

## A STUDY ON HEXAPOD ROBOTS AND MODELING BY MEANS OF CAD TECHNIQUES

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**Abstract.** Several denominations can be used for mobile robots classification, and usually they are divided in relation to the: anatomy; control type; functionality, and movement. In relation to anatomy, the robots can be: aerial, aquatic or terrestrial, being last ones the most common, using wheels, tracks or legs. The work presented here is related to the study of legged mobile robots, in particular, a robot model with six legs, simply denominated hexapod robot. The mechanical structure and operation of a hexapod robot is based on animals (usually insects), using biomimetics principles. From the study of the robot and its characteristics, a modeling using CAD techniques was performed. This research has educational applications in the area of Mechanical Engineering, mainly in the project of mechanisms and robotics.

**Keywords:** hexapods; robotics; CAD.

### 1. INTRODUCTION

Usually, mobile robots can be classified in relation to some characteristics, such as: anatomy; control type; functionality, and movement. From anatomical viewpoint, the robots can be aerial, aquatic or terrestrial. The last ones being the most common, having wheels (Fig. 1), tracks (Fig. 2) or legs (Fig. 3).

In relation to the control type, the mobile robots can be: remote controlled, in which an operator defines all of the movements that the robot will execute; semi-autonomous, where an operator indicates the command macro to be executed and the robot executes it alone; and autonomous, in which they accomplish their tasks alone, making their own decisions.

Taking into consideration the functionality, we have: the industrial robots, used in production lines; service robots, that are used for generic tasks, working in well known structured environments; field robots, that work in non structured environments, little known and usually dangerous; and personal robots, that are sold in shelves, they don't develop specific tasks, but interact with the human beings.



Figure 1. Mobile robot with wheels.



Figure 2. Mobile robot with tracks.

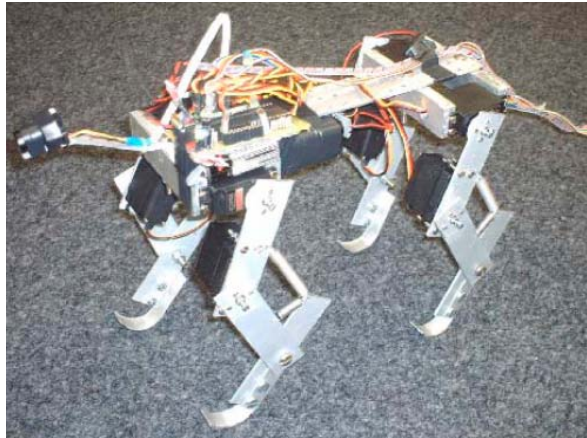


Figure 3. Mobile robot with legs.

About movement, robots can be classified into: holonomic, in which the controllable degrees of freedom are greater than or equal to the total degrees of freedom; and non holonomic in which the controllable degrees of freedom are less than the total degrees of freedom.

From those characteristics it is possible to define the robot's application. As examples can be mentioned robots used in internal (structured) environments as in the areas of transports, services, industry, cleaning of great areas, surveillance, researches and entertainment (Fig. 4), or robots used in external (non structured) environments as in mining companies, sewer tubes, agriculture, forests (Fig. 5), constructions, fires, military applications and even in space (Fig. 6). It is also possible to use mobile robots to motivate the teaching and formation in Mechatronics and Artificial Intelligence, as for example through robot's soccer competitions.

The work presented here is related to legged mobile robot's study, at first a robot model with six legs, simply denominated the hexapod robot.

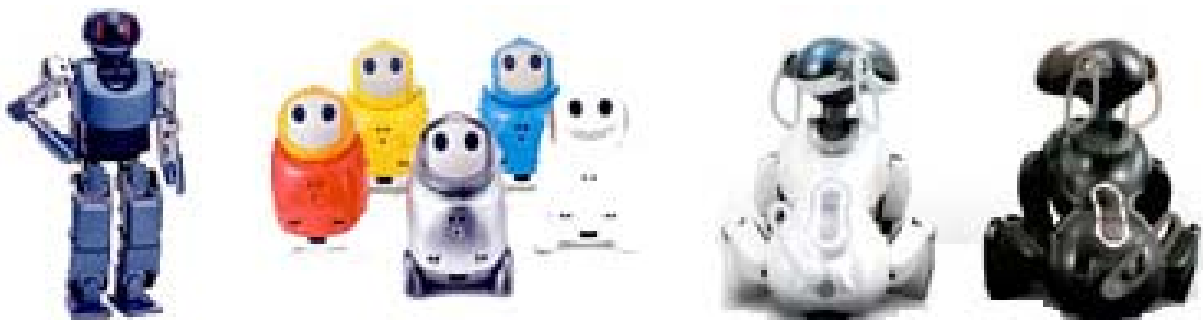


Figure 4. NEC and NEDO Robots <<http://www.incx.nec.co.jp/>>.



Figure 5. Forest Robot, design by Pulstech <<http://www.plustech.fi/>>.

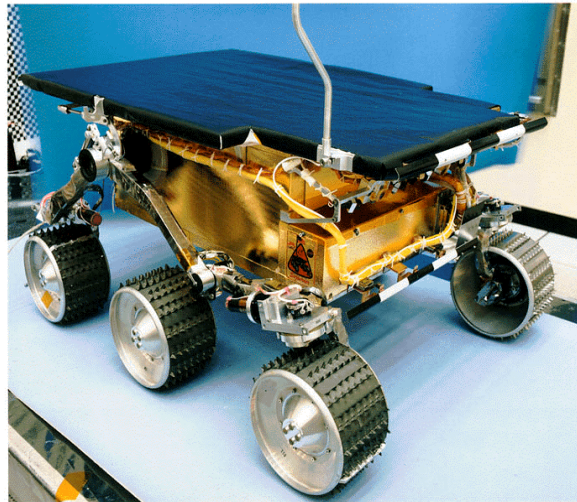


Figure 6. Sojourner, first robot in Mars <[http://ranier.oact.hq.nasa.gov/telerobotics\\_page/telerobotics.shtml](http://ranier.oact.hq.nasa.gov/telerobotics_page/telerobotics.shtml)>.

## 2. HEXAPOD ROBOTS

The mechanical structure and operation of a hexapod robot is based on animals (usually insects), from the biomimetics principles (Bailey et al., 2000), science based on the imitation of existent mechanisms in nature, trying to learn its workings and applying such knowledge in the project of artificial mechanisms similar to the natural ones.

The word "biomimetics" is the combination of the Greek terms "bios", that means life, and "mimesis", that means imitation. Therefore, it can be said that the biomimetics is the imitation of life. Nowadays, the biomimetics represents a research area that is in great development in the field of the science and technology. Several mechanisms have been developed starting from knowledge acquired with systems natural or biological.

Figures 7 and 8 show two examples of robots inspired in insects.

The objective of this work is to present a study and the modeling of a hexapod robot using programs of CAD, more precisely AutoCAD from Autodesk. We intend to present a simple however efficient methodology for the 3D modeling and subsequent operation simulations. This research has educational applications in the area of Mechanical Engineering, mainly in the project of machines and robots.

## 3. CHARACTERISTICS OF THE ROBOTS

The great advantage of mobile robots with six legs, when compared the biped and quadruped robots, it is the possibility of movement in larger speeds allied to the static stability, which is conserved. In biped robots, the demands on the control system are well higher, once to maintain the static stability, this robot type he has to move with low speed and have a larger support (foot).

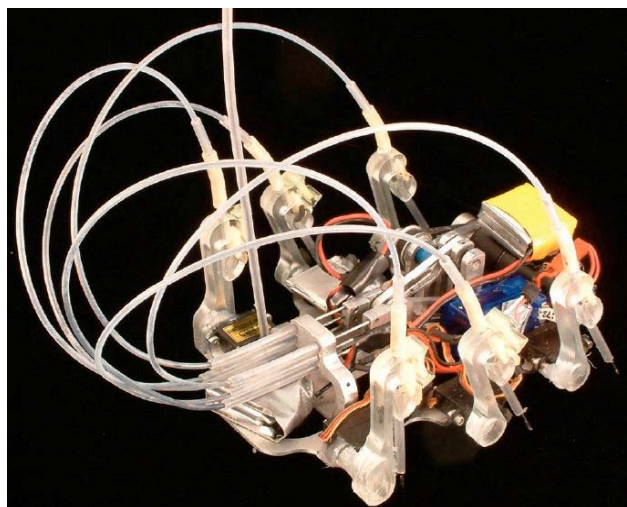


Figure 7. iSprawl robot (Kim et al., 2007).



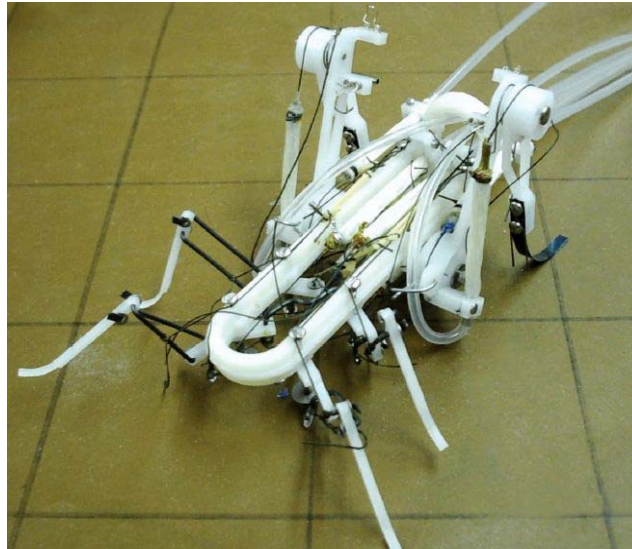


Figure 8. Robot inspired in a cricket (Quinn, 2007).

Studies indicate that all of the calculations (cinematic, dynamic, control, etc.) would have to be accomplished every 20 meters.

In the case of robots with four legs, to maintain the static stability, three legs would have to stay in the ground so that the fourth could be moved. This makes the movement of this type of robot extremely slow, limiting its applicability, and in that way being little used commercially.

A disadvantage of the hexapod robots is that in the case of the biomimetic system, a group of 18 actuators would have to be implemented, making for a high components and control system cost.

Nevertheless, the study of the movement of insects and its application in the design of robots with six legs is very widespread in the research centers, which have several models of hexapod robots.

An interesting example of hexapod robot, built from biomimetic concepts, is the "Sprawlita", whose project was based on the principles of biomechanical cockroach (Fig. 9).

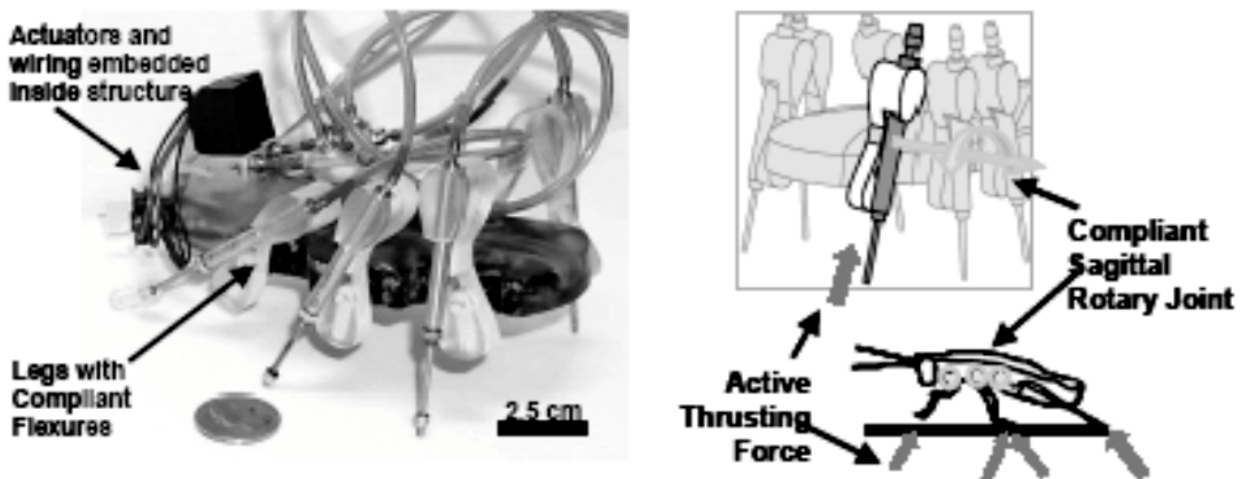


Figure 9. Hexapod robot "Sprawlita" (Bailey et al., 2000).

A very interesting feature of the cockroach's locomotive system is the presence of a natural braking mechanism. Due to this, the cockroach is capable of performing movements at high speed, being able to stop and change direction quick and efficiently (Fig. 10).

Due to all benefits previously described, the hexapod robot represents an interesting object of study in researches being conducted at the Federal University of Rio de Janeiro. One of the most interesting works on this topic was developed by Costa Netto (2001), in which was used a set of piston with shape memory materials to actuate the leg systems.

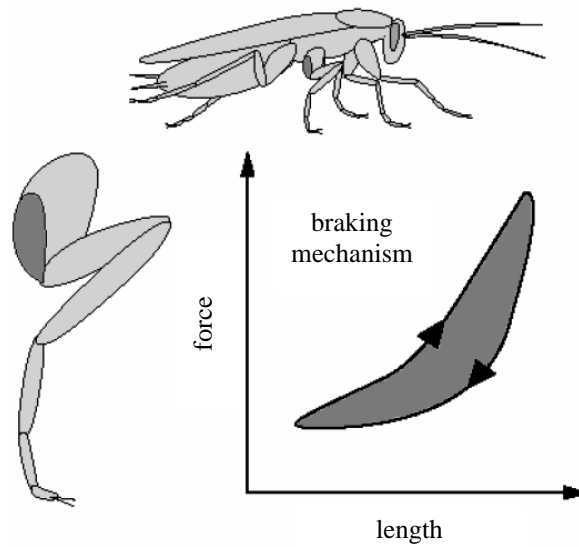


Figure 10. Natural braking mechanism (Tsakiris, 2007).

#### 4. MODELING OF A HEXAPOD ROBOT

To achieve the goals proposed for the research, we have implemented an organized series of activities, targeting from learning about mobile robots to the final modeling of the six-legged robot.

From the features already presented in the previous section, a study was conducted on the principles and definitions of mobile robots and their differences with respect to other types of robots. In this research the aim was to obtain the greatest possible knowledge regarding the movement of the bidding joints of the robot (Gomide and Gudwin, 1994), examining whether they perform a angular movement (between two axes), rotation (around the axis) or prismatic (linear), and if these movements classified the machine as a mobile robot or handler. Also studied were topics such as robot kinematics, movement control and sensors (types and characteristics) (Adade Filho, 1992).

The first stage of construction of our robot was the development of the leg set of the hexapod system, shown in Fig. 11.

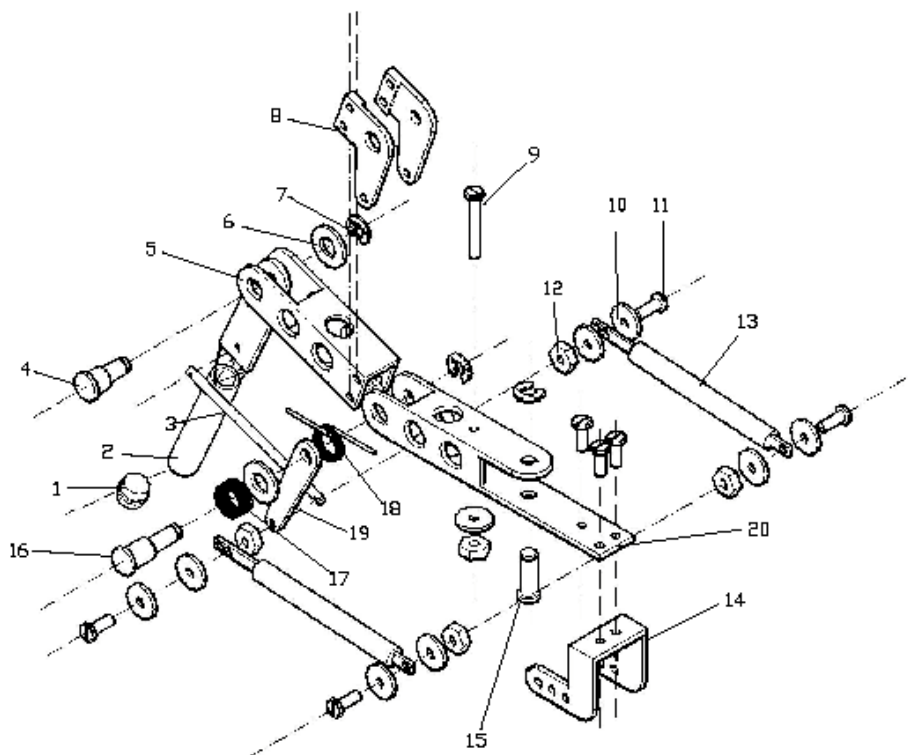


Figure 11. "Exploded" isometric view of the leg.

This segment consists of 20 pieces formed mainly by the main supports, actuator pistons, connection axes, springs, screws and washers. Figure 12 shows the isometric view of the leg already assembled. Figure 13 presents the main orthographic views (front and top) of the whole leg.

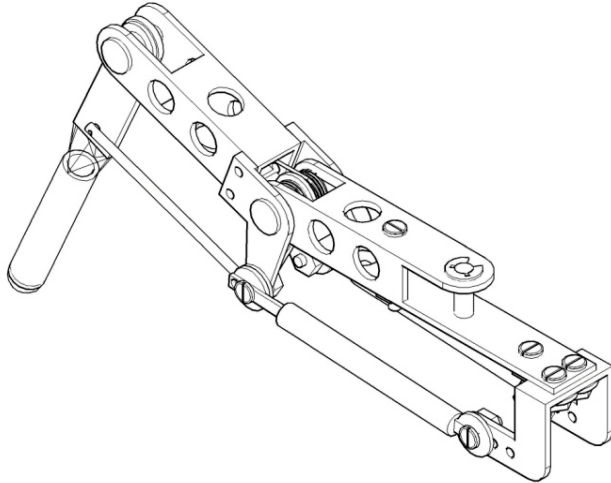


Figure 12. “Assembled” isometric view of the leg.

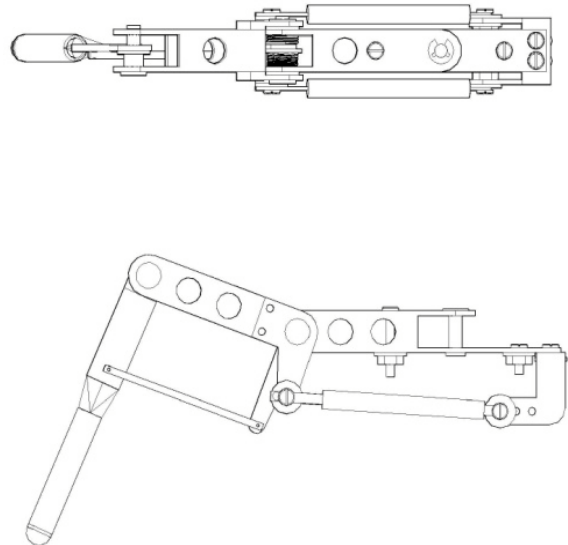


Figure 13. Orthographic views of the leg.

The movement axis of the leg in relation to the piston actuator can be given in Fig. 14.

The second stage of construction of our robot was based on the development of modeling of the body and the supports for the leg, as shown in Fig. 15.

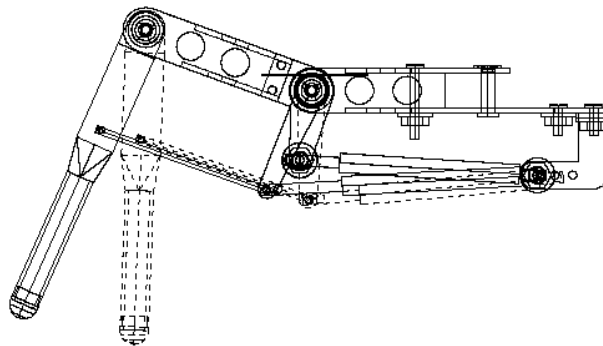


Figure 14. Possibilities of movement of the leg.

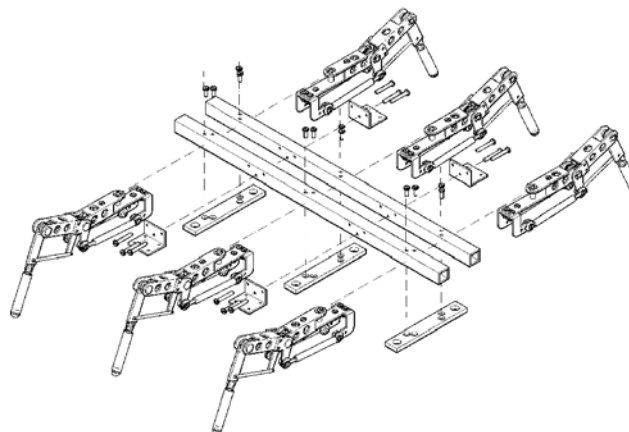


Figure 15. “Exploded” isometric view of the robot.

Upon completion of this stage remains only the introduction of the Pistons responsible for the angular movement of the leg, which can be seen in Fig. 16. Figure 17 presents the hexapod robot totally assembled, finishing the desired modeling.

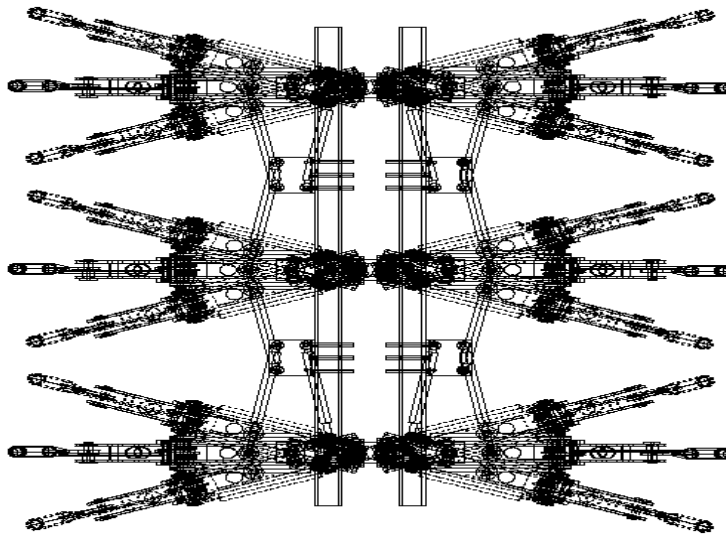


Figure 16. Possibilities of movements of the robot.

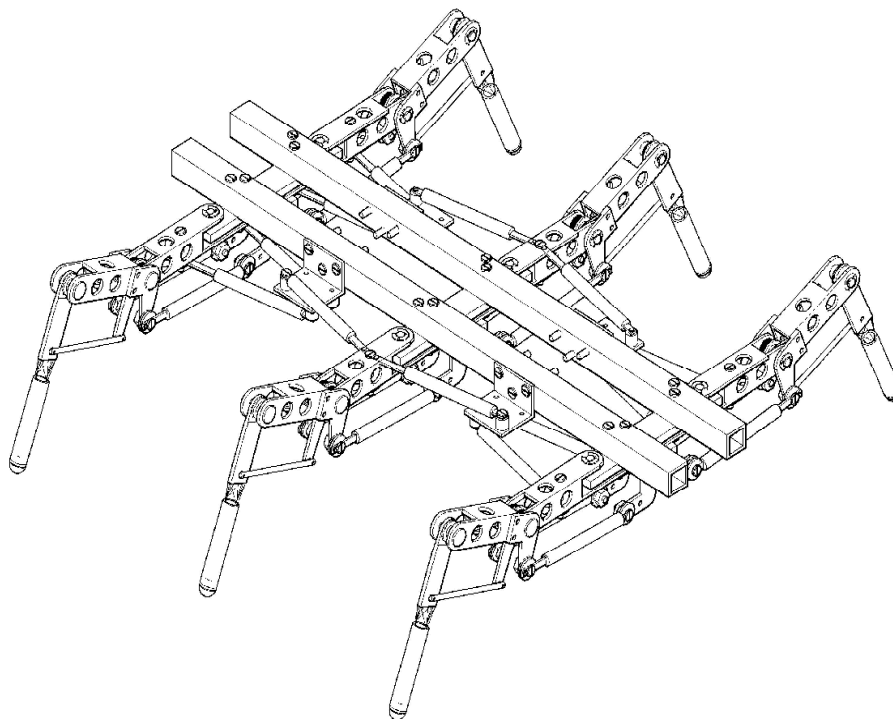


Figure 17. Isometric view of the robot totally assembled.

## 5. CONCLUSION

The research presented here can be used in under-graduation courses, such as: Mechanics, Mechatronics, Control and Automation, etc. The methodology consists in the project of a mechanism using computational tools, where is possible to make tests changing some parts of the robot, evaluating the results from the motion simulation. Considering the diverse parts used for assembling the robot, it will be possible to estimate the manufacture cost. The use of computational modeling supply useful results to the project, avoiding the waste of time and money.

From the main objectives of work, a study on mobile hexapod robots was presented and a computational model was built, capable to represent, as faithfully as possible, a real robot, considering the mechanical parts that constitute it. This research has applications in the educational area of Mechanical Engineering, particularly in the design of machines and robots. Continuity will be given to the work with simulations of it working and the modeling of other mobile robots.

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## 7. RESPONSIBILITY NOTICE

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