

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800

Open access books available

122,000

International authors and editors

135M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities

**WEB OF SCIENCE™**Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.

For more information visit www.intechopen.com

Mechanical Synthesis for Easy and Fast Operation in Climbing and Walking Robots

Antonio Gonzalez-Rodriguez, Angel G. Gonzalez-Rodriguez
and Rafael Morales

*University of Castilla-La Mancha, University of Jaen
Spain*

1. Introduction

This chapter deals with the importance of the mechanical design in devices used in mobile robots. A good synthesis of mechanisms will improve the robot's operation. This idea will be explained via two examples.

In the first example, the mechanical design of a staircase climbing wheelchair will be presented. A wheelchair is intended to be a commercial unit, and its control unit must, therefore, be robust, efficient and low-cost.

The second example deals with the mechanical design of an easy-to-operate leg for a mobile robot. This is a research project, but easy operation is fundamental if we are to ensure that the steps that the leg takes are as rapid as possible, which is of great importance in making actual walking robots faster.

2. Design of a new Design for a Staircase Wheelchair

2.1 Review of the current approaches

People with disabilities find that their mobility is improved with the help of powered wheelchairs. However, these chairs are often rendered useless by architectural barriers whose total elimination from the urban landscape is expensive, if not impossible. These barriers appear in many different geometrical shapes, of which staircases are the most difficult obstacle to overcome.

Various designs have been developed to allow a wheelchair climb a stair. One of the first and most common solutions are tracks (Yoneda et al., 2001; Lawn et al., 2001) owing to the simplicity of their control, and their robustness in adapting to different shapes such as spiral staircases. However this solution has important drawbacks: the vehicles that use tracks are uncomfortable and of low efficiency when they work in barrier-free environments; a high friction coefficient between the edge of the step and the track can deteriorate this edge, and the entrance to and exit from the staircase are dangerous and difficult to control.

Another common solution consists of various wheels attached to a rotation link (Lawn & Ishimatzu, 2003). The main problem with this solution is its fixed geometry which cannot be adjusted to the step, and the prototype therefore only works satisfactorily with obstacles

which are similar to the step used to define the geometry of the rotating link. Further problems with this solution are that each of the wheels must have their own transmission, which increases the wheelchair's weight, or that the user's resulting trajectory is uncomfortable and difficult to control.

An alternative strategy for the design of the staircase climbing wheelchair will be presented in this paper. This strategy is based on splitting the climbing problem into two sub-problems (Morales et al., 2004; Morales et al., 2006): single step-climbing of each axle, and front and rear axle positioning. Two independent mechanisms have been designed to overcome these sub-problems: the climbing mechanism and the positioning mechanism, respectively.

The final mechanism must be able to successfully negotiate all the staircases designed under international standards. This paper describes the latest prototype, together with the experimental results obtained when the wheelchair climbs different staircases.

2.2 Description and performance of the mechanical system

Fig. 1 shows a CAD model of our proposed design. The prototype can be seen in Fig. 2. The kinematical scheme of the overall system can be seen in Fig. 3, in which the sub-scheme labeled 1 corresponds to the climbing mechanism and the sub-scheme labeled 2 corresponds to the positioning mechanism.

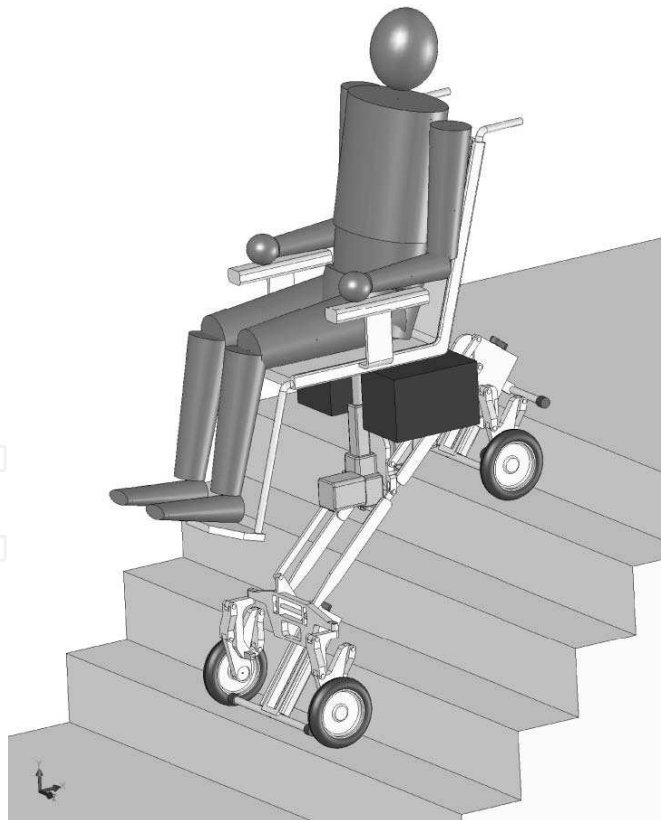


Fig. 1. CAD model of the proposed design



Fig. 2. The staircase climbing mechanism proposed

2.2.1 Climbing mechanism

The climbing mechanism allows an axle climb a single step. There is one climbing mechanism for the rear axle and another for the front axle. These have been designed to adapt to different obstacle geometries, and to guarantee that the system is always in stable equilibrium. This last objective is satisfied by permanently ensuring a wide support polygon with four contact points, two for each axle.

When the climbing mechanism reaches a step, a sliding support (1.5 in Fig. 3) is deployed. A prismatic joint connects this support to the chassis (2.3) at a fixed angle μ .

A new degree of freedom resulting from a four link mechanism (bars 1.1, 1.2, 1.3 and 1.4 in Fig. 3) allows the wheel (1.6) to move backwards to avoid interference from the step. An electromagnetic lock cancels this degree of freedom, e.g. when the system is in a barrier-free environment. The climbing sequence is presented in Fig. 4.

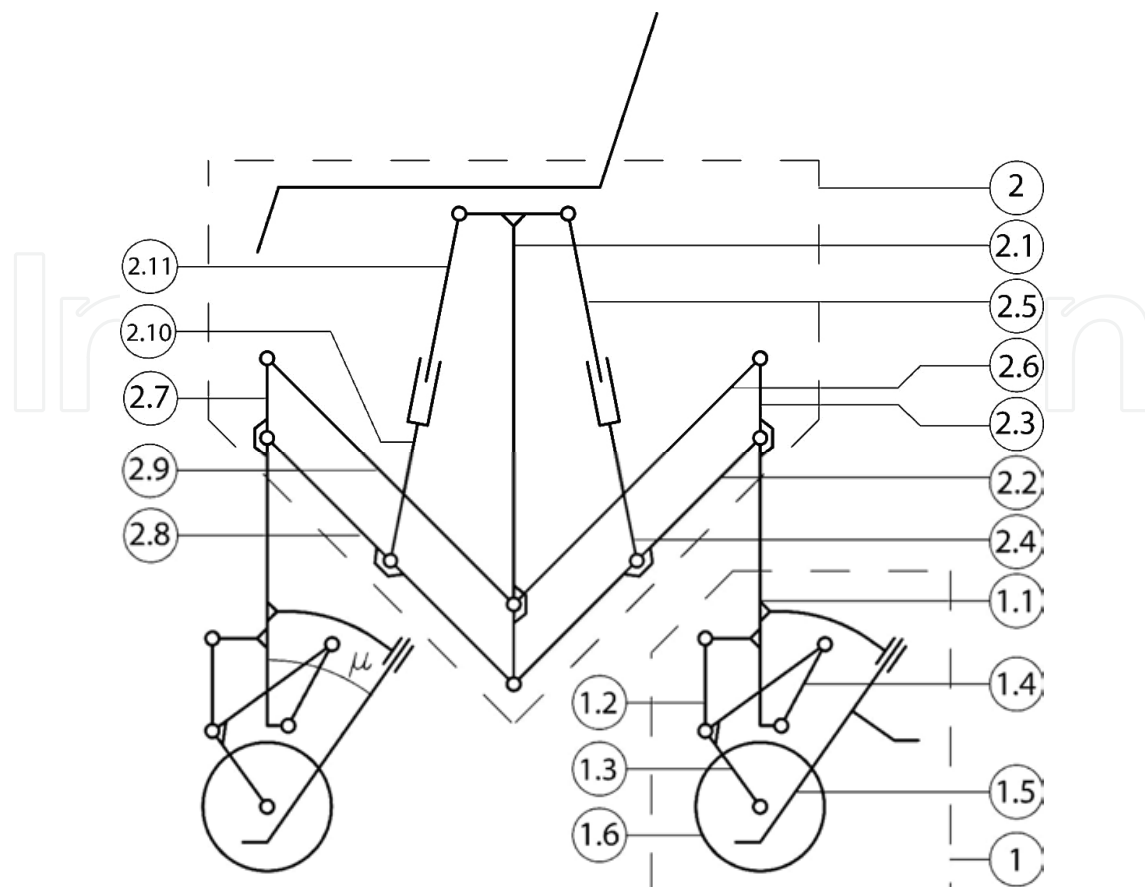


Fig. 3. Scheme of the entire prototype



Fig. 4. Climbing sequence for the rear axle

Upon completion of this process, the sliding support is retracted to prepare the system for the following step. The descent process is essentially the same, but the sequence of actions is inverted. In this case, the orientation of the wheelchair follows the normal direction of movement, and hence, the first operating axle is the front one.

One important feature of this system is its high payload capacity, which is of great importance in the carriage of large patients and heavy batteries. The proposed prototype can climb a staircase with a 200kg load (batteries not included). Table 1 shows the weight and weight-payload ratio for other climbing systems. The ratio of the proposed prototype is not achieved with actual tracks or rotating wheel clusters.

Vehicle	Locomotion system	Weight (kg)	Payload/Weight
Presented vehicle	Hybrid locomotion	72	2.53
XEVIUS (Yoneda et al. 2001)	Single Tracks	65	0.92
IBOT 3000	Wheel cluster	131	0.86
Stair-Climbing Wheelchair with High Single-Step Capability. (Lawn et al 2003)	Wheel cluster	160	0.5
ALDURO (Germann et al. 2005)	Hybrid locomotion	1500	0.32
Stair-Climbing Wheelchair in Nagasaki (Lawn et al. 2001)	Double tracks	250	0.32

Table 1. Weight and Weight-Payload Ratio for Actual Climbing Vehicles

2.2. Positioning mechanism

A closed-loop mechanism has been added to accomplish the positioning task, which is responsible for placing the climbing mechanism in such a way that the stability of the system is ensured. If only one step needs to be climbed then this is the only task accomplished by the positioning mechanism. But if it is necessary for both (rear and front) axles to be coordinated in order to climb a staircase, then the positioning mechanism must also accommodate the wheel base to the stair tread. Besides a time reduction, the coordinated climbing of both axles also facilitates control and increases energy efficiency.

The positioning mechanism is a closed-loop mechanism, and thus has a good performance in terms of rigidity, which consists of three platforms. The central platform (2.1 in Fig. 3) houses the seat and the batteries. The two lateral platforms (2.3 and 2.7) house the climbing mechanisms. The platforms are joined by two parallelograms (2.2, 2.6, 2.8 and 2.9, in gray) that prevent relative rotation between platforms. The system has two degrees of freedom which are driven by two linear actuators (2.4-2.5 and 2.10-2.10). These allow the system to alter both the vertical and the horizontal distance between the wheels, which allows the wheel base to be accommodated to the stair treads. The two degree of freedom system can also alter the height and orientation of the seat.

International standards impose a maximum and minimum width and height for steps. The positioning mechanism has been synthesized to maintain system stability for all the staircases built according to German Standard DIN 18065 (Fig. 5a). There are four extreme positions:

- N : maximum width and height. In this position the wheels are at maximum separation and both parallelograms will be collinear.
- N' : minimum width and maximum height. This is the staircase with the maximum slope (dark gray stairs in Fig. 5a).
- N'' : minimum width and height.
- N''' : maximum width and minimum height. This is the staircase with the minimum slope (light gray stairs in Fig. 5a).

These four points are the corner of a rectangle called an objective rectangle. When one of the wheels is in contact with the upper step, if the positioning mechanism is able to place the other wheel in the four corners of the objective rectangle, then the accommodation process for any staircase is achievable.

The design of the mechanism is an iterative process to synthesize the parallelograms. This process searches for a mechanism which can reach points N and N' (in this case points N'' and N''' can be also reached, as is shown by the dashed lines in Fig. 5a).

Fig. 5b shows the vectors used in the synthesis process, where r and s represent the lower bars of both parallelograms when the centre of the wheel is at N . When the wheel moves to N' these bars are represented by r' and s' . Vectors $R2$ and $R3$ belong to the lateral platforms and join the centers of the wheels with the joints of the parallelograms. The point P is the common joint of the parallelograms with the central platform.

The first step consists of defining vectors $R2$ and $R3$ according to the geometrical restrictions of the wheelchair. For example, the vertical component of $R2$ must be as short as possible because a large value implies that the seat is too high.

L will be defined as $L = r + s$, therefore $r = cL$, where c is a constant. The equation of the vector-pair r - s can therefore be written as follows (Erdman & Sandor, 1994):

$$cL(e^{i\alpha} - 1) + (1 - c)L(e^{i\beta} - 1) = D \quad (1)$$

where D joins points N and N' .

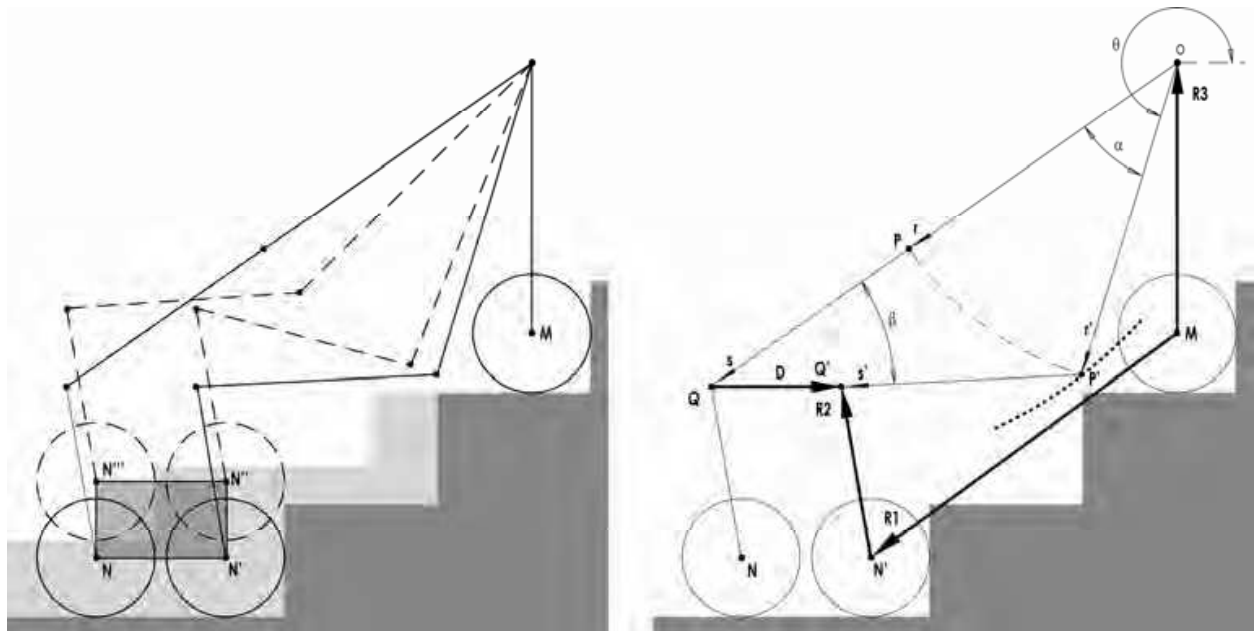


Fig. 5. a) Objective Rectangle and b) vectors used for the dimensioning

In this vectorial equation α , β , and c are unknown variables. If β is taken as a parameter, the analytical solution for α can be obtained.

$$\tan \alpha = \frac{(V_Y^2 - V_X^2 + 1) \sin \beta + 2V_X V_Y \cos \beta - 2V_Y}{(V_X^2 - V_Y^2 + 1) \cos \beta + 2V_X V_Y \sin \beta - 2V_X} \quad (2)$$

where

$$V = \frac{D}{L} - e^{i\beta} + 1 \quad (3)$$

The geometry of the system can be easily rebuilt when α is known. The dotted line in figure 5b represents the position of P for different values of parameter β . The position of P allows us to verify the suitability of the mechanism in order to avoid interferences with stairs. If a valid solution has not been found the process returns to the first step, and the initial values for $R2$ and $R3$ are altered.

The final geometry for Fig. 6 is obtained by repeating the iterative process for the positioning mechanism. The figure also shows the workspace (light gray) and objective rectangle (dark gray). It is worth mentioning that the wheelchair can climb the staircase even when the accommodating process is not carried out. It may thus be reasonable to use a narrower objective rectangle in order to obtain a more compact wheelchair. This rectangle should be chosen in such a way that the most usual staircases are included.

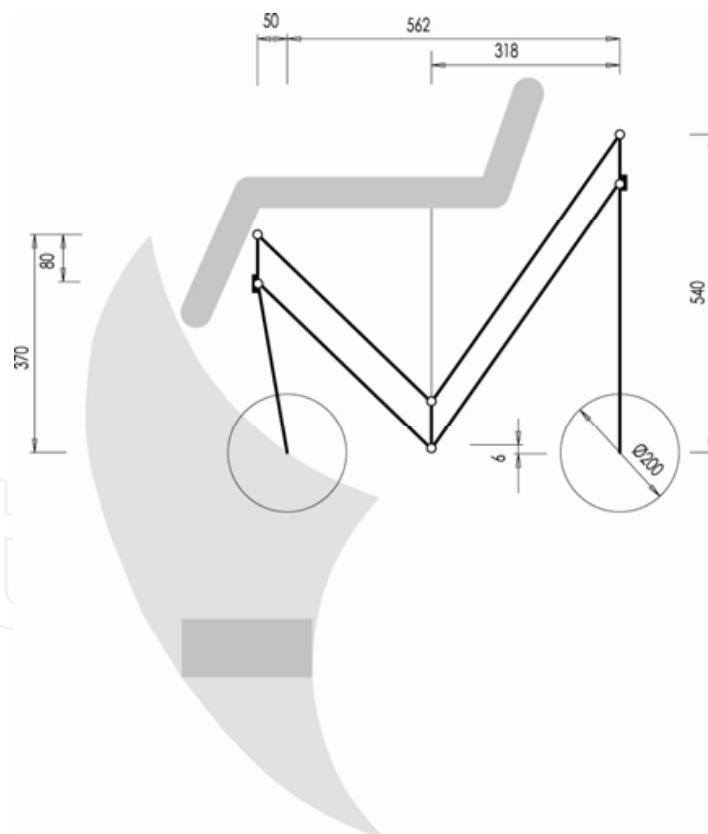


Fig. 6. Workspace, objective rectangle and final geometry

2.3 Experimental results

This section shows the experimental results obtained when the wheelchair climbs a single step of different heights, and when the wheelchair climbs a three-step staircase. The 3D positions of several points of interest have been measured with the Optotrack motion system, which is prepared with several infrared markers to record the trajectories of the platform and wheels, as is shown in Fig. 7.



Fig. 7. Position of the markers

In the first experiment, the wheelchair must separately climb single steps of 0.16m, 0.18m and 0.2m, with the aim of studying the horizontality of the seat.

The horizontality is maintained with a bang-bang control that receives the measurement of an inclinometer placed on the rear platform as the fed backward signal. This type of control has been chosen owing to the wide dead band of the linear actuators that make the use of continuous law control unsuitable. This gives rise to performances with slight oscillations due to natural or forced hysteresis in the control (see Fig. 8). Its frequency and amplitude can be reduced at the expense of a higher control effort.

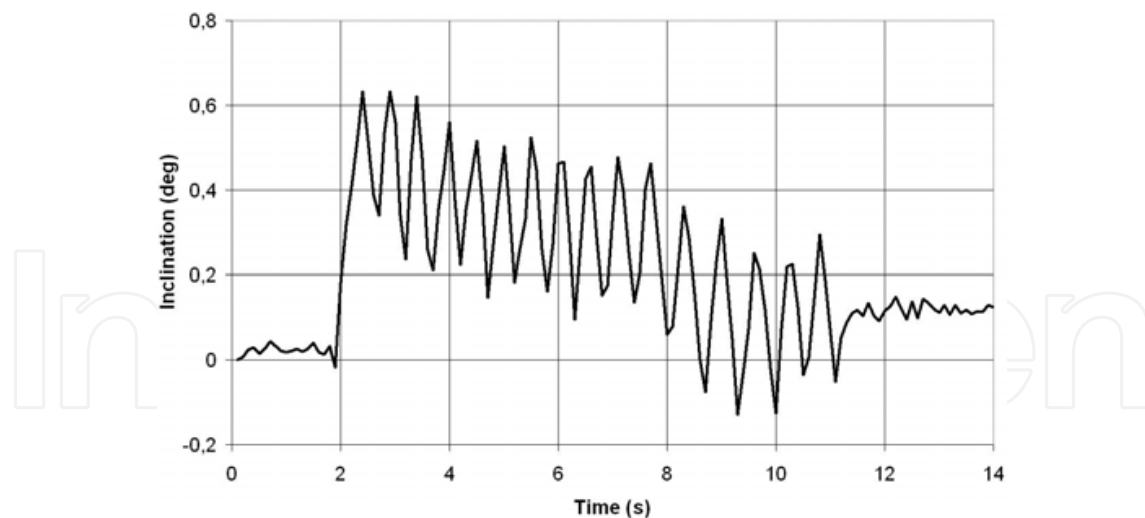


Fig. 8. Inclination of the prototype while climbing a 0.2m height step.

As Fig. 9 shows, markers 1 and 2 follow the trajectory of the sliding support (1.5 of Fig. 3), while marker 3 – the center of the rear wheel – presents a curved trajectory owing to the movement of the four link mechanism that allows the wheel to move backwards and avoid interference from the step.

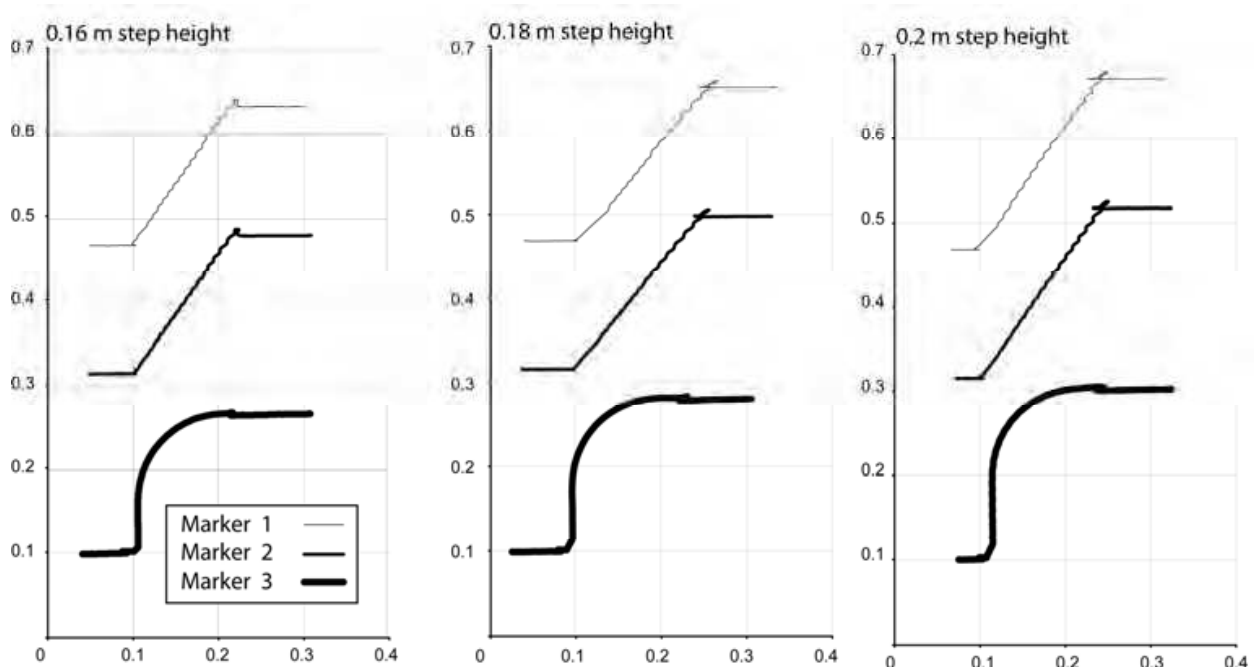


Fig. 9. Climbing of steps with 0.16, 0.18 and 0.2m step height

In the second experiment, the wheelchair climbs a three-step staircase. In order to maintain the center of masses as low as possible, the wheelchair is positioned backwards before accomplishing the climb. Figure 10 shows the trajectories regarding the rear axle markers in thick gray lines (markers 1, 2 and 3) and those of the front axle markers (4 and 5), in thin black lines. As pointed out in Fig. 10, the experiment passes through three stages:

- A. Climbing of rear axle while front axle remains on the floor. Segments of the trajectories that belong to this stage are labeled A in Fig. 10. The amplitude and the frequency of the oscillations are wider in this experiment because the hysteresis of the control loop has been increased.
- B. Simultaneous climbing of the rear and front axles. The segments of the trajectories that belong to this stage are labeled B in Fig. 10. The accommodation process must be performed in order to climb with both axles at once. In this stage the actuators of both parallelograms remain inactive and, therefore, the oscillations of the platforms are completely eliminated.
- C. Climbing of front axle with the rear axle on the upper floor. Segments of the trajectories that belong to this stage are labeled C in Fig. 10.

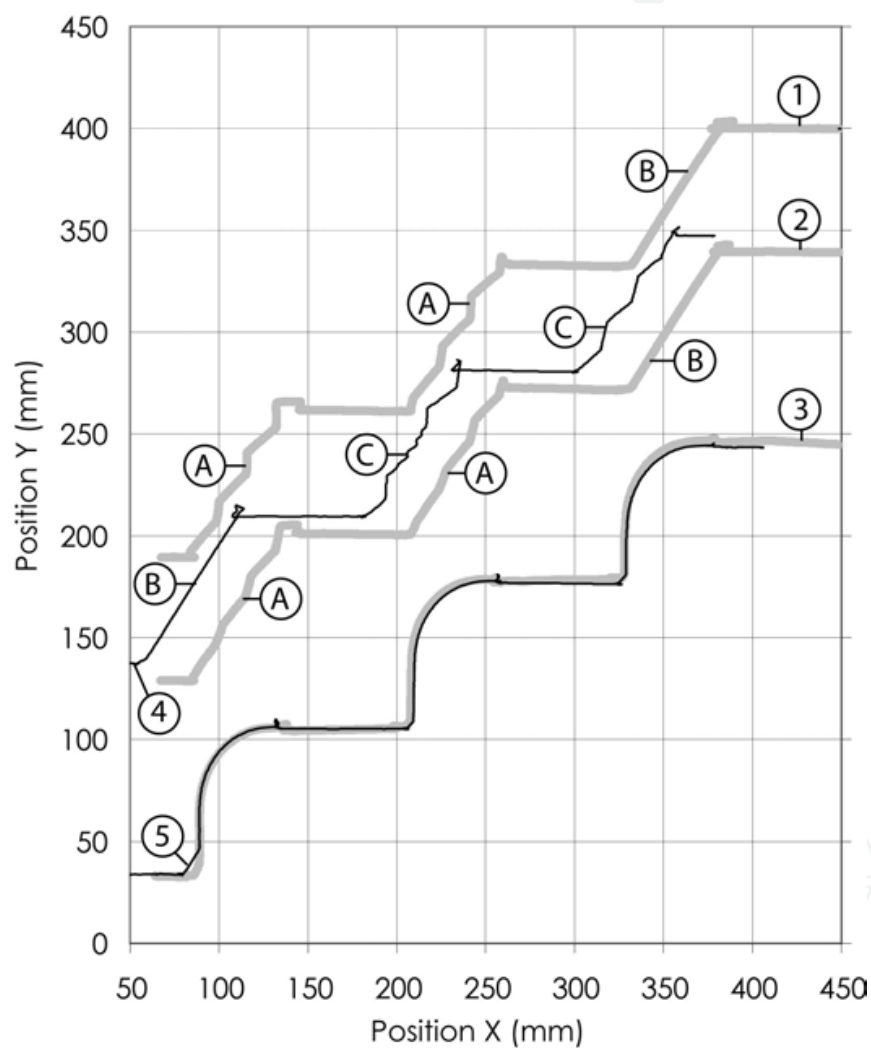


Fig. 10. Trajectories of rear and front platforms while climbing a three step staircase

3. Design of a Fast Controlled Leg for Walking Robots

3.1 Review of the current trend

In the present day, and owing to the power and low price of control units, a disregard is shown for the mechanical structure design of mobile robot legs. The structures currently used are based on serial combinations of joint + link, in which the actuator directly drives the joint. These structures are apparently similar to those in the human body or to those of certain animals.

However, these structures have several drawbacks:

- It is necessary to solve the inverse kinematics in order to establish the particular trajectories of each joint, which take the end of the leg to a determinate trajectory.
- The joint trajectories must be defined point to point, which implies:
 - A control unit for every joint
 - Continuous speed changes during acceleration and braking that drastically increase the energy wasted during the trajectory execution.
- There is a coupling between different joints to perform a determinate movement, which forces the designer to select the actuators in order to satisfy the requirements of force/torque and speed for the more demanding movements.
- The impacts suffered by the end of the leg against the floor or unavoided obstacles are directed towards the actuator shafts, which reduces its life time.

A partial copy of the human or animal structure therefore requires a high response speed from the control units, and a complexity that is not observed in the walking process of humans or animals. The low efficiency of the walking cycles and overdimensioning of the actuators signify that these robots have little autonomy, which is one of their main drawbacks.

In order to overcome this disadvantage, McGeer in (McGeer, 1990 and McGeer, 1990) introduced a new design of low-energy robots based on the concept of passive-dynamic walker, that could walk downhill a slope without consuming energy, only exchanging gravitational energy and kinetic energy, and finally converting them into losses due to friction and collisions.

With the same purpose but with a different approach, a new leg has been designed whose mechanical structure decouples the vertical and horizontal movement. A single control unit is therefore sufficient to set the trajectory of all the legs through the designation of few (4 or 5) points per cycle and leg. Furthermore, the motors are driven at a constant speed or constant acceleration during the majority of this operation, which increases efficiency.

Other advantages of the presented design are:

- It is possible to correctly select dimensioned actuators, with different characteristics, for each kind of movement: faster but with a lower load capacity for horizontal movements, and with a higher force/torque but slower for vertical movements.
- The decoupling of the movements simplifies the introduction of muscles with adaptable compliance (Gonzalez-Rodriguez et al., 2009), although this kind of mechanisms are not ready in present days to be used in active robots, except in the case of pneumatic robots (Grizzle et Poulakakis, 2008).
- A design that does not aim to mimic animal structures allows the actuator to be located at the hip, and far from the directions of reaction impact. Therefore and

respectively, the leg inertia is reduced – in the same way as for industrial robots – and the lifetime and reliability are increased.

It is also possible to include springs, in order to store and recover part of the kinetic energy, and therefore reduce energy losses.

3.2 Mechanical Design to facilitate the control

If a mechanism is intended to operate solely in obstacle-free terrains, the most suitable option is a wheeled vehicle, with higher performance in terms of efficiency, price, controllability, speed and payload.

However, when the terrain has certain characteristics that impede a wheeled robot from circulating, then it will also require some kind of legs, thus necessitating the configuration of a hybrid robot or a walking robot. The robot must also perform in an appropriate manner in terms of speed and autonomy when operating in obstacle-free terrains, which will probably be the most of the time.

This work presents a new design for a robot leg, whose synthesis searches for the simplification of the walking operation control in order to increase the robot's speed and efficiency when operating on a surface without obstacles. The structure of the leg and its control system must simultaneously be able to overcome obstacles (including steps) that are within the workspace of the end of the leg.

In a first stage, the structure has been designed as a mechanism with two degrees of freedom, which allows the end of the leg to move up/down and forwards/backwards. The (sagittal) plane within which the movement is performed will be called the *movement plane* and is parallel to the movement direction and to the vertical line.

Secondly, and with the aim of maintaining the robot's balance, a third degree of freedom has been added which permits movement plane rotation around the direction of the robot's movement. The operation of this actuator will not be dealt with in this work, and only the two degrees of freedom acting on the movement plane will be described.

The mechanism has been designed under the restriction that the traction movement, when the end of the leg is in contact with the floor, is performed by only one actuator, the other actuator being inactive. This implies that when in contact with the floor, the action on the traction actuator gives rise to a straight trajectory. To obtain this goal, two four-bar mechanisms have been included (see Fig. 11): the first is formed of segments a , b , c and d , and the second is formed of f , g , h and i . The input bar of the first four-bar mechanism (triangle $d f e$) is the frame of the second mechanism, and the coupler of the first four-bar mechanism (segment c) is joined to the input bar of the second mechanism.

Horizontal movement (the first DOF) is thus established by acting on the DC motor, and vertical movement (the second DOF) is determined by changing the length of the output bar b of the first four-bar mechanism, which is accomplished by means of the linear actuator.

Five precision points along the traction trajectory (Fig. 11a) have been used for the synthesis process (Erdmann & Sandor, 1994). The relatively low number of precision points allows us to choose the length of certain segments of the mechanism, and those remaining have been obtained by imposing that point P reaches the five precision points. These values are listed in Fig. 11.

This solution yields a straight segment for the trajectory of point P , and the traction trajectory can therefore be accomplished without the use of the unit control to continuously track the movement. The operation of the leg is therefore considerably easier.

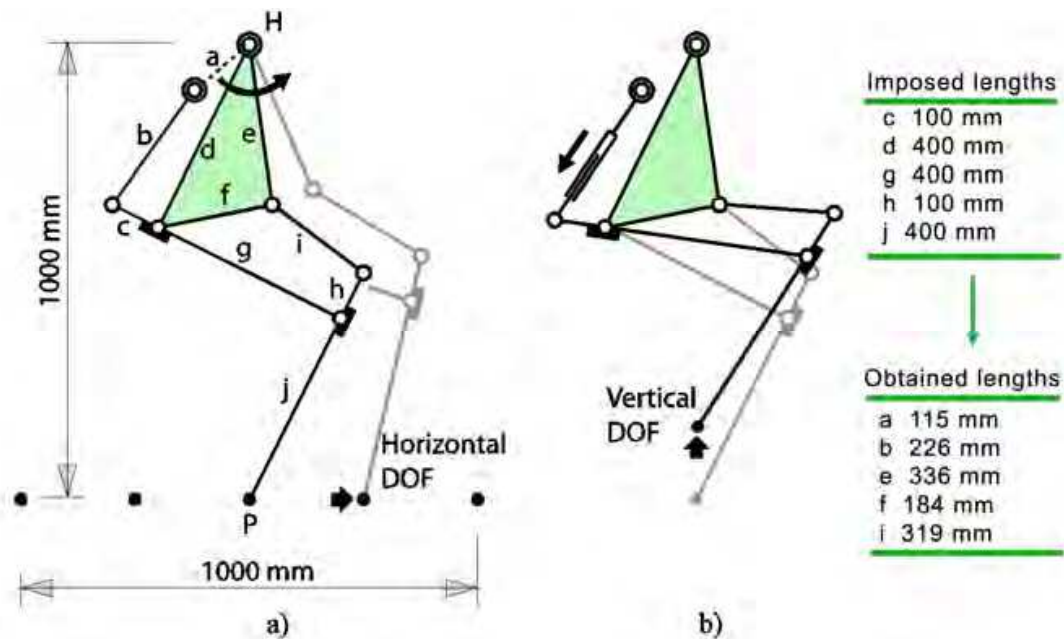


Fig. 11. a) Operation of first DOF of the proposed leg. b) Operation of the second DOF of the proposed leg with the starting and obtained lengths.

Mechanisms that trace a straight segment have been used in some low cost robots (Ottaviano & Ceccarelli, 2002) with only one DOF, but they are not able to overcome obstacles, and do not therefore show any advantage over wheeled robots. This ability is provided by a second DOF which, in the present design, alters the length of b in Fig. 11.

With regard to this DOF, a new condition has been imposed: when the frame of the second four-bar mechanism (which is responsible for vertical movement) is fixed and the point P is in the middle point of the horizontal trajectory, the actuation on the second DOF must give rise to a vertical movement of this point P . Vertical and horizontal movement can thus be operated quasi-independently, and the length of the remaining segments and the angle of the frame can therefore be obtained.

Fig. 12 shows a scheme that improves the performance of the previous scheme by adding a new four bar mechanism (the segments k, l, m and n). The new four bar mechanism has been synthesized as a function generator by using four-point Freudenstein equations as is shown in (Erdman & Sandor, 1994). The points in the function generation have been chosen in order to obtain a constant velocity of point P in the central part of the trajectory, specifically within the central 600mm, that is the rated step length of the mechanism. Despite this rated value, the leg is capable of taking shorter or longer steps (up to 1 m).

Far from the conditions in which the synthesis has been made, the trajectories are not straight lines and there is some coupling between vertical and horizontal movement. However, this coupling does not interfere with the good execution of the step in normal operation. A more complicated control of the trajectories is required when it is necessary for the leg to overcome an obstacle.

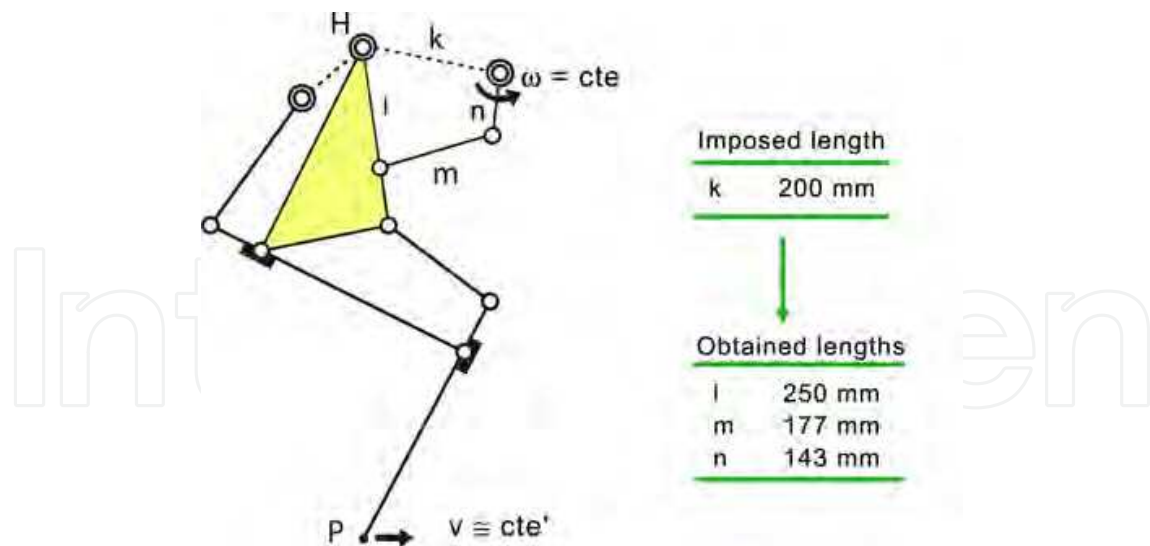


Fig. 12. A constant angular speed in the actuator is translated into a constant linear speed of point P

3.3. Simulation of the leg kinematics

In order to check the motion of the end P of the leg, a CAD model of the mechanism has been created, and an application to analyze mechanisms has been exported to ADAMS by following this geometry.

In the first step, simulations were performed to generate the workspace of the mechanism, shown in Fig. 13. The central line of the figure is the trajectory described by the support P when it commences a movement from the third precision point when only the linear actuator is being activated. The coordinate origin is at the hip H . As can be seen, the leg is able to overcome obstacles of up to 450 mm.

The validity of the synthesis is proven in Fig. 14, and the deviation of the support point P with regard to a straight line is presented in Fig. 14a) which shows variations lower than 2mm for a step of 0.6m long. This signifies a horizontality error of less than 0.4%, which is difficult to achieve by means of conventional robot legs when they are operated at normal speed.

Additionally, Fig. 14b) shows the linear speed of point P when the DC motor is driven at a constant speed of 150deg/s, and also for a step of 0.6m. For a vehicle speed of 1.5m/s, the speed variations are about 100mm/s, less than 7%. Although these are perfectly acceptable, and are also less than those of other legged robots, these variations between two legs in contact with the ground could give rise to the undesirable sliding of one of the legs.

With this design, since the horizontal movement of the leg can be accomplished by acting on a single actuator, the drive card is easily able to impose a torque control (the same value for both actuators) rather than a speed control to compensate the movements of both legs which, with the help of the inertia, makes the movement smoother and more energetically efficient.

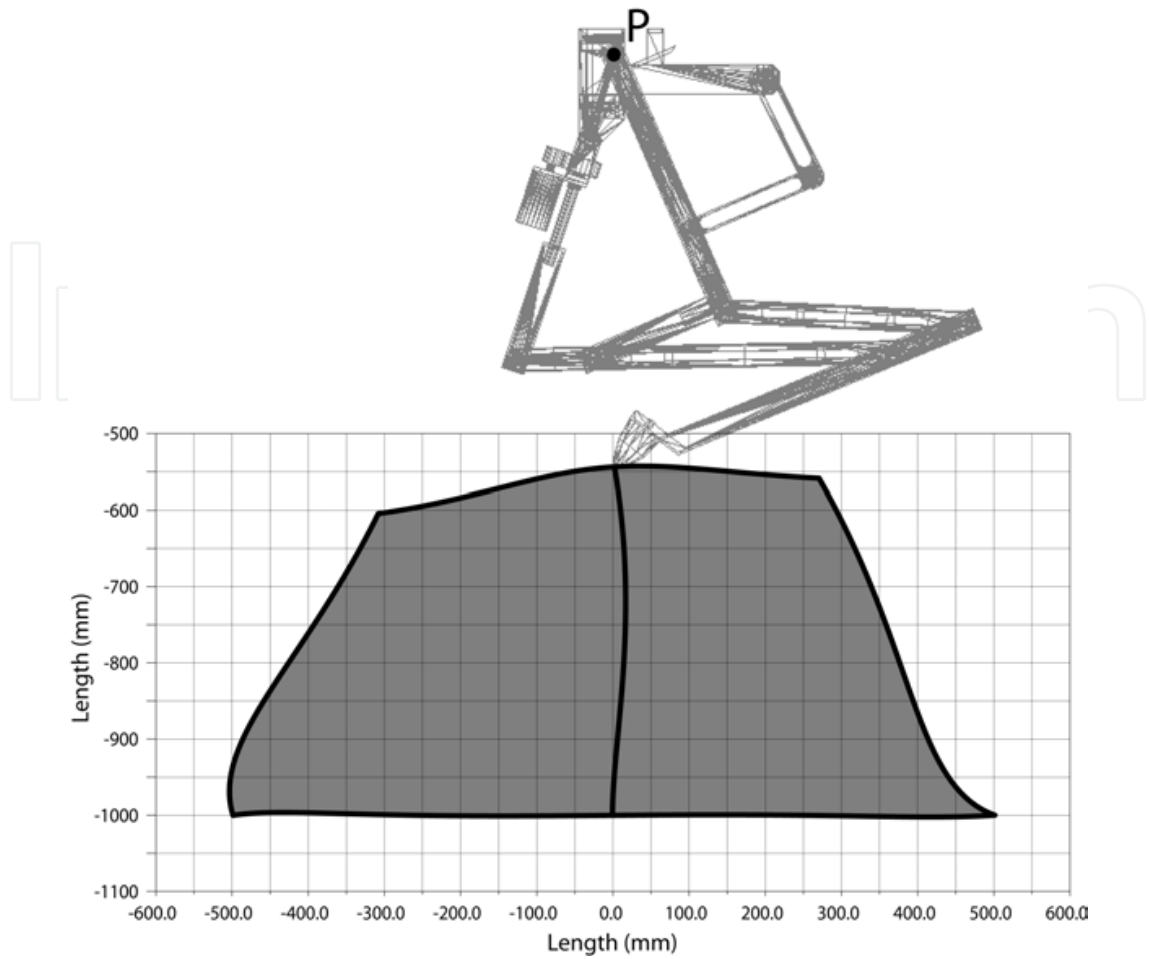


Fig. 13. ADAMS model of the leg and its workspace

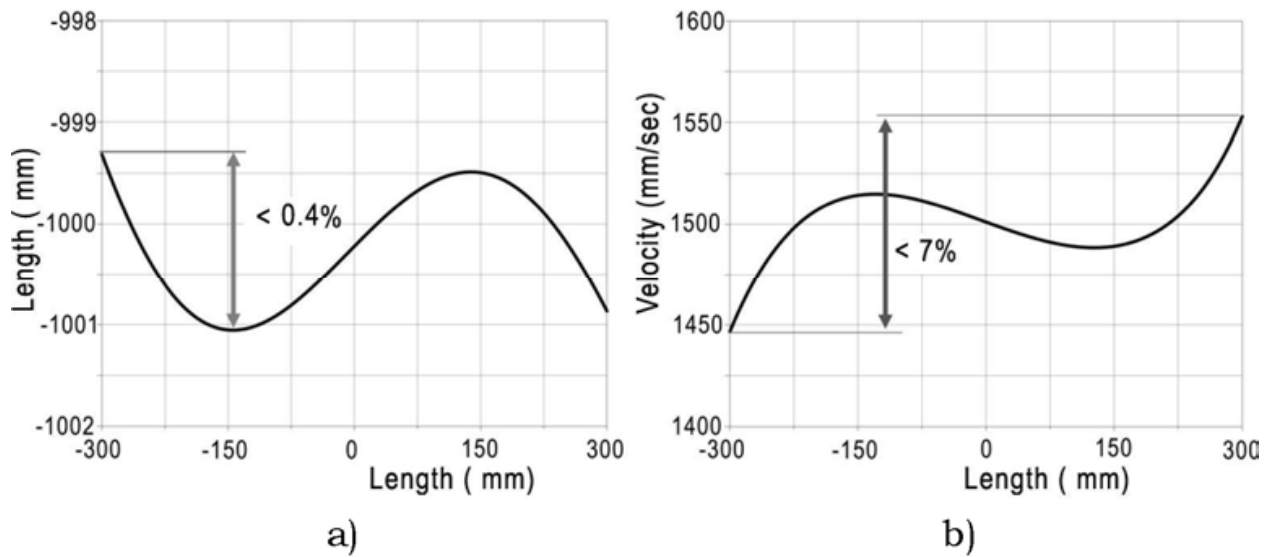


Fig. 14. a) Vertical position and b) horizontal speed of point P when only the horizontal movement motor is actuating

3.4. Simulations of the leg performance in a hybrid locomotion robot

The proposed mechanism was first included in a hybrid motion robot (Fig. 15) in which, as in the model described in (Chevallereau et al. 2003), the problem of lateral stability was initially disregarded. In our case two rear wheels have been added. The robot therefore consists of two articulated legs (those whose structure has been described) and two passive wheels located at the ends of another two articulated legs (those at the rear). These rear legs are fixed for movements on flat terrain, but will be controlled in future in order to overcome obstacles.

The 3D mechanical CAD program SolidWorks was first used to design the model, which was subsequently exported to ADAMS, although the rear legs ending in wheels were simplified as simple wheels, as can be seen in Fig. 15.

The values for stiffness and damping of the rubber support on the ends of the leg and the wheel tires have been experimentally obtained by means of a hydraulic actuator load cell. The obtained values have been incorporated into the ADAMS model in order to accomplish the dynamic simulation of the hybrid motion robot.

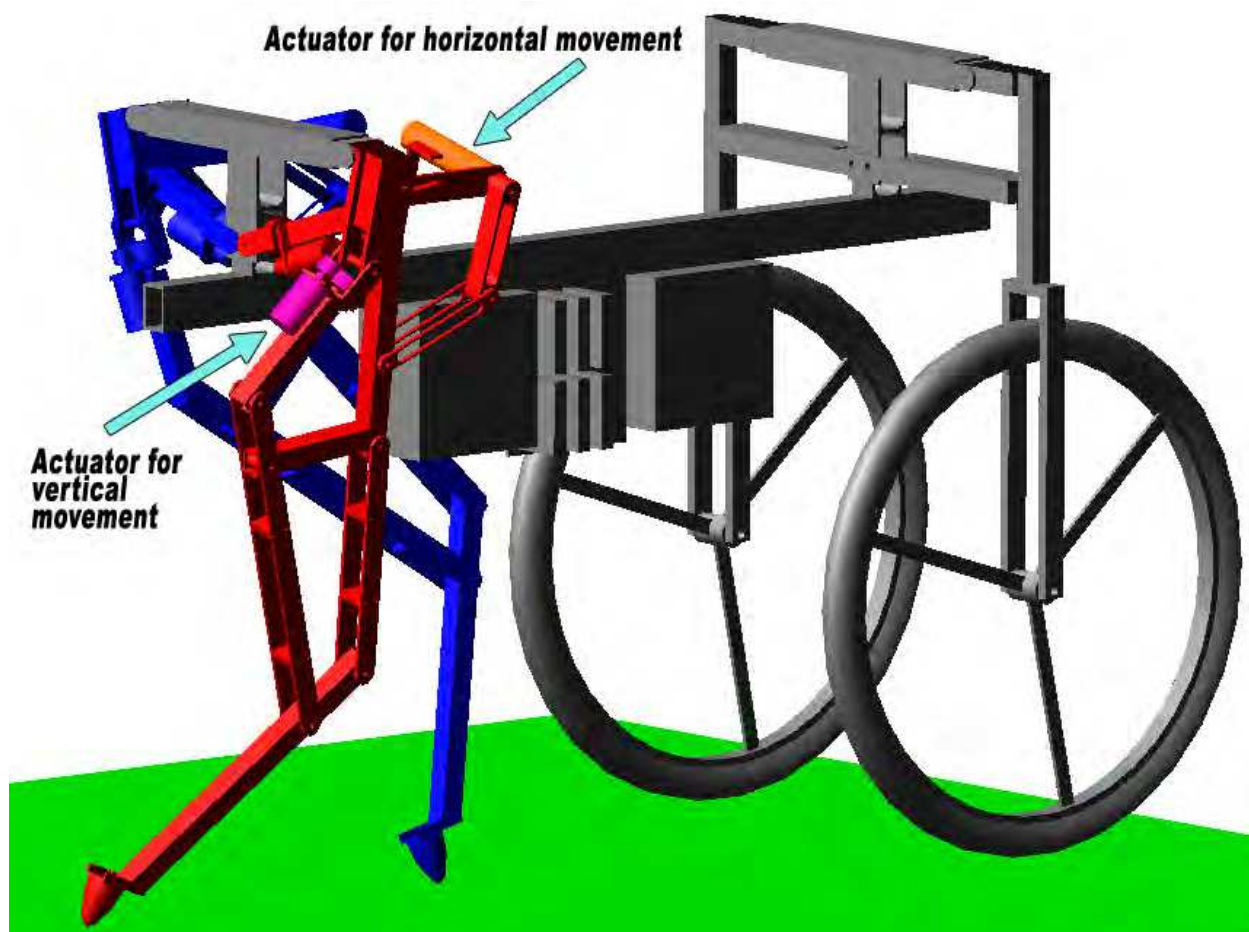


Fig. 15. ADAMS model of the hybrid locomotion robot used to test the proposed leg design

Figures Fig. 16 and Fig. 17 show, respectively, the speed patterns imposed on the linear actuator responsible for the vertical movement and on the DC motors for the horizontal movement. A transient stage can be seen at the beginning of the simulation with regard to the robot acceleration.

As can be seen, both the trajectories and the calculations involved are very simple. The velocity of the chassis center of mass is presented in Fig. 18, and has oscillations of less than 10% of the advance speed.

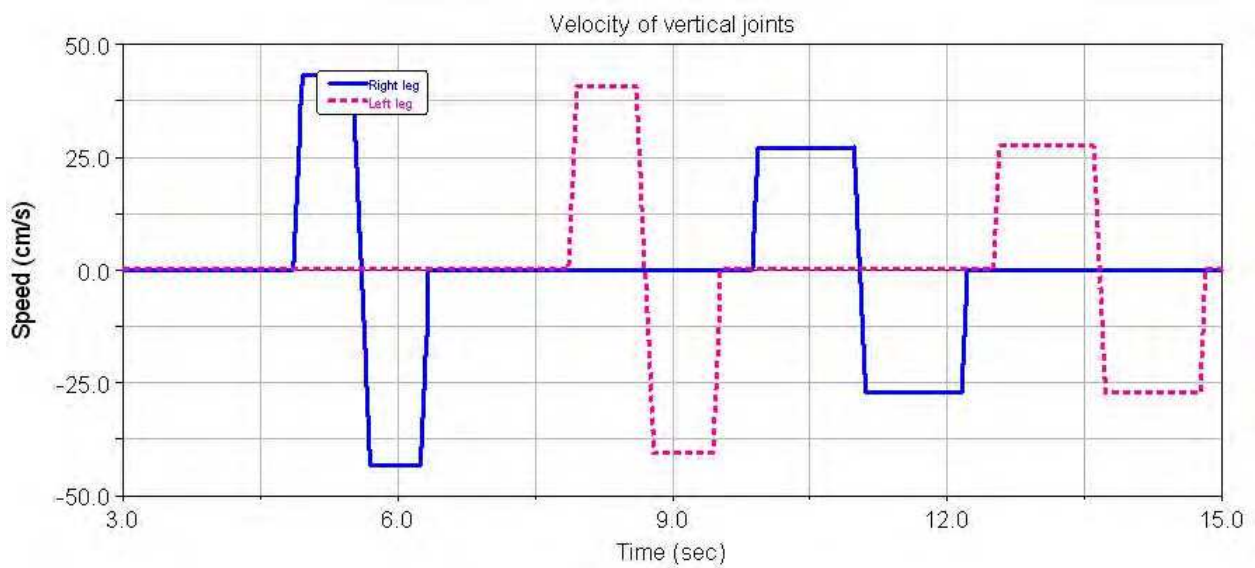


Fig. 16. Speed pattern for the actuator responsible for the vertical movement. The first patterns corresponds to the acceleration transient

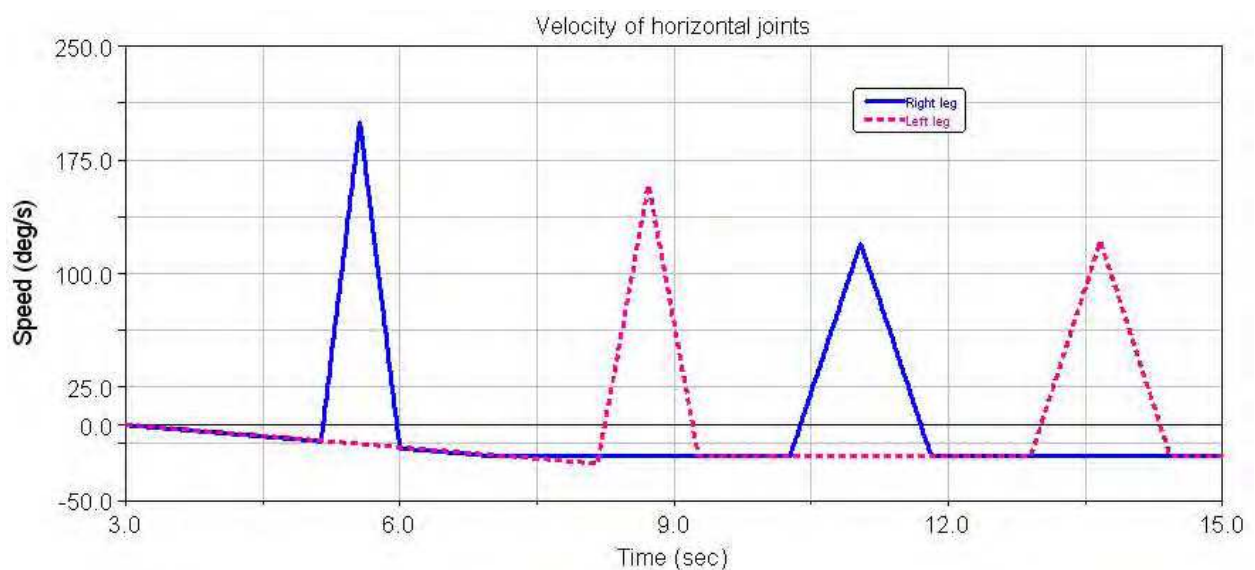


Fig. 17. Speed pattern for the actuator responsible for the horizontal movement

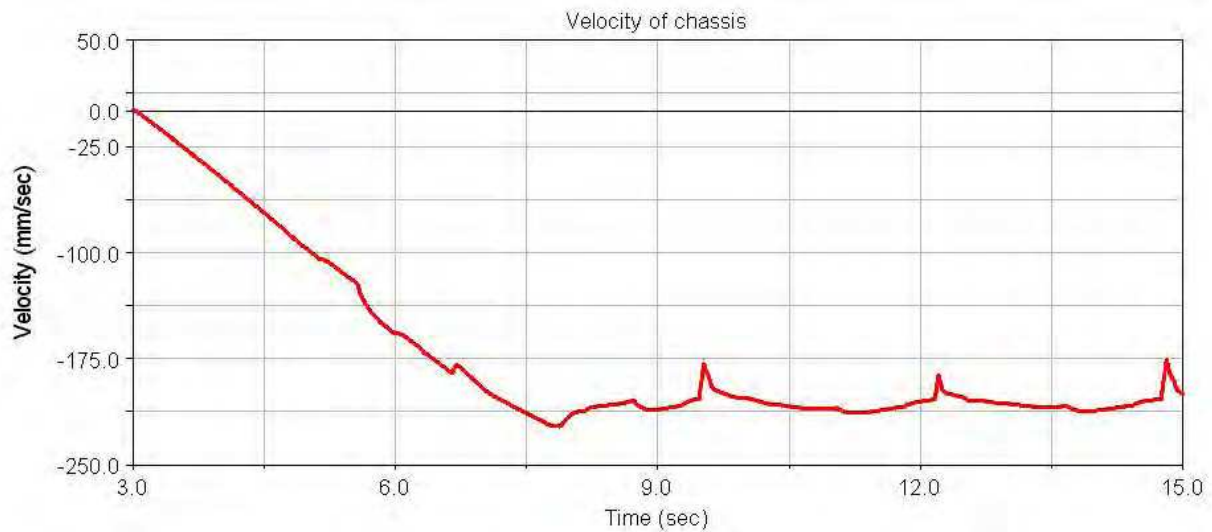


Fig. 18. Velocity of the robot chassis during acceleration and normal operation

Finally, the motor torques required to obtain the aforementioned speed patterns are shown in Fig. 19. The force for the vertical actuator appears as a dashed purple line, while the torque for the horizontal actuator is a solid blue line. The control signals for the actuators have been obtained through a closed loop PI controller, where the output speeds have been fed backward.

In order to perform a more realistic simulation, the control signals have been saturated to the maximum currents that the power electronic control units which will eventually be installed are able to supply.

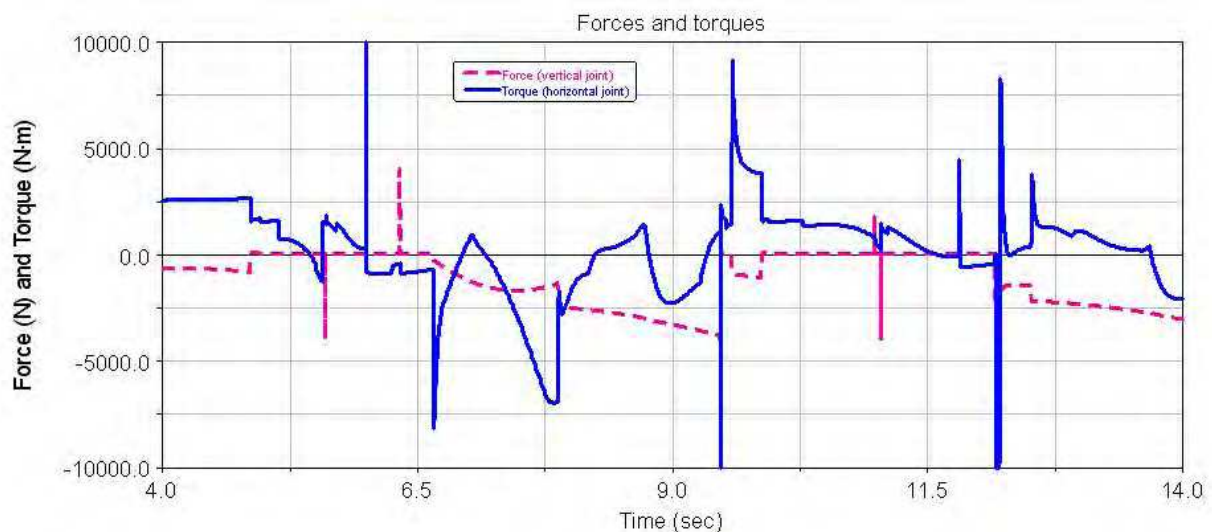


Fig. 19. Force and torque exerted by the actuators responsible for vertical and horizontal movements

4. Conclusions

Two different designs have been presented that contribute new approaches towards existing mechanical schemes.

The first prototype is a stair-climbing wheelchair designed with a new approach, based on splitting the stair-climbing process into two sub-problems: the ascent of each single step, and the positioning of the rear and front axles.

Each sub-problem is solved by using two independent mechanisms which are linked to create the final wheelchair. This new wheelchair has been modeled, built and tested. Its main features are:

- a) The ability to climb any staircase built according to international standards.
- b) Very high capacity load and weight ratio.
- c) Stable equilibrium is guaranteed.

The second prototype consists in a new design for a leg to be used in legged or hybrid robots.

The characteristics pursued and the advantages of the proposed structure are the following:

- The horizontal and vertical movement of the support point are decoupled, at least when in contact with the ground.
- The control task is very simple, with only two vertical movement commands and three horizontal movement commands per step and leg being necessary.
- The low number of movement commands leads to a high speed and high efficiency performance.
- The legged structure allows the robot to overcome obstacles, although in this case the control is not so direct, and the movements are not so fast and efficient, owing to the fact that the trajectory must be imposed not only during the traction but also during the flight stage.
- The motors and actuators can be independently selected for the vertical and horizontal movements, which allows the designer to select the gearboxes in order to achieve a higher speed for the horizontal movement and the load capacity for the vertical movement, without increasing the actuator capacity, and therefore without increasing its volume, height or price.
- A torque control rather than a speed control can be accomplished which facilitates the synchronization between the legs and smoothes the movements.

In the case of both designs, the authors wish to point out the importance of a suitable mechanical scheme, fitted to the problem to be solved, in the global design of a robot. This allows the system to increase its efficiency and performance, discharging the unit control for an unnecessary task.

5. References

- Chevallereau, C.; Abba, G.; Aoustin, Y.; Plestan, F.; Westervelt, E. R.; Canudas-De-Wit, C.; Grizzle & J. W. (2003). RABBIT: a testbed for advanced control theory. *Control Systems Magazine, IEEE*. Volume 23, Issue 5, (October 2003) pp 57 - 79, ISSN 0272-1708
- Erdman, A. G.; Sandor, G. N. (1994). *Mechanism Design: Analysis and Synthesis*, Prentice-Hall, ISBN 978-0132677820, New Jersey
- Germann, D.; Hiller, M. & Schramm, D. (2005). Design and control of the quadruped walking robot ALDURO. *Proceedings of 22nd International Symposium on Automation and Robotics in Construction, ISARC 2005*, pp 1-6. Ferrara, Italy, September 2005.
- Gonzalez-Rodriguez, A.; Nava, N. & Gonzalez-Rodriguez, A. G. (2009). Design and validation of a novel actuator with adaptable compliance for application in human-like robotics. *Industrial Robots*. Vol. 36, No. 1, (2009), pp. 84-90, ISSN 0143-991X
- Grizzle, J. & Poulakakis, I. (2008) Delft Pneumatic Biped. *Control Systems Magazine, IEEE*. Vol.28, no.4, (August 2008), pp.99-101, ISSN 0272-1708
- Lawn, M. J.; Sakai, T.; Kuroiwa, M. & Ishimatzu T. (2001). Development and practical application of a stairclimbing wheelchair in Nagasaki. *Journal of Human Friendly Welfare Robotic Systems*. Vol. 2, No.2, (2001) pp 33-39, ISSN 1598-3250
- Lawn, M. J. & Ishimatzu, T. (2003). Modeling of a Stair-Climbing Wheelchair Mechanism with High Single-Step Capability. *IEEE Transaction on Neural Systems and Rehabilitation Engineering*, Vol. 11, No. 3, (September 2003) pp 323-332, ISSN 1534-4320
- McGeer T., Passive dynamic walking, *International Journal of Robotics Research*, Vol. 9, No. 2, (1990) pp. 62-82, ISSN 0278-3649
- McGeer, T. (1990) Passive walking with knees, *Proceedings of IEEE Robotics & Automation Conference*, pp. 1640-1645, ISBN 1050-4729, Cincinnati, Ohio, May 1990
- Morales, R.; Gonzalez, A.; Feliu, V. & Pintado, P. (2004). Kinematics of a New Staircase Climbing Wheelchair. *Proceedings of the 7th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR 2004)*, pp 249-264, ISBN 978-3-540-22992-6, September 2004, Springer Berlin
- Morales, R.; Feliu, V.; González, A. & Pintado, P. (2006) Kinematic Model of a New Staircase Climbing Wheelchair and its Experimental Validation. *International Journal of Robotic Research*, Vol 25, No. 9, (2006), pp 825-841, ISSN 0278-3649
- Ottaviano E. & Ceccarelli M. (2002). Optimal design of CaPaMan (Cassino Parallel Manipulator) with a specified orientation workspace, *Robotica* vol. 20, No.2 (March 2002), pp.159-166, ISSN 0263-5747
- Yoneda, K.; Ota, Y. & Hirose, S. (2001). Development of a Hi-Grip Stair Climbing Crawler with Hysteresis Compliant Blocks, *Proceedings of 4th International Conference on Climbing and Walking Robots (CLAWAR 2001)*, pp. 569-576, ISBN 1-86058-365-2, Karlsruhe, Germany, September, 2001, Professional Engineering Publishing, Suffolk UK



Climbing and Walking Robots

Edited by Behnam Miripour

ISBN 978-953-307-030-8

Hard cover, 508 pages

Publisher InTech

Published online 01, March, 2010

Published in print edition March, 2010

Nowadays robotics is one of the most dynamic fields of scientific researches. The shift of robotics researches from manufacturing to services applications is clear. During the last decades interest in studying climbing and walking robots has been increased. This increasing interest has been in many areas that most important ones of them are: mechanics, electronics, medical engineering, cybernetics, controls, and computers. Today's climbing and walking robots are a combination of manipulative, perceptive, communicative, and cognitive abilities and they are capable of performing many tasks in industrial and non- industrial environments. Surveillance, planetary exploration, emergence rescue operations, reconnaissance, petrochemical applications, construction, entertainment, personal services, intervention in severe environments, transportation, medical and etc are some applications from a very diverse application fields of climbing and walking robots. By great progress in this area of robotics it is anticipated that next generation climbing and walking robots will enhance lives and will change the way the human works, thinks and makes decisions. This book presents the state of the art achievements, recent developments, applications and future challenges of climbing and walking robots. These are presented in 24 chapters by authors throughout the world. The book serves as a reference especially for the researchers who are interested in mobile robots. It also is useful for industrial engineers and graduate students in advanced study.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Antonio Gonzalez-Rodriguez, Angel G. Gonzalez-Rodriguez and Rafael Morales (2010). Mechanical Synthesis for Easy and Fast Operation in Climbing and Walking Robots, *Climbing and Walking Robots*, Behnam Miripour (Ed.), ISBN: 978-953-307-030-8, InTech, Available from: <http://www.intechopen.com/books/climbing-and-walking-robots/mechanical-synthesis-for-easy-and-fast-operation-in-climbing-and-walking-robots>

INTECH
open science | open minds

InTech Europe

University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

www.intechopen.com

www.intechopen.com

IntechOpen

IntechOpen

© 2010 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike-3.0 License](#), which permits use, distribution and reproduction for non-commercial purposes, provided the original is properly cited and derivative works building on this content are distributed under the same license.

IntechOpen

IntechOpen