Article **Journal Computational Simulation**
June 2021, Vol.5 No.13 24-28

Construction of a PUMA-type robot with 3 degrees of freedom

Construcción de un robot tipo PUMA de 3 grados de libertad

DE ANDA, Rosa†, VALLE, Pablo, ACEVEDO, Francisco and LÓPEZ, José

ID 1st Author: *Rosa, De Anda*

ID 1st Co-author: *Pablo, Valle*

ID 2nd Co-author: *Francisco, Acevedo*

ID 3rd Co-author: *José, López*

DOI: 10.35429/JCS.2021.13.5.24.28 Received: January 30, 2021; Accepted June 30, 2021

Abstract

Construction of a PUMA robot type 3 degrees of as technology has improved, specialized machines have been developed to perform various tasks. Most existing robots today are those which are used in the industry, so-called industrial robots, which are constituted by one or more arms. The robotic arm, PUMA (Programmable Universal Machine for Assembly, or Programmable Universal Manipulation Arm), for its acronym in English, which is presented below consists of three axes to move, 3GDL (degree of freedom), where it was considered essentially for teaching purposes, purchase an industrial type robot is very expensive, so it becomes viable development and make it available to the lab, so that students achieve their associated practices. To construct specialized software was used for design SolidsWorks , and linked with Matlab SimMechanics. LabView, for virtual and physical communication, arduino one card was used to provide the link between engines and software, currently tests are done with the Compaq Rio NI card to improve communication. The relevance of this project is the dynamic analysis, design, manufacturing and programming, and the whole process was conducted within the premises of the University.

Robot, GDL, Programming, Design, Communication

Resumen

A medida que se ha mejorado la tecnología, se han desarrollado máquinas especializadas para ejecutar diversas tareas. La mayoría de los robots existentes en nuestros días son aquellos que son utilizados en la industria, llamados robots industriales, los cuales están constituidos por uno o más brazos. El brazo robótico presentado a continuación consta de tres ejes para movilizarse, 3GDL, y utilizarlo para una aplicación industrial o ya sea para una aplicación especial, especialmente para aspectos didácticos. Para su construcción se utiliza software especializado, SolidsWorks para el diseño, y vinculado con Matlab y SimMechanics. LabView, para la comunicación virtual y física, se utilizó una tarjeta Arduino para proporcionar el enlace entre los motores y el software, en la actualidad se realizan pruebas con la tarjeta Compaq Rio NI para mejorar la comunicación. La relevancia de este proyecto es el análisis dinámico, diseño, fabricación y programación, todo el proceso se llevó a cabo dentro de las instalaciones de la Universidad.

Robot, GDL, Programación, Diseño, Comunicación

Citation: DE ANDA, Rosa, VALLE, Pablo, ACEVEDO, Francisco and LÓPEZ, José. Construction of a PUMA-type robot with 3 degrees of freedom. Journal Computational Simulation. 2021. 5-13:24-28.

† Researcher contributing as first author.

Introduction

When we hear the word Robot, we think of those movies that have surprised us by presenting us with robots that perform actions superior to the capabilities of the human being. Perhaps the most famous robot models have been those created by George Lucas in his movie Stars Wars whom we knew as C_3PO and R_2D_2. However, the idea that the films present to us is quite far from the industrial application of robots, which are considered as a type of machine-tools (Ogata, 2003). The eighteenth century is the time of the birth of industrial robotics. More than two hundred years ago, mechanical dolls were built, the size of a human being, that played musical pieces. Undoubtedly, today it can be said that the development of machine tools has been extremely accelerated.

An industrial robot is a reprogrammable multifunctional manipulator, capable of moving materials, parts, tools, or special devices, according to variable trajectories, programmed to perform various tasks (Barrientos, Peñín, alaguer, & Aracil, 1997).

A PUMA-type robot (Programmable Universal Machine for Assembly, or Programmable Universal Manipulation Arm) is an industrial robot arm developed by Victor Scheinman at the robotics pioneer Animation. Initially developed for General Motors, the PUMA robot arm grew out of initial designs invented by Scheinman while he was at MIT and Stanford University.

Animation produced PUMAs for a few years until it was absorbed by Westinghouse (ca. 1980), and later by the Swiss company Stäubli (1988) (Barrientos, Peñín, alaguer, & Aracil, 1997).

The Technological University currently has a robotic arm, Motorman brand, with six degrees of freedom, the great disadvantage with which it works is that commercial models have a specific work environment, a programming model and specific types of controllers by the manufacturer.

This situation impoverishes the learning process, the study program requires students to develop the design of a robot, from its conceptual design, its manufacture, its manufacture and the design and development of the control part.

The objective of this work is to generate the design and construction of a PUMA-type robot with 3 DOFs, which allows for versatility in the control stage and programming environments, which is didactic, placing it in the robotics laboratory of the institution so that be used by students of the subject.

In the methodology section, the techniques used to solve the problem are presented. It is important to note that the important part of the work is the development of skills in control and design techniques, which although they are not new in the field, they are for the University.

The results section shows the mechanism and control designs that were built by the researchers.

And the part of conclusions, the achievement obtained is presented, as well as future works and their applications.

Methodology to develop

A robot is mainly composed of three parts: the mechanical part (shape and size of the casing), the electronic part (composed of the robot's control circuit and sensors), and the power part (control of the robot's servo motors). The casing constitutes the mechanical part, its shape is one of the determining factors in the success of the development of a certain task. The electronic part is constituted by the control circuit that in turn contains a microcontroller which is programmed using a certain algorithm, in said algorithm lies all the decisions that the robot is going to make in certain given cases according to the problem (Hutchinson, Vidyasagar, & Mark, 2001).

Model of the robot

The structure to be used is based on a PUMA robot with 3 rotational degrees of freedom (DOF), so that the dynamic model of the robot is simpler and more manipulable to carry out the control and redundancy is avoided as far as possible.

Same the following and specifications, shown in table 1:

Estructura mecánica	Especificaciones
Número de ejes	3
Rango de movimiento en los ejes. Eje 1: cintura Eje 2: hombro Eje 3: codo	 310° 310° 310°
Máximo radio de operación	340 mm
Home físico	Por posición fija de cada eje, determinado por microswitchs
Actuadores	Motores PITTMAN a 24VCC (GM9234C212-R3)
Características de motores	45 oz-in @ 1090 rpm 2.5 A

Table 1 DOF PUMA Robot Specifications

The robot model was obtained in 2 ways, using the Biomechanics application of MATLAB, and through the Lagrange mathematical model.

A model was obtained through the MATLAB calculation tool, working on the mechanical design made by Solidworks, obtaining the following diagram, which considers each of the robot's joints, as shown in figure 1.

Characterization

Knowing the variables of the joints, the position of the end of the forearm in the PUMA will be determined. The variables of the joints are the angles between the links in the case of rotational joints, and the extension of the link in the case of prismatic or sliding joints, the Denavit-Hartenverg analysis proposal will be used.

Dynamic Model

The Lagrange equations of motion will be used to obtain the dynamic model of the manipulator (Kelly & Santibáñez, 2003).

Results

The meaning of the various constants as well as their numerical values are summarized in Table 2.

Descripción	Notación	Valor	Unidades
Longitud del eslabón 1		0.350	
Longitud del eslabón 2		0.150	
Longitud del eslabón 3		0.150	
Distancia del centro de masa de eslabón 1		0.003	
Distancia del centro de masa de eslabón 2		0.024	
Distancia del centro de masa de eslabón 3		0.033	
Masa eslabón 1		2.010	
Masa eslabón 2		2.450	
Masa eslabón 3		0.675	
inercia eslabón 1 respecto al centro de masa			
inercia eslabón 2 respecto al centro de masa			
inercia eslabón 3 respecto al centro de masa			
Aceleración de la gravedad		9.81	—
Offset		0.14	

Table 2 PUMA parameters

It is important to note that the design was made using the Solid Works software, to link it with Biomechanics and Mat lab, to perform the kinematic, direct and inverse analysis, as well as the dynamics.

The robot design can be seen in figure 1.

ISSN: 2523-6865

Figure 1 CAD design of robot type PUMA BY 3GDL

Derived from the dynamic analysis of the arm, the following results were obtained, as shown in figure 2, the analysis was performed in MATLAB and Biomechanics:

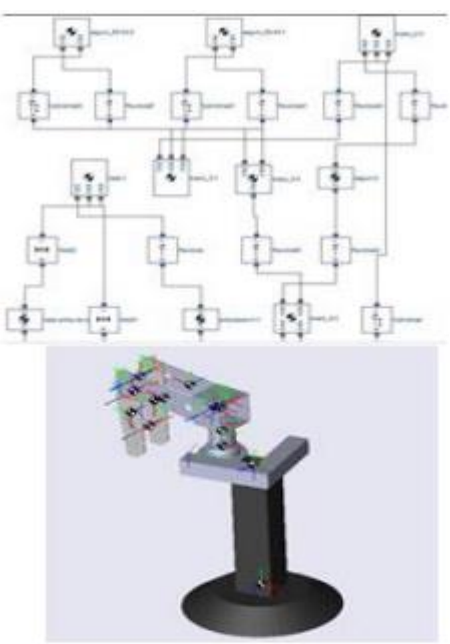

Figure 2 And dynamic analysis of the arm

The movement that was obtained in the joints is shown in table 3, in figure 3 the range of operation of the designed arm is shown.

Número de eje	Articulación	Movimiento	Número de motor
1	Cintura	Rota el cuerpo	1
2	Hombro	Sube y baja el brazo	2
3	Codo	Sube y baja el antebrazo	3

Table 3 Joint movement specifications

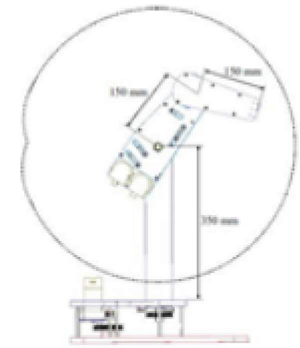

Figure 3 Operating Range

Transmission system

Figure 4 shows the high-torque toothed pulleys that transmit the movement of the motors to the waist, shoulder, and elbow joints. For the three movements, toothed pulleys are used in two stages to increase the reductions and their respective tensioners. The choice of the bands was made considering the criteria proposed by the manufacturer (FACE, 2001).

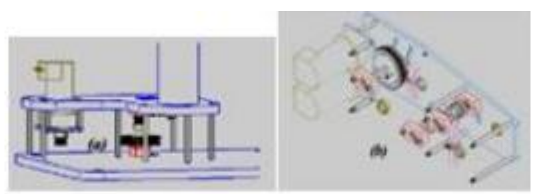

Figure 4 Powiats pulleys, shoulder pulleys

Electronic and control system

In the electronics part, an external power card was designed, since the selected card, which was the Arduino UNO, did not support the torque required by the servomotors. For the control part, an Arduino card and Lab View control software are used, it is important to mention that a power stage was required, since the Arduino card did not support the power required by the servomotors, as shown in figure 5.

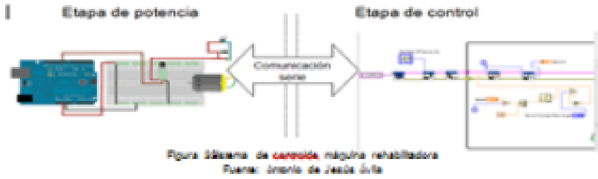

Figure 5 Robot control and power for a sevomotor

Figure 6 shows the work prototype, which was designed, manufactured, and to which the control systems are applied, using a personal computer as a work tool.

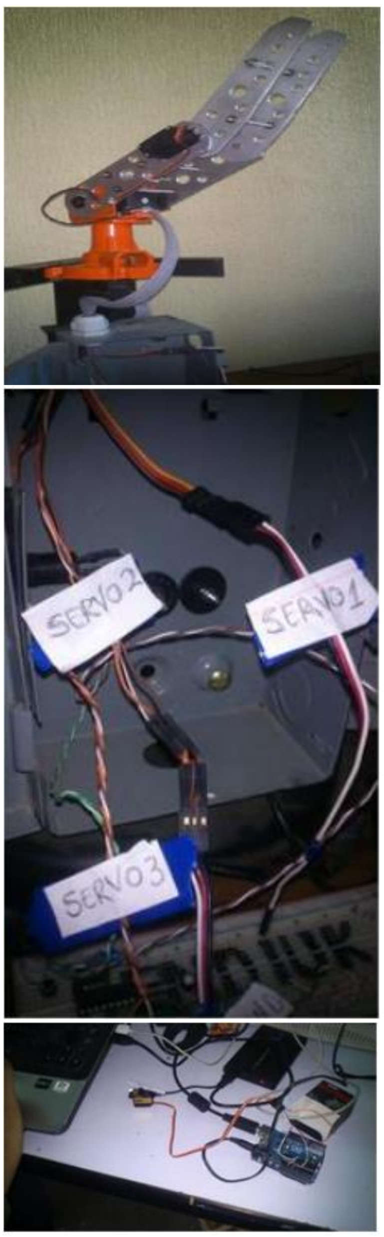

Figure 6 Robot prototype PUMA type of 3GDL

Gratitude

The work was supported by PROMEP to strengthen key academic bodies: UTSEM-CA-2, IDCA: 9786, for which we express our most sincere gratitude.

Conclusions

It was possible to carry out the design and manufacture of the 3GDL PUMA-type robotic arm, likewise tests are being carried out to identify which is the best control that can be had, the physical and virtual control interface is being developed.

The mass-length relationship for each element-link must always be taken into account and thus not require too much torque from the base links. Currently, the communication platform with Lab View is still being developed.

It is important to mention that currently the tenth semester students are already working with this model, they have developed a programming platform, communication, and communication using USB is currently being developed, it is expected to generate communication using Wi-Fi.

References

Barrientos, A., Peñín, L. F., alaguer, C., & Aracil, R. (1997). Fundamentos de robótica. Madrid: Mc Graw Hill/interamericana de España, S.A.

FACE. (2001). Catálogo Face. Mechanics Standard CoFactory Automation.

Hutchinson, S., Vidyasagar, M., & Mark, W. (2001). Robot Modeling and Spong.

Ogata, K. (2003). Ingeniería de control moderna. Pearson.