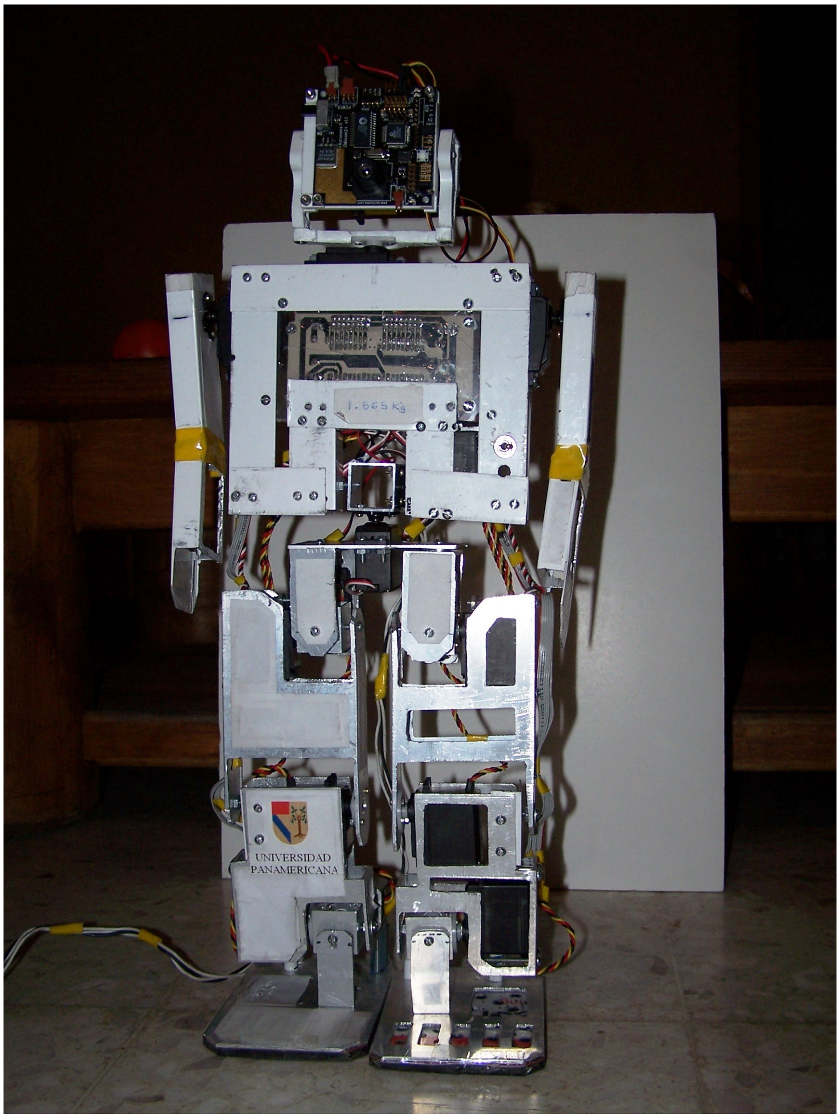

Fig.1. Image of the robot (Charrobot)

3 Name of the robot

Charrobot

4 Robot height

The height of the robot was determine by (1):

$$H = \min(H_{top} 2.2 \bullet H_{com}) \quad (1)$$

The total height (Htop) of our robot is of 52 cm, and the center of mass (Hcom) is at a distance of 27 cm from the floor. Applying this distances in equation (1), we obtain H.

$$H = \min(52cm, 2.2 \bullet 27cm)$$

Because H is 52 cm and contemplating that our robot is participating in the Kid Size Category it fulfills the next condition (2).

$$30cm \leq H \leq 60cm \quad (2)$$

$$30cm \leq 52cm \leq 60cm$$

5 Size of the robot

Fulfilling with the Humanoid Robots Specifications we will present de general sizes of the robot.

Each foot of the robot must fit in an area of (3):

$$A = \frac{H^2}{22} \quad (3)$$

$$A = \frac{52^2}{22} = 1352cm^2$$

The robot must fit in cylinder diameter of (4):

$$D = \frac{H}{2} \quad (4)$$

$$D = \frac{52}{2} = 26cm$$

The arms extensión maximally streched in horizontal direction is less than (5):

$$1.2 \bullet H \tag{5}$$

$$1.2 \bullet 52 = 62.4cm$$

The robot does not possess a configuration where it is extended longer than (6):

$$1.5H \tag{6}$$

$$1.5 \bullet 52 = 78cm$$

The length of the legs Hleg=23.5, including the feet, satisfies (7):

$$.04 \bullet H \leq H_{leg} \leq .6H \tag{7}$$

$$.04 \bullet 52cm \leq 23.5 \leq .6 \bullet 52cm$$

The height of the head Hhead= 7.5cm, including the neck, satisfies (8):

$$0.1 \bullet H_{head} \leq 0.2 \bullet H \tag{8}$$

$$0.1 \bullet 7.5cm \leq 0.2 \bullet 52cm$$

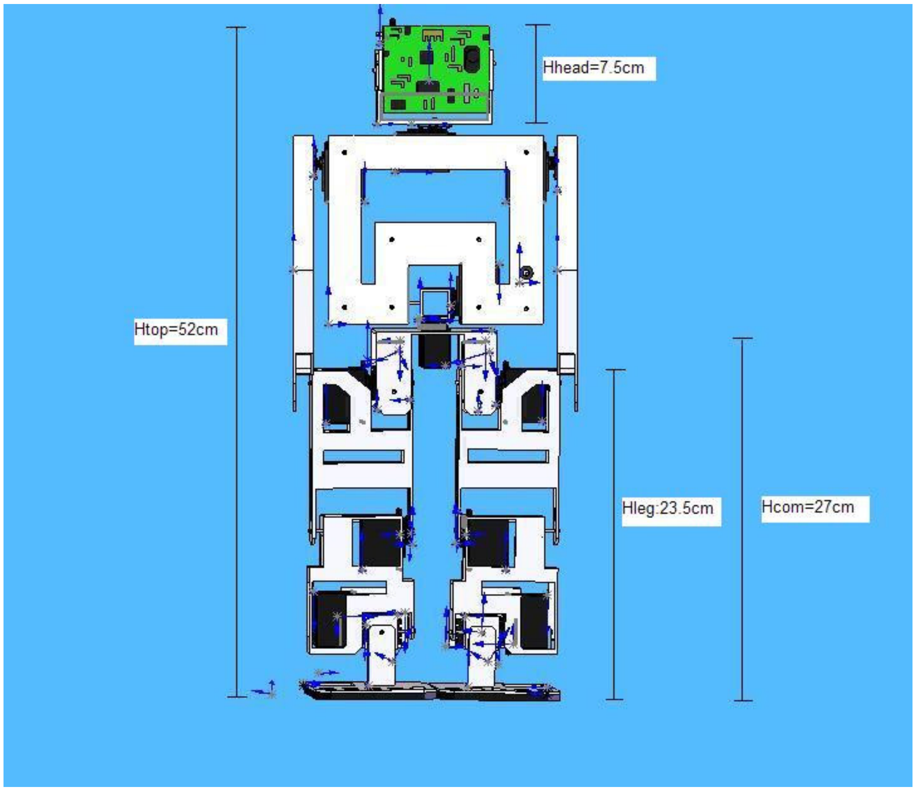

Fig.2. Heights of the robot (H_{head},H_{Top},H_{leg},H_{com})

6 Weight of the robot

The weight of the robot is of 2.1 kg and was design so that the torque of our motors could move all the joints in an efficient way. We decide to cut some of the unnecessary aluminum parts that will help us reduce weight without sacrificing resistance joints.
We also distributed the weight of the robot so that the center of mass will help us achieve the necessary height so that this will be in an specified range.

7 Number of degrees of freedom (DOF)

The total number of degrees of freedom in our robot is 16. In each one of the joints of the robot we decided to put a servo motor that each one will represent a (DOF).

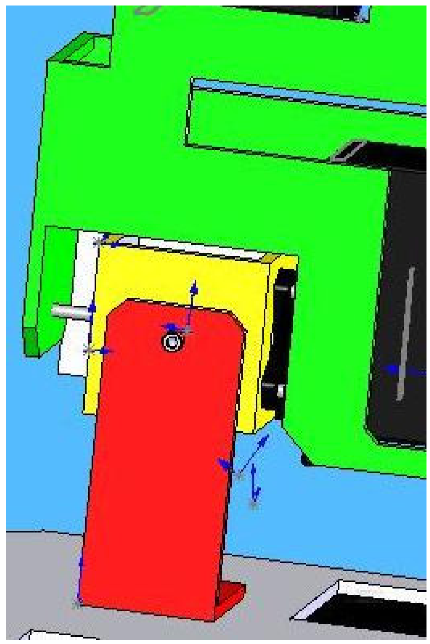

Fig.3. Ankle Joint

Developing each one of the parts of the robot we have:

Head: 2 servo motor, therefore we have 2 (DOF)
Arms (2): 1 servo motor in each arm, therefore we have 2 (DOF)
Waist: 2 servo motors, therefore we have 2 (DOF)
Ingle: 4 servo motor, therefore we have 4 (DOF)
Knee (2): 1 servo motor in each knee, therefore we have 2 (DOF)
Ankle (4): 2 servo motor in each ankle, therefore we have 4 (DOF)

7.1 Actuators

The total number of actuators in our design is of 16 servo motors. Our robot in conform of two different torque servo motor. The first one is a FUTABA S3003 with a torque of 3kg-cm and the second one is a HITEC HS-5645MG with a torque of 12 kg-cm, both with a speed of 60°/0.19 sec.
We decide to use the HITEC HS-5645 MG of 12 kg-cm of torque in the lowest part of the robot, because is where he needs more force to walk,

kick and stand up in case of falling. By the opposite we use the FUTABA S3003 with a torque of 3kg-cm in the upper part of the robot.
Head: 2 servo motor, FUTABA S3003
Arms (2): 1 servo motor in each arm, FUTABA S3003
Waist: 2 servo motors, FUTABA S3003
Ingle: 4 servo motor, the HITEC HS-5645 MG
Knee (2): 1 servo motor in each knee, the HITEC HS-5645 MG
Ankle (4): 2 servo motor in each ankle, the HITEC HS-5645 MG

Fig.4. Servomotors (Futaba & Hitec)

8 Communication

The robot was designed to act autonomously during the competition, so no external power supplies, teleoperation, of any kind of remote control are used on the system. The start and stop signals are sent them manually to the robot using the control panel; it was programmed to give the robot handler a few seconds to leave the field before it starts to move.

In this occasion, being our first participation and because of the short time in which we developed the project, we did not use a remote control system; without blocking that the robot fulfills with the established rules since it must be able to play even without a wireless network or a low signal of it. However , this will not interference with the robot's performance and fulfillments of the rules.

The communication between the robots, base in our design, was not necessary because each of the robots has specific duties and therefore the programming of each one was independent.

9 Processing boards

It only counts of a processor board that is the brain and was design and construct by members of the team. This contains the microcontroller, he's oscillating circuit, two voltage regulators and connection for the feeding and the control signal of the 16 servomotors. Next we present the distribution of the electronic components of the board.

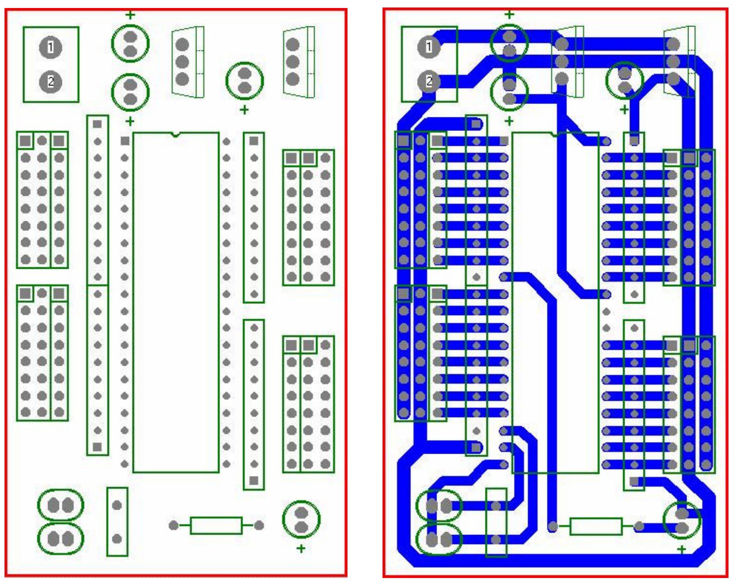

Fig.5. PCB layout

9.1 Battery

Analyzing the electronic system, we saw that the peak current of the robot its 2 amperes and the operational current its 0.8 amperes, therefore the robot is using four rechargeable AA batteries of 1.2 volts each one and they work at 1200mAh.

Fig.6. rechargeable AA batteries of 1.2 volts

10 Control

The control system of the robot is basically a microcontroller in which several sensors are connected that provide necessary information to assure the correct operation. The brain is microcontroller AT89S8252 of the 8051 family of ATMEL. We choose this element because of his low price, easy programming and because of the four ports of 8 bits of entrance and exits for handling data. The program code its shown in appendix because the program was made in assembler language.

Below is a diagram of the elements that conform it and we will explain its operation ahead.

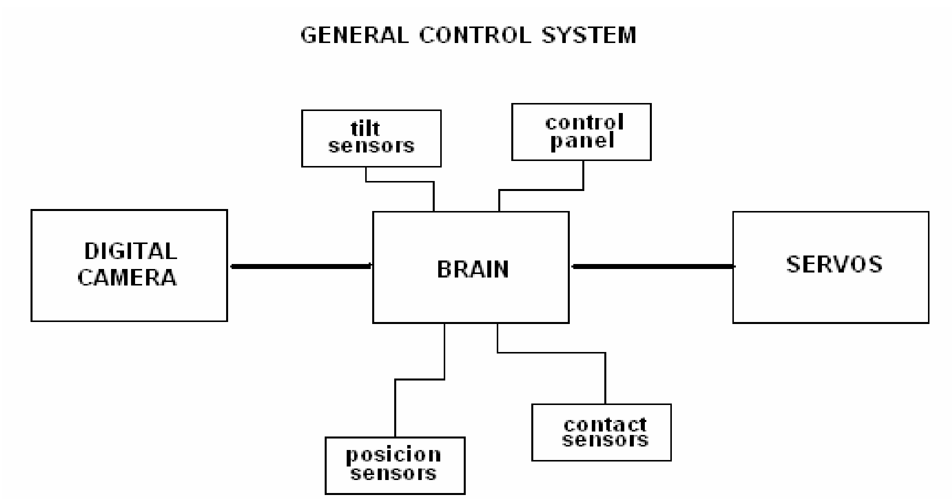

Fig.7. Block diagram of the general control system

10.1 Digital Camera

The main sensor placed on the robot's head is the camera CMUcam2 and it consists of a SX52 microcontroller interfaced with an OV7620 Omnivision CMOS camera on a chip that allows simple high level data to be extracted from the camera's streaming video. The board communicates via a RS-232 or a TTL serial port and has the following functionality:

• Track user defined color blobs at up to 50 Frames Per Second*
• Track motion using frame differencing at 26 Frames Per Second
• Find the centroid of any tracking data
• Gather mean color and variance data
• Gather a 28 bin histogram of each color channel

• Manipulate Horizontally Pixel Differenced Images
• Transfer a real-time binary bitmap of the tracked pixels in an image
• Arbitrary image windowing
• Adjust the camera’s image properties
• Dump a raw image (single or multiple channels)
• Up to 160 x 255 Resolution[1]
• Supports Multiple Baudrates: 115,200 57,600 38,400 19,200 9,600 4,800 2,400 1,200
• Control 5 servo outputs
• Slave parallel image processing mode off of a single camera bus
• Automatically use servos to do two axis color tracking
• B/W Analog video output (PAL or NTSC)

Fig.8. Digital camera (CMUcam2)

The primary uses of the CMUcam2 is to track or monitor the color and shape of the ball. Tracking colorful objects are used to localize landmarks, follow lines, or chase a moving beacon, in this case the ball or the opponents. This options are programmed by the manufacturer and we just adapt it to our system.

The CMUcam2 is vision system because it processes the camera image and interprets this information to generate PWM signals that control a pair of servomotors, one adjust the tilt and other the pam, this with the objective of chasing the shape and the color of the object programmed to follow.

The PWM signal that controls these movements of the head will be too introduce to the brain o microcontroller and will be interpreted like a type of coordinates that indicate us were is the ball and were should the robot walk.

[1] Frame rate depends on window size

10.2 Tilt sensors

We also used a pair of tilt sensors to detect when the robot fall to the ground or exceed the limit of tilde and this information is used by the microcontroller to decide the actions to take to get up or to keep the balance.

These are just switches who close when certain inclination is reached or when they are in an horizontal position.

10.3 Position and contact sensors

The position sensors are located in the ankle and knee joints of both legs of the robot and are variable resistances that when they are connected to a oscillator circuit, any variation in the doblez of the joint will be represented like a lineal variation of the period and the duty cycle of the exit signals of the oscillators, that will be too introduce to the micro.

The exit signals of the sensors indicate us sufficient precision the position of the legs of the robot with respect to a reference fija that is the stop position. This information its very important when the land where he is walking its irregular since it provides a new reference of the land and this will help maintain the necessary balance to walk in the land.

The contact sensors that are push buttons will be localized under the feet of the robot and when its connected to the brain, they will have like objective to indicate the moment in which the foot of the robot makes contact with any surface.

11 Conclusions

This project was a great experience for all of us in several aspects, and helped us to discover our different capabilities as well as our weaknesses, that we could handle and fix with the teamwork.

The teamwork was our better strength because we had a lot of problems along the project that we had to solve sometimes briefly, and the way we solved them, which we consider the best one, was the teamwork, since although we were divided in two parts; control system and mechanics; we helped each other in difficult situations and we never forgot that we are a team and we all took this project seriously and with the disposition needed, because this is a not easy project and it demands many time and sacrifice, as well as good will after all what happened even the situation of possible contest cancellation, what did not stop us from working.

This project help us to comprehend the different movements of human beings, because we had to analyze carefully how persons move to program our robot an try to imitate the exact movements.
It also help us to understand more about development of prothesis and the advantages that this offers to does people that need to recover their movements.

A very important thing is the fact that we received complete support from our University, part of the budget was supported by them and other resources like electronics and tool labs, computers, software. Another part of the budget was support by the members of the team.
It was a really good thing counting with their help all this time long, what we are very thankful of.

During this project we applied part of the knowledge acquired along the engineering studies, and in some occasions we had to investigate on subjects that didn't know about, and ask for support of some teachers who had the knowledge and the experience to advise us.

12 Appendix

12.1 Program code

```
ORG   00H

                  MOV   21H,#41H ;1       ;carga los
registros en la posición cero
                  MOV   23H,#18H ;2
                    MOV 25H,#30H ;3
                    MOV 27H,#4CH ;4
                    MOV 29H,#26H ;5
                    MOV 2BH,#82H;10H ;6
                    MOV 2DH,#31H ;7
                    MOV 2FH,#42H ;8
                  MOV   31H,#40H ;9
                  MOV   33H,#30H ;10
                  MOV   35H,#2CH ;11
                  MOV     37H,#12H;82H ;12
                  MOV   39H,#3DH ;13
                  MOV     3BH,#26H ;14
                  MOV   3DH,#6EH ;15
                  MOV   3FH,#2EH ;16
```

```
                    MOV   41H,21H            ;SERVO1
            ;CARGO LA POSICIÓN INICIAL PARA EVITAR QUE
SE VUELVAN LOCOS AL PRINCIPIO
                  MOV   43H,23H        ;SERVO2
                  MOV   45H,25H        ;SERVO3
                  MOV   47H,27H            ;SERVO4

                  MOV   49H,29H        ;SERVO5
                  MOV   4BH,2BH        ;SERVO6
                  MOV   4DH,2DH        ;SERVO7
                  MOV   4FH,2FH        ;SERVO8
                  MOV   51H,31H            ;SERVO9

                  MOV   53H,33H        ;SERVO10
                  MOV   55H,35H        ;SERVO11
                  MOV   57H,37H        ;SERVO12
                  MOV   59H,39H        ;SERVO13
                  MOV   5BH,3BH            ;SERVO14

                  MOV   5DH,3DH        ;SERVO15
                  MOV   5FH,3FH        ;SERVO16

                        MOV   75H,#06H    ;CARGO LA VEL
                  LCALL DESPLAZA

                  MOV   51H,#41H    ;QUÉDATE UN MOMENTO
                  MOV   75H,#0FFH
                  LCALL DESPLAZA
; EMPIEZA A CAMINAR-------------------------------------
----------------------------------------


                  MOV   41H,#37H ;1       ;SE INCLINA A
LA IZQUIERDA
                  MOV   43H,#0EH ;2
                    MOV 4FH,#38H ;8
                  MOV     5BH,#1CH ;14

                  MOV   45H,#33H;UN POCO AGACHADO

                  MOV   75H,#02H
                  LCALL DESPLAZA


                  MOV   41H,#2CH ;1 ;SE INCLINA A LA
IZQUIERDA
                  MOV   43H,#03H ;2             ;SOLO
"A" POSICIONES
```

```
          MOV 4FH,#2DH ;8
        MOV     5BH,#12H ;14

              MOV   49H,#2EH    ;MUEVE PIE
DERECHO PA DELANTE, 8 POSICIONES
              MOV   59H,#45H

        MOV   47H,#54H    ;MUEVE EL PIE IZQ
PARA ATRÁS 8 POSICIONES
        MOV   4DH,#39H

        MOV     4BH,#16H; DOBLA UN POCO
"4"POS, LAS RODILLAS
        MOV   57H,#7CH

        MOV   5DH,#66H    ;MUEVE LOS BRAZOS
              MOV   5FH,#26H
        MOV   75H,#02H       ;VELOCIDAD
        LCALL DESPLAZA

        MOV   41H,#41H ;1       ;PARADITO
        MOV   43H,#18H ;2
          MOV 4FH,#42H ;8
        MOV     5BH,#26H ;14

        MOV   45H,#30H;ERGIDO OTRA VEZ

              MOV   5DH,#5CH    ;MUEVE LOS
BRAZOS
              MOV   5FH,#1CH
              MOV     4BH,#14H; REGRESA
"2"POS, LAS RODILLAS
        MOV   57H,#7EH

        MOV   75H,#02H
        LCALL DESPLAZA

        MOV   51H,#41H    ;QUÉDATE UN MOMENTO
        MOV   75H,#0AFH
        LCALL DESPLAZA

;----------------------------------SEGUNDO PASO--------
-----------------------------------;

        MOV   41H,#4BH ;1       ;SE INCLINA A
LA DERECHA "A" POSICIONES
        MOV   43H,#22H ;2
          MOV 4FH,#4CH ;8
```

```
                  MOV     5BH,#30H ;14
                  MOV   45H,#34H ;UN POCO AGACHADO

                  MOV   75H,#02H ;CARGA VELOCIDAD
                  LCALL DESPLAZA

                  MOV   41H,#5AH ;1 ;SE INCLINA A LA
DERECHA
                  MOV   43H,#31H ;2     ;SOLO "A"
POSICIONES
                    MOV 4FH,#56H ;8
                  MOV     5BH,#3AH ;14

                    MOV 49H,#26H ;5     ;MUEVE PIE DER
PA TRAS, 8 POSICIONES
                  MOV   59H,#3DH ;13

                    MOV 47H,#4CH ;4 ;MUEVE PIE IZQ PA
DELANTE, 8 POSICIONES
                    MOV 4DH,#31H ;7

                  MOV   5DH,#6EH ;15    ;MUEVE LOS
BRAZOS
                  MOV   5FH,#2EH ;16
                  MOV   75H,#02H       ;VELOCIDAD
                  LCALL DESPLAZA

                  MOV   41H,#41H ;1       ;PARADITO
                  MOV   43H,#18H ;2
                    MOV 4FH,#42H ;8
                  MOV     5BH,#26H ;14

                  MOV   45H,#30H;ERGIDO OTRA VEZ

                        MOV   5DH,#76H    ;MUEVE LOS
BRAZOS
                        MOV   5FH,#38H

                  MOV   75H,#02H
                  LCALL DESPLAZA

                  MOV   51H,#41H    ;QUÉDATE UN MOMENTO
                  MOV   75H,#0AFH
                  LCALL DESPLAZA

                        MOV   41H,#41H ;1       ;carga
los registros en la posición cero
                  MOV   43H,#18H ;2
```

```
                MOV 45H,#30H ;3
                MOV 47H,#4CH ;4
                MOV 49H,#26H ;5
                MOV 4BH,#12H;10H ;6
                MOV 4DH,#31H ;7
                MOV 4FH,#42H ;8
              MOV   51H,#40H ;9
              MOV   53H,#30H ;10
              MOV   55H,#2CH ;11
              MOV     57H,#80H;82H ;12
              MOV   59H,#3DH ;13
              MOV     5BH,#26H ;14
              MOV   5DH,#6EH ;15
              MOV   5FH,#2EH ;16

                        MOV   75H,#01H
EMPEZARE:               LCALL DESPLAZA
                        LJMP  EMPEZARE  ;por ahora
vuelvo a empezar


;TODAS LAS DE ABAJO SON SUBRUTINAS DE NIVEL BÁSICO (PWM
Y CONTROL DE VELOCIDAD)

DESPLAZA:         MOV   77H,#00H         ;BORRA LAS
BANDERAS
                  MOV   78H,#0C0H ;por ahora un C0
porque solo manejamos 14 servos
CARGAPWM:         MOV   R1,75H                 ;CARGA
VELOCIDAD
OTROPWM:          LCALL PWM                    ;CORRE
PWM
                  DJNZ  R1,OTROPWM




DAMEOTRO1:        MOV   A,21H            ;EMPIEZA LAS
COMPARACIONES
                  CJNE  A,41H,QUELADO1         ;COMPARA
SERVO 1
                  ORL   77H,#01H

                  SJMP  DAMEOTRO2
QUELADO1:         CLR   C
                  MOV   A,21H
                  SUBB  A,41H
                  JC    MENOR1
```

```
                DEC   21H
                SJMP  DAMEOTRO2
MENOR1:               INC   21H

DAMEOTRO2:      MOV   A,23H             ;COMPARA SERVO
2
                CJNE  A,43H,QUELADO2
                ORL   77H,#02H

                SJMP  DAMEOTRO3
QUELADO2:       CLR   C
                MOV   A,23H
                SUBB  A,43H
                JC    MENOR2
                DEC   23H
                SJMP  DAMEOTRO3
MENOR2:               INC   23H

DAMEOTRO3:      MOV   A,25H             ;COMPARA SERVO
3
                CJNE  A,45H,QUELADO3
                ORL   77H,#04H

                SJMP  DAMEOTRO4
QUELADO3:       CLR   C
                MOV   A,25H
                SUBB  A,45H
                JC    MENOR3
                DEC   25H
                SJMP  DAMEOTRO4
MENOR3:               INC   25H


DAMEOTRO4:      MOV   A,27H             ;COMPARA SERVO
4
                CJNE  A,47H,QUELADO4
                ORL   77H,#08H

                SJMP  DAMEOTRO5
QUELADO4:       CLR   C
                MOV   A,27H
                SUBB  A,47H
                JC    MENOR4
                DEC   27H
                SJMP  DAMEOTRO5
MENOR4:               INC   27H
```

```
DAMEOTRO5:          MOV   A,29H               ;COMPARA SERVO
5
                    CJNE  A,49H,QUELADO5
                    ORL   77H,#10H

                    SJMP  DAMEOTRO6
QUELADO5:           CLR   C
                    MOV   A,29H
                    SUBB  A,49H
                    JC    MENOR5
                    DEC   29H
                    SJMP  DAMEOTRO6
MENOR5:                   INC   29H

DAMEOTRO6:          MOV   A,2BH               ;COMPARA SERVO
6
                    CJNE  A,4BH,QUELADO6
                    ORL   77H,#20H

                    SJMP  DAMEOTRO7
QUELADO6:           CLR   C
                    MOV   A,2BH
                    SUBB  A,4BH
                    JC    MENOR6
                    DEC   2BH
                    SJMP  DAMEOTRO7
MENOR6:                   INC   2BH


DAMEOTRO7:          MOV   A,2DH               ;COMPARA SERVO
7
                    CJNE  A,4DH,QUELADO7
                    ORL   77H,#40H

                    SJMP  DAMEOTRO8
QUELADO7:           CLR   C
                    MOV   A,2DH
                    SUBB  A,4DH
                    JC    MENOR7
                    DEC   2DH
                    SJMP  DAMEOTRO8
MENOR7:                   INC   2DH


DAMEOTRO8:          MOV   A,2FH               ;COMPARA SERVO
8
                    CJNE  A,4FH,QUELADO8
```

```
                  ORL   77H,#80H

                  SJMP  DAMEOTRO9
QUELADO8:         CLR   C
                  MOV   A,2FH
                  SUBB  A,4FH
                  JC    MENOR8
                  DEC   2FH
                  SJMP  DAMEOTRO9
MENOR8:                 INC   2FH

DAMEOTRO9:        MOV   A,31H            ;COMPARA SERVO
9
                  CJNE  A,51H,QUELADO9
                  ORL   78H,#01H

                  SJMP  DAMEOTRO10
QUELADO9:         CLR   C
                  MOV   A,31H
                  SUBB  A,51H
                  JC    MENOR9
                  DEC   31H
                  SJMP  DAMEOTRO10
MENOR9:                 INC   31H


DAMEOTRO10:       MOV   A,3DH            ;COMPARA SERVO
15
                  CJNE  A,5DH,QUELADO10
                  ORL   78H,#02H

                  SJMP  DAMEOTRO11
QUELADO10:        CLR   C
                  MOV   A,3DH
                  SUBB  A,5DH
                  JC    MENOR10
                  DEC   3DH
                  SJMP  DAMEOTRO11
MENOR10:          INC   3DH

DAMEOTRO11:       MOV   A,3FH            ;COMPARA SERVO
16
                  CJNE  A,5FH,QUELADO11
                  ORL   78H,#04H

                  SJMP  DAMEOTRO12
QUELADO11:        CLR   C
                  MOV   A,3FH
```

```
                    SUBB  A,5FH
                    JC    MENOR11
                    DEC   3FH
                    SJMP  DAMEOTRO12
MENOR11:            INC   3FH

DAMEOTRO12:         MOV   A,37H              ;COMPARA SERVO
12
                    CJNE  A,57H,QUELADO12
                    ORL   78H,#08H

                    SJMP  DAMEOTRO13
QUELADO12:          CLR   C
                    MOV   A,37H
                    SUBB  A,57H
                    JC    MENOR12
                    DEC   37H
                    SJMP  DAMEOTRO13
MENOR12:            INC   37H


DAMEOTRO13:         MOV   A,39H              ;COMPARA SERVO
13
                    CJNE  A,59H,QUELADO13
                    ORL   78H,#10H

                    SJMP  DAMEOTRO14
QUELADO13:          CLR   C
                    MOV   A,39H
                    SUBB  A,59H
                    JC    MENOR13
                    DEC   39H
                    SJMP  DAMEOTRO14
MENOR13:            INC   39H



DAMEOTRO14:         MOV   A,3BH              ;COMPARA SERVO
14
                    CJNE  A,5BH,QUELADO14
                    ORL   78H,#20H

                    SJMP  DAMEOTRO17
QUELADO14:          CLR   C
                    MOV   A,3BH
                    SUBB  A,5BH
                    JC    MENOR14
                    DEC   3BH
```

```
                  SJMP  DAMEOTRO17
MENOR14:          INC   3BH



DAMEOTRO17:       MOV   A,77H                   ;CHECA
LAS BANDERAS Y NO DEJA PASAR HASTA QUE TODAS ESTEN
HABILITADAS
                  CJNE  A,#0FFH,BRINCOTE
                  MOV   A,78H
                  CJNE  A,#0FFH,BRINCOTE
                  SJMP  AREGRESO
BRINCOTE:         LJMP  CARGAPWM
AREGRESO:         RET



PWM:              SETB  P1.0                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  1 Y 2
                  SETB  P1.1
                  LCALL RETA1MS
                  MOV   R0,#90H
OTRO1:                  MOV   A,20H
                  CJNE  A,21H,DDOS
                  CLR   P1.0
                  SJMP  DOSS
DDOS:             INC   20H
                  NOP
                  SETB  P1.0
DOSS:             MOV   A,22H
                  CJNE  A,23H,TTRES
                  CLR   P1.1
                  SJMP  FIN1
TTRES:                  INC   22H
                  NOP
                  SETB  P1.1
FIN1:             DJNZ  R0,OTRO1
                        MOV   20H,#00H
                        MOV   22H,#00H



RUTINA2:          SETB  P1.2                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  3 Y 4
                  SETB  P1.3
                  LCALL RETA1MS
                  MOV   R0,#90H
```

```
OTRO2:                MOV   A,24H
                CJNE  A,25H,CCUATRO
                CLR   P1.2
                SJMP  CUATROO
CCUATRO:        INC   24H
                NOP
                SETB  P1.2
CUATROO:        MOV   A,26H
                CJNE  A,27H,CCINCO
                CLR   P1.3
                SJMP  FIN2
CCINCO:               INC   26H
                NOP
                SETB  P1.3
FIN2:           DJNZ  R0,OTRO2
                      MOV   24H,#00H
                      MOV   26H,#00H

RUTINA3:        SETB  P1.4                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  5 Y 6
                SETB  P1.5
                LCALL RETA1MS
                MOV   R0,#90H
OTRO3:                MOV   A,28H
                CJNE  A,29H,SSEIS
                CLR   P1.4
                SJMP  SEISS
SSEIS:                INC   28H
                NOP
                SETB  P1.4
SEISS:                MOV   A,2AH
                CJNE  A,2BH,SSIETE
                CLR   P1.5
                SJMP  FIN3
SSIETE:               INC   2AH
                NOP
                SETB  P1.5
FIN3:           DJNZ  R0,OTRO3
                      MOV   28H,#00H
                      MOV   2AH,#00H


RUTINA4:        SETB  P1.6                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  7 Y 8
                SETB  P1.7
                LCALL RETA1MS
                MOV   R0,#90H
OTRO4:                MOV   A,2CH
```

```
                  CJNE  A,2DH,OOCHO
                  CLR   P1.6
                  SJMP  OCHOO
OOCHO:                  INC   2CH
                  NOP
                  SETB  P1.6
OCHOO:                  MOV   A,2EH
                  CJNE  A,2FH,NNUEVE
                  CLR   P1.7
                  SJMP  FIN4
NNUEVE:                 INC   2EH
                  NOP
                  SETB  P1.7
FIN4:             DJNZ  R0,OTRO4
                        MOV   2CH,#00H
                        MOV   2EH,#00H


RUTINA5:          SETB  P3.0                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  9 Y
10
                  SETB  P3.1
                  LCALL RETA1MS
                  MOV   R0,#90H
OTRO5:                  MOV   A,30H
                  CJNE  A,31H,DDIEZ
                  CLR   P3.0
                  SJMP  DIEZZ
DDIEZ:                  INC   30H
                  NOP
                  SETB  P3.0
DIEZZ:                  MOV   A,32H
                  CJNE  A,33H,OONCE
                  CLR   P3.1
                  SJMP  FIN5
OONCE:                  INC   32H
                  NOP
                  SETB  P3.1
FIN5:             DJNZ  R0,OTRO5
                        MOV   30H,#00H
                        MOV   32H,#00H


RUTINA6:          SETB  P3.2                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  11 Y
12
                  SETB  P3.3
                  LCALL RETA1MS
```

```
                  MOV   R0,#90H
OTRO6:                  MOV   A,34H
                  CJNE  A,35H,DDOCE
                  CLR   P3.2
                  SJMP  DOCEE
DDOCE:                  INC   34H
                  NOP
                  SETB  P3.2
DOCEE:                  MOV   A,36H
                  CJNE  A,37H,TTRECE
                  CLR   P3.3
                  SJMP  FIN6
TTRECE:                 INC   36H
                  NOP
                  SETB  P3.3
FIN6:             DJNZ  R0,OTRO6
                        MOV   34H,#00H
                        MOV   36H,#00H


RUTINA7:          SETB  P3.4                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  13 Y
14
                  SETB  P3.5
                  LCALL RETA1MS
                  MOV   R0,#90H
OTRO7:                  MOV   A,38H
                  CJNE  A,39H,CCATORCE
                  CLR   P3.4
                  SJMP  CATORCEE
CCATORCE:         INC   38H
                  NOP
                  SETB  P3.4
CATORCEE:         MOV   A,3AH
                  CJNE  A,3BH,QQUINCE
                  CLR   P3.5
                  SJMP  FIN7
QQUINCE:          INC   3AH
                  NOP
                  SETB  P3.5
FIN7:             DJNZ  R0,OTRO7
                        MOV   38H,#00H
                        MOV   3AH,#00H
```

```
RUTINA8:           SETB  P3.6                    ;RUTINA
DE 2mS QUE ACTUALIZA 2 REGISTROS A LA VEZ SERVOS  15 Y
16
                   SETB  P3.7
                   LCALL RETA1MS
                   MOV   R0,#90H
OTRO8:                   MOV   A,3CH
                   CJNE  A,3DH,DDIECISEIS
                   CLR   P3.6
                   SJMP  DIECISEISS
DDIECISEIS:        INC   3CH
                   NOP
                   SETB  P3.6
DIECISEISS:        MOV   A,3EH
                   CJNE  A,3FH,DDIECISIETE
                   CLR   P3.7
                   SJMP  FIN8
DDIECISIETE:             INC   3EH
                   NOP
                   SETB  P3.7
FIN8:              DJNZ  R0,OTRO8
                         MOV   3CH,#00H
                         MOV   3EH,#00H

                         LCALL RETA1MS     ;RETARDO DE
4mS PARA FINALIZAR LA RUTINA DE PWM
                         LCALL RETA1MS
                         LCALL RETA1MS
                         LCALL RETA1MS
                         RET

RETA1MS:             MOV R5,#04H
;RETARDO DE 1mS
TIEMPO1:           MOV   R4,#0FAH
TIEMPO2:           DJNZ  R4    TIEMPO2
                   DJNZ  R5      TIEMPO1
                   RET

                   END
```

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