The Journal of Polish Society for Geometry and Engineering Graphics
Volume 25 (2013), 57 - 65

SOME REMARKS ABOUT THE 3D PRINTING AND PARAMETRIC MODELLING OF THE PARTS AND JOINTS OF AN ANIMATED PUPPET THAT SIMULATE A HUMANOID ROBOT

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Abstract. The aim of this paper is to present an empirical evidence of the mechanism of an animate puppet that simulates the behavior of living things taking into account the principles of bionics through graphical representation. We use applications CAD-CAE-CAM to perform the development of the parts that can be used to build and generate the joints movements of a prototype. This paper present the articulated prototype created by the student: Mario López Vázquez at the Autonomous Metropolitan University, Cuajimalpa, Mexico City, as a result of the research that was conducted.

Keywords: Descriptive geometry, parametric modeling, animated puppet

1 Introduction

The term, robot comes from the Czech word "robota" meaning "forced labor." This term was first used by the Czech novelist and playwright, Karel Capek in the play called RUR (Rossum's Universal Robots) in 1921.

Today the creation of robots has taken different directions among which we find: industrial robots, mobile robots, service robotics and intelligent robots.

These robots are built by the electronics engineers, since the robots have sensors, actuators, digital systems, analog systems, power systems, communication systems, control systems and artificial intelligence, and we can say that each of the robots perform different movements.

The configuration of the robots movements are classified into: 1. Cartesian: three linear movements, 2. Cylindrical: two linear movements and one rotational motion, 3. Polar, three different movements: rotational, angular and linear and 4. Angular: one rotational movement and two angular movements.

A humanoid robot (Fig. 1) mimics human appearance and some aspects of their behavior, but from the point of view of the designer, these robots are seen as a puppet animated by using mechanisms that simulates the behavior of living things.

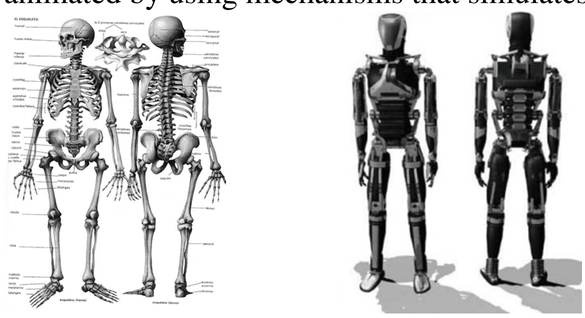

Figure 1: (a) Human skeleton (b) Humanoid Robot

ISSN 1644-9363 / PLN 15.00

The aim of this paper is to present the use of parametric modeling for the design and assembly of the parts of a prototype that simulates the movements of a puppet animated.

To achieve the objective of this research, this study considered the principles of bionics and mechanics. The Bionic is the branch of cybernetics that tries to simulate the behavior of living beings by means of mechanical instruments, such as the joints.

The main function of the joints are the union of various bones of the skeleton and providing stability and movement, allowing, e.g. the upright posture, so characteristic of the human species.

In mechanical, movement is a change in position in space of some material under a physical observer. Mechanically, a robot is comprised of a series of elements or links joined by hinges that allow movement relative between two consecutive links.

The motion of each joint may be by displacement, by rotation or the combination of the two. Each movement of the joints is called degrees of freedom (DOF) and these movements are classified as follows (Tab.1):

Table 1: Classification of joint movements

Spherical	3 DOF
Planar	3DOF
Screw	1 DOF
Prismatic	1 DOF
Rotation	1 DOF
Cylindrical	2 DOF

This project started from the premise of creating an articulated prototype, where they are used the elements and resources of descriptive geometry, to develop and describe the parametric modeling of the parts that make up a puppet animated, using the following methodology:

- Development of the parametric modeling of the joint movements,
- Generation of parametric design,
- Build the prototype.

This paper is organized as follows: in Section 2 we give a brief explanation of the 3D printing, in Section 3 we explain the parametric modeling. In Section 4 we present the assembling of the parties and in Section 5 the results.

We want to mention that all the figures presented in this paper are original and created by the author at the Autonomous Metropolitan University, Cuajimalpa in Mexico City.

2 3D printing

Before designing any piece, it is necessary to know the technology to be used and the processes that must be followed to reach a good result. For the study of a product design, 3D printing is used by designers to realize their virtual designs created in a CAD system.

CAD (Computer Aided Design) is in essence the use of technology for the design of parts or elements. These parts can be performed in two and three dimensions (Autocad) or performed through the parametric modeling (Inventor, Solid Works).

Once finished the three-dimensional modeling or the parametric modeling, it is saved as an STL file, the 3D printer software parsed the file and it begins to build the prototype in the work area.

The work area of the 3D printer is 200 x 200 x 250 mm and the process to build the prototype is as follows (Fig. 2): the printer has two containers of equal size, where one of them is filled with plaster (very fine white powder) and the other is empty.

An arm moves in the plane "x, y" which first releases the binder (resin used as adhesive), and then drag the plaster to build layers of 1.00 mm thick in the "z" axis, repeating this process to form the 3D part. Once the prototype is built is cleaned and infiltrated with a resin to give it firmness.

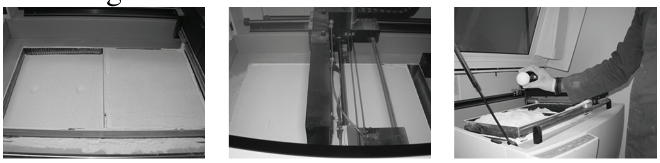

Figure 2: 3D printer

We have to know two things before printing any 3D object. What happens if the parties are very thin? The parties fail to print or are broken during cleaning, and, what happens if the parties are very thick? The parties would be heavy solids that would not allow controlling the movements of a mechanism, and assembly could not be done.

Another important thing to consider in the design of the parties is the tolerance. The tolerance is considered as the limit of margin of measure that can have a piece. A tolerance of shape, position, orientation or oscillation of a geometric element (point, line, area or volume) defines the theoretical area within which must be contained the element, so it is recommended to perform various tolerance tests before printing the final prototype.

In the laboratory of the university, considering the 3D printer material, we perform several tests of tolerance for realize the assembling of the pieces, and the conclusion reached was that if we multiply the value of the hole diameter by 0.08 we have no problem in assembling. But the pieces might remain just. If this happens, the pieces can be sanded up to reaching the needed tolerance, since if we give a major tolerance, could affect the assembling of the pieces.

3 Parametric modeling

The parametric modeling is defined as the method of modeling three-dimensional objects from their dimensional and geometric relations. In parametric modeling numerical values are used to determine the behavior of the graphical entities and define the relationships between the components of the model.

In this research, we used the 2012 Inventor program to generate the parametric modeling of each of the parties, the assembling, and the simulations and used the prism, cylinder and sphere for the design of the prototype articulated.

To model parametrically a prism (Fig. 3a), we must give the geometrical dimensions of width and length of the base and then extrude the height. To model parametrically a cylinder (Fig. 3b), is necessary to provide the geometrical dimensions of the diameter of the base and then extrude the height, and to model parametrically a sphere (Fig.3c), we trace a line which limits the diameter of the circle and its corresponding arc, i.e. we trace a semicircle, the diameter line is used as a rotation axis to revolve 360° the circular plane.

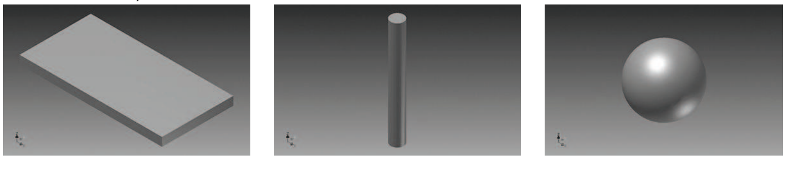

Figure 3: (a) Prism, (b) Cylinder and (c) Sphere

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Any design parts that we want to assembling so they can have the movement of rotate, must be hollow. It is necessary to take into account in a hollow piece, the thickness of the solid, the walls thickness (it is recommended that these walls are at least 5mm thick) and most importantly is that when printing the plaster can be removed.

3.1 First case, pieces hollow

In this case the cylinder is hollow and has no lids.

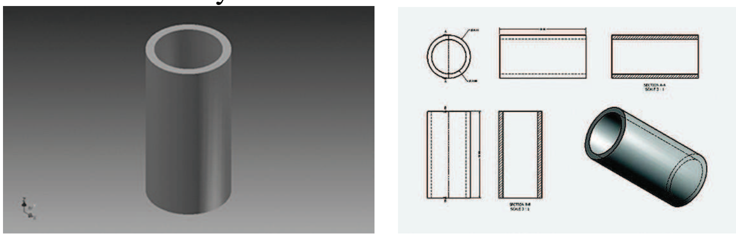

Figure 4: First case, hollow cylinder

3.2 Second case, pieces hollow

In this case we open a hole in two of the faces of the solids (the prism, cylinder and sphere), the holes may be a circle or a polygon.

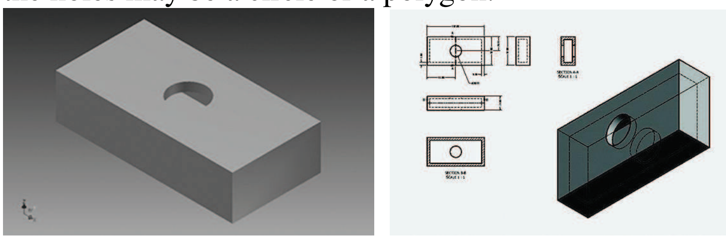

Figure 5: Second case, hollow prism

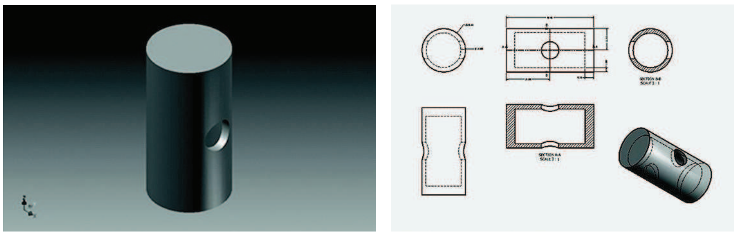

Figure 6: Second case, hollow cylinder

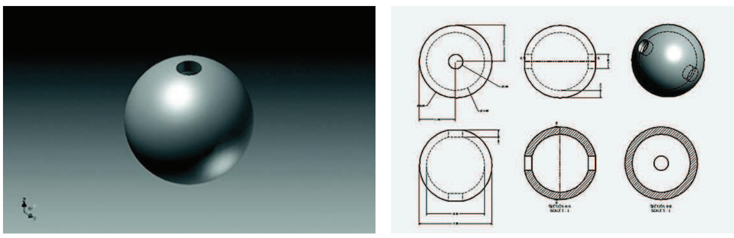

Figure 7: Second case, hollow sphere

3.3 Third case, pieces hollow

In this case we cut the solids (prism, sphere and cylinder) into two equal parts and place the padlocks. The padlocks serve so that the pieces fit together and can be pasted.

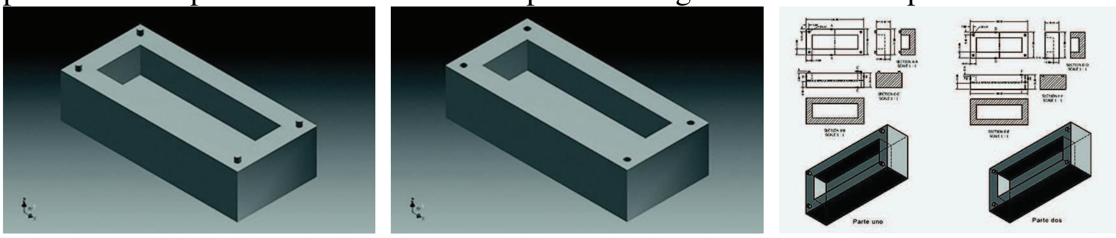

Figure 8: Third case, hollow prism

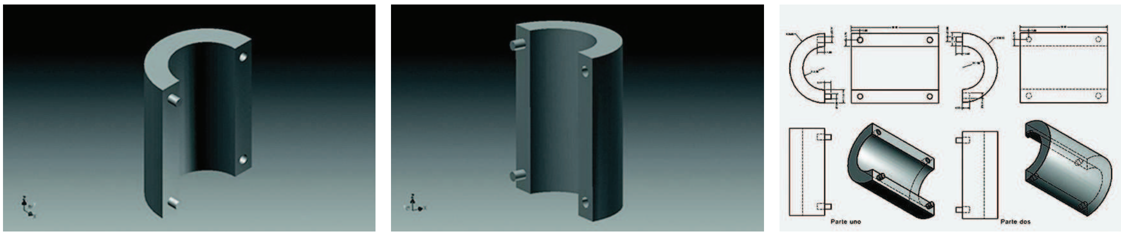

Figure 9: Third case, hollow cylinder

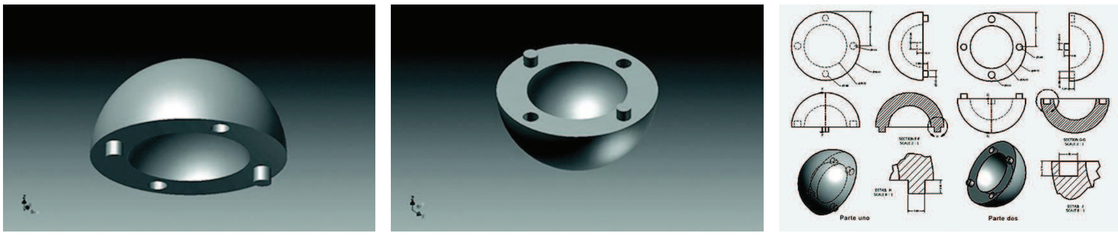

Figure 10: Third case, hollow sphere

In each of the above and following cases can be observed the 3D parts and the associated drawings, the dimensions given are not what should be taken to design the puppet, these dimensions are exaggerated in order to understand the construction of each parts and the joints**.**

4 Assembling of the parties

The assembly word is derived from the French verb "assembler" and is defined as the union of two pieces forming part of a structure.

When assemble each of the parts of a structure should be considered the displacement movements and rotational movements. In this investigation we only consider the rotational movement, which is defined as the motion of a rigid object in a circular trajectory.

4.1 First case of assembling

In this case we use a cylinder with three prisms to the assembling. The central prism rotates, and the other two prisms, which are at the ends are fixed.

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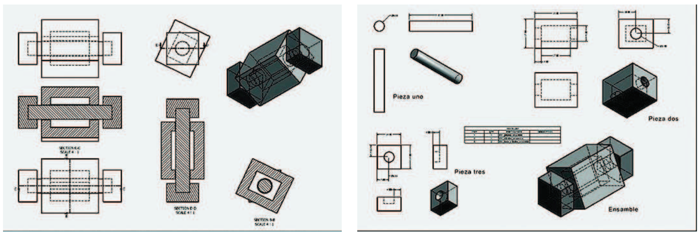

Figure 11: Assembling of a cylinder with three prisms

4.2 Second case of assembling

In this case we use a cylinder with three prisms to the assembling. The three prisms rotates.

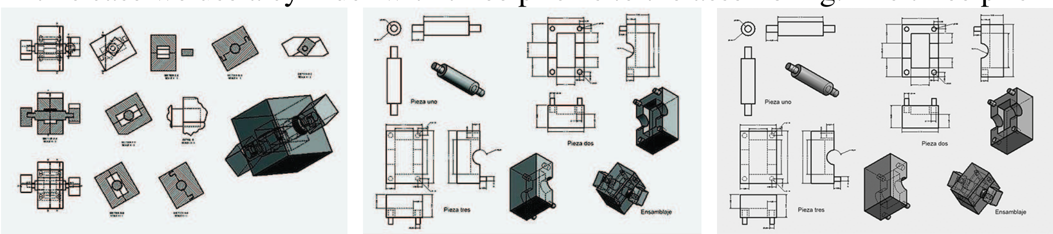

Figure 12: Second case of assembling

4.3 Third case of assembling

In this case we use a cylinder with a sphere to the assembling. The sphere rotates.

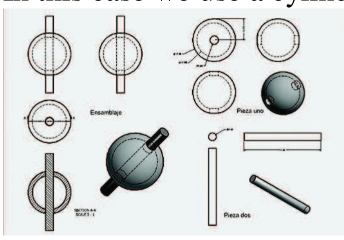

Figure 13: Third case of assembling

4.4 Fourth case of assembling

In this case we use two cylinders with one prism to the assembling. The interior cylinder rotates.

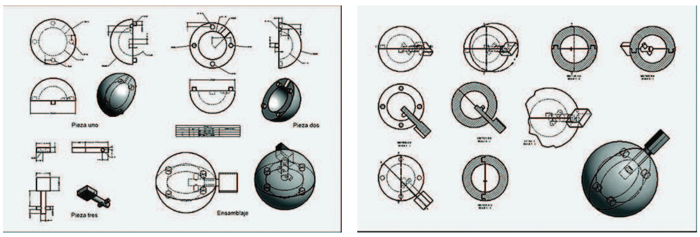

Figure 14: Fourth case of assembling

4.5 Fifth case of assembling

In this case we use two spheres to the assembling. The interior sphere rotates.

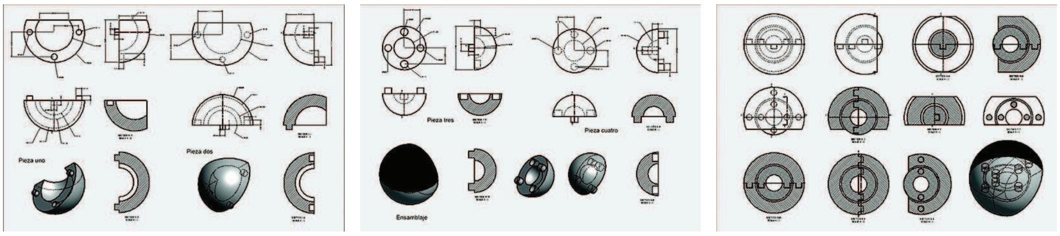

Figure 15: Fifth case of assembling

5 Results

For this study we considered the construction of two objects, the robots and the puppets. From each of these objects are analyzed the movements of its joints in order to perform a prototype that mimics the movements of living things.

To establish the characteristics of the movements of the puppet were used several prism, cylinders and sphere hollow. To model parametrical each of the solids, was used the Inventor 2012 software. This software allows us to make the assembling of the model, using the restriction, insert. Since with this restriction it determined the relative position of the geometry of the parties, respect to the axes of the cylinders.

This paper present the articulated prototype created by the student: Mario López Vázquez at the Autonomous Metropolitan University, Cuajimalpa, Mexico City, as a result of the research that was conducted.

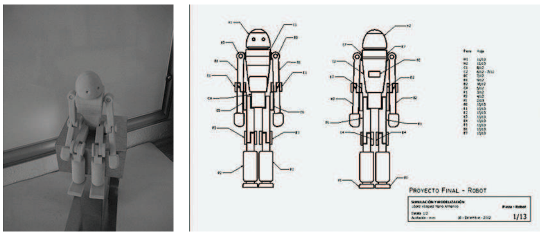

Figure 16: (a) Prototype, (b) Plans

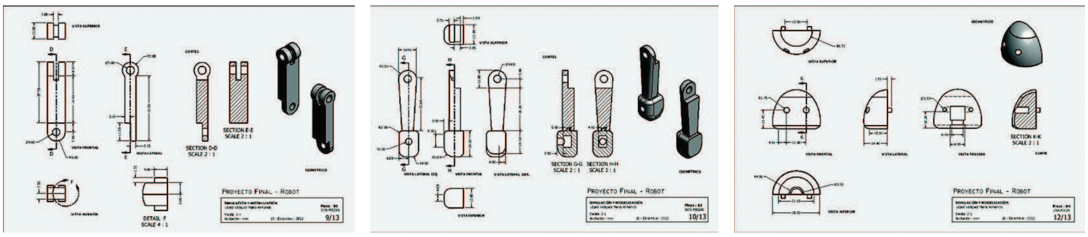

Figure 17: Plans

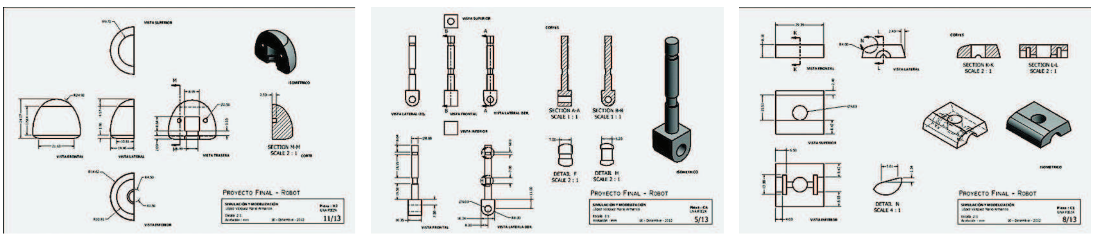

Figure 18: Plans

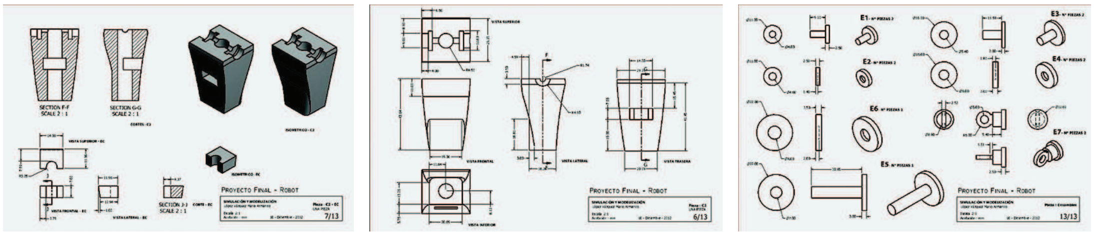

Figure 19: Plans

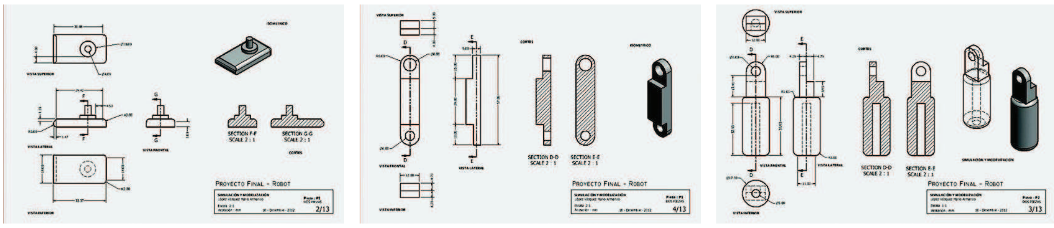

Figure 20: Plans

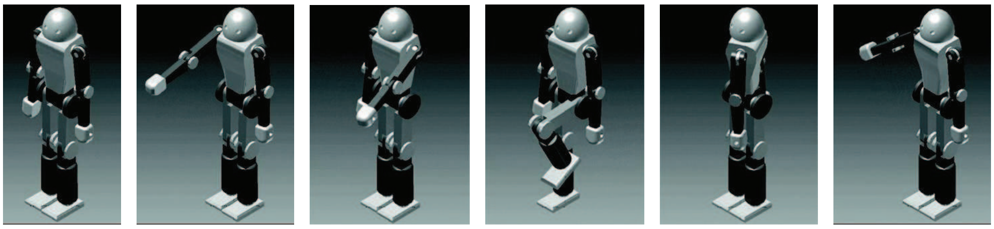

Figure 21: Quantitative simulation

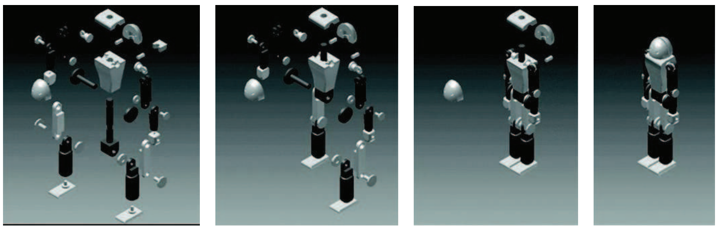

Figure 22: Explosion

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O PARAMETRYCZNYM MODELOWANIU I WIZUALIZACJI 3D ELEMENTÓW STAWÓW ANIMOWANEGO PROTOTYPU PRZEGUBOWEGO ROBOTA

Celem artykułu jest ilustracja symulacji geometrycznej mechanizmów ożywionych modeli istot żywych, skonstruowanych zgodnie z zasadami bioniki. Korzystając z aplikacji CAD-CAE-CAM zaprojektowano i wykonano elementy, które zostały użyte do tworzenia i generowania ruchu stawów prototypu. W artykule został zaprezentowany przegubowy prototyp stworzony przez studenta: Mario López Vázquez z Autonomicznego Metropolitalnego Uniwersytetu, Cuajimalpa, w Meksyku.