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Biped Robot Driven By Single Actuator

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Abstract
Humanoid robots have always been a fascination for the human race. The biped robots are the most primitive form of humanoids which can exist. A biped robot can closely replicate the walking cycle of the humans. However to produce this cycle and to maintain its walk, the conventional biped robots utilize a number of actuators. The conventional styles of bipeds consist of an actuator to drive almost each joint individually. This individual control of each joint makes the control system complicated, demands high power, reduces the speed (If manually controlled) and requires large amount of feedback. Thus to reduce these losses and increase the output, a set of mechanisms can be used instead of actuators. It is found that if the number of mechanisms is increased by a meager amount then the actuators can be minimized to unity. The concept of a biped robot replicating the human walk cycle can thus be achieved by a single driving actuator.

Keywords: *Actuator, biped, walk cycle, power, feedback, unity*

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INTRODUCTION

The history of biped dates back to the year 1206 when the first biped design was presented by Al-Jazari. Leonardo Da Vinci also presented an idea of the automated biped robots in the 15th century. From this it can be easily understood that the trend of smudging the lines between the synthetic robot world and the organic human world started quite early and man has tried to search for the best and the simplest of ways to achieve it. The word biped comes from the Latin word Bi-'two' and Ped-'legs'. Hence anything walking on two legs is considered a biped. The biped robot with a single actuator is a completely mechanism based product[1].

The mechanism involves a set-up of gears and links which are synchronized efficiently with the proper suspension system to make the biped stable and smooth functioning. The stability of the robot is the major concern and that is well tackled in the design. The analysis shows that the angle at which the actuator is driving the robot also controls the 'turning while walking' phenomenon.

The major objective of the research is to spread the concept of under actuated sustainable robots resulting in low power consumption and to synthesize the human walk pattern on a robot driven by single actuator.

METHODOLOGY

The mechanism used in the making of the biped includes three major divisions. These three major divisions have been designed carefully to maintain stability and smoothness of the walking cycle.

The three divisions are as follows:

Bevel Gear/Differential Set-up

The differential setup as we know is used in automobiles to reduce the speed of one of the wheels while taking a turn. However the differential's most basic function is to provide an equal and opposite torque and turn to the shaft attached at each end. Hence the setup takes advantage of this basic function and utilizes it for the alternative forward and backward motion of the arm and the legs while walking.

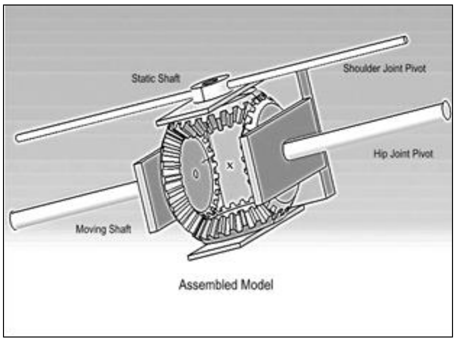


Fig. 1: *Differential Setup with Joints Shaft.*

In this we know that the coincidental shafts rotate in opposite direction and hence when one leg is forward the other leg will have to go back. When one leg pushes the biped front the second leg goes forward to land and achieve the first step. The most important feature of the differential is that it becomes completely locked and motion is not inhibited until and unless one of the gears is not driven and hence it will stay rigid when the power transmission stops. Hence, it will stand.

The same mechanism is used for the hands as well for the back and forth swing of the arm with alternate leg movement at same instant of time.

Reciprocating Elbow and Knee Mechanism

The elbows and most importantly the knee bending is crucial to maintain a continuous walk. Therefore with each swing of the arm and each step of the leg the elbow and the knee have to bend respectively. This is done using the concept that a point on the diameter of the circle will change its respective position from any fixed point P if the point does not lie on the centre of the circle. The basic anomaly of this concept is seen in slider-crank mechanism[3].

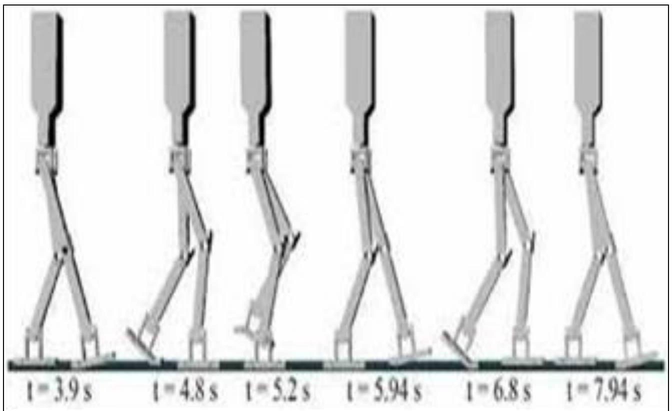


Fig. 2: *Swinging Motion of Arm and Leg[2].*

This knee is bent by using an external link which is attached to the hip. This external link is connected to a point on the diameter of the circle apart from the centre. Hence when the legs move forward or backward the external link applies a force on the point to which it is connected and hence forces the link of the knee to bend. Thus by the use of the analogous slider crank reciprocating mechanism the elbow and the knees can be controlled on every step individually and this angle of swing motion can be controlled by the number of revolutions of the actuator input.

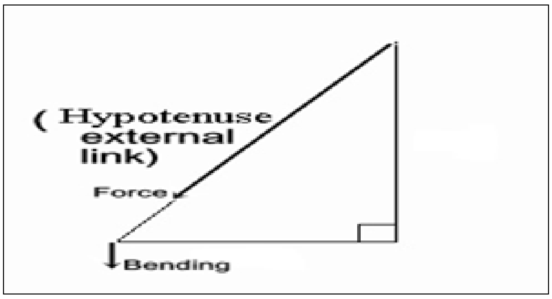


Fig. 3: *Analogous Slider Crank Mechanism.*

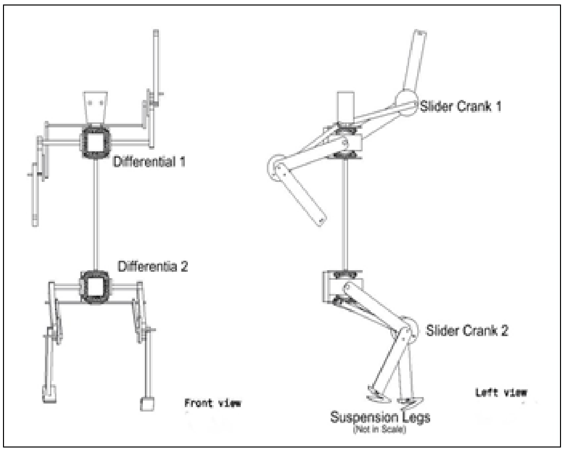


Fig. 4: *Rate of Change of Angle of the Knees in One Cycle of Walk[4].*

Suspension Mechanism (Feet Design) and Probable Profiles

The most basic requirements from the feets for a biped is the traction that it provides and the stability that it can give to the biped in both static and dynamic positions by proper load distribution.

Biomic studies have shown that the load or the stress acting on the legs are distributed. However this distribution is not completely equal on all the parts. It is rather unequally divided. The part of the feet containing the fingers recieves 10% of the total stress whereas the remaining back foot recieves the 90%. From this study alone we can conclude to a basic approach towards the designing of the profile and strengtheing of the sections of the foot[6].

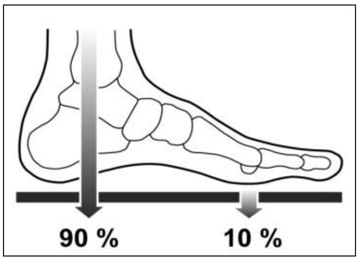


Fig. 5: *Load Distribution of Human Feet[5].*

The suspension system includes a compression spring at the backfoot which is designed in such a manner that when the entire load of the robot acts on it, it compresses and hence it enables proper pressure on the surface of the floor to provide better traction.

Another traction providing element will be the rubber sole made out of neoprene. Like the soles of ruber shoes or slippers the robotic feet will also consist of a similar traction bed below its sole.

It will ensure that the feet pushes the robot forward and slipping is avoided. Neoprene is chosen as the sole element because it is light in weight, doesn't undergo wear and tear quickly, also its deformation is less and it is hard in nature.

When cut, their inner surafce becomes optimum for the purpose.

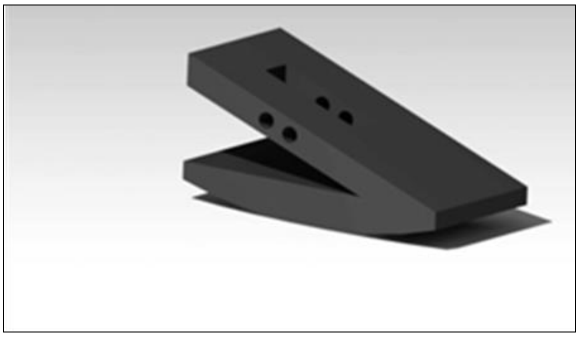


Fig. 6: *Neoprene Polymer Feet with Convex Hull Surface for Self Elastic Effect and Stability.*

BIPED ROBOT ASSEMBLY

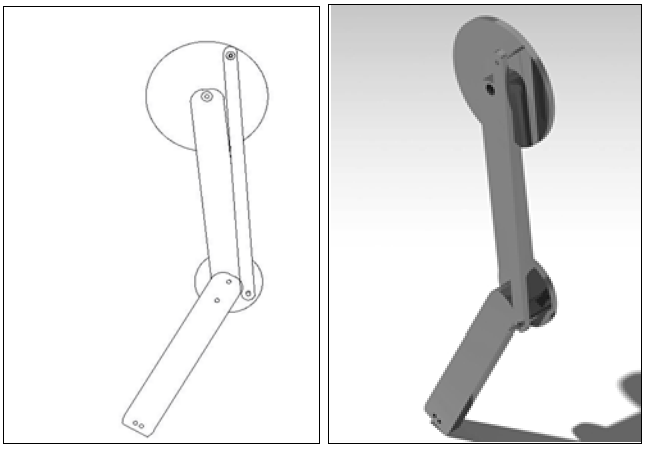


Fig. 7: *Assembly of Part Models using CATIA V5 2009.*

We can see a central shaft in the body of the robot. It is the shaft through which the power is transmitted throughout the body.

The motor is housed below the differential setup at the abdomen. This drives all the gears and the links in a well synchronized way to achieve the walk.

Biped Robot Specifications

- DC servo motor: 25 nm torque, Rated speed: 2000 rpm;
- Robot arm length: (upper arm: 300 mm) and (lower arm: 380 mm);
- Robot leg length: (thigh: 400 mm) and (shin: 480 mm);
- Total biped height: 1700 mm.

COMPARISION WITH CONVENTIONAL BIPED

A visiual inspection of the other biped robots present in the world today will tell us exactly how much less power this biped consumes. Also, the number of actuators used are easily spotted in them.

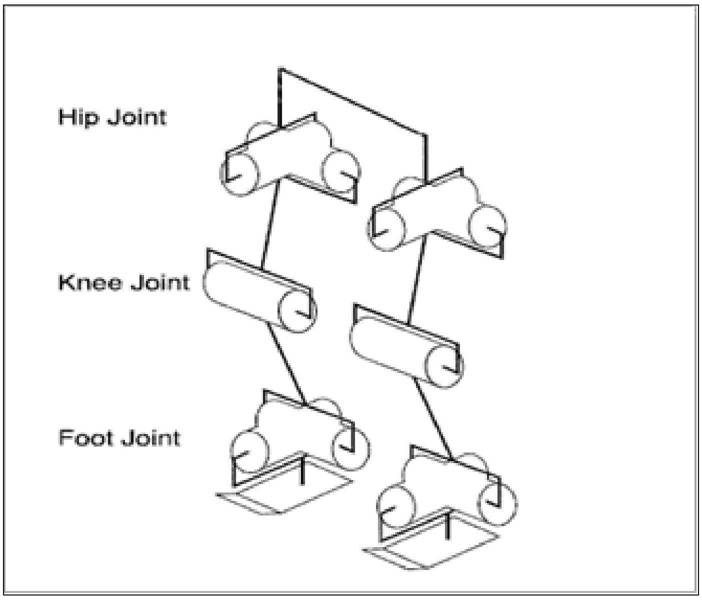


Fig. 8: *The Integration of the Three Set of Mechanisms leads to the Final Model of the Biped Driven by Single Actuator.*

Fig. 9: *The Conventional Robot Consisting of only Legs Housing Ten Actuators.*

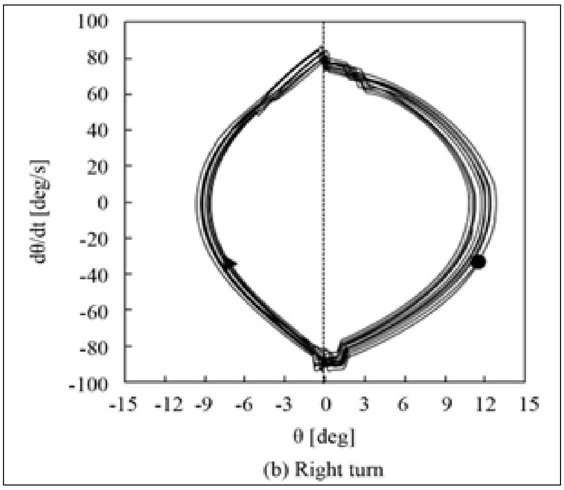
Since, a conventional biped uses a minimum of ten actuators for the motion of leg itself, power consumed by these biped compared with ours is 20 times more for the same walking mechanism.

The energy required by our proposed model is almost equal to the energy of human walking that is 700 kcal.

ANALYSIS

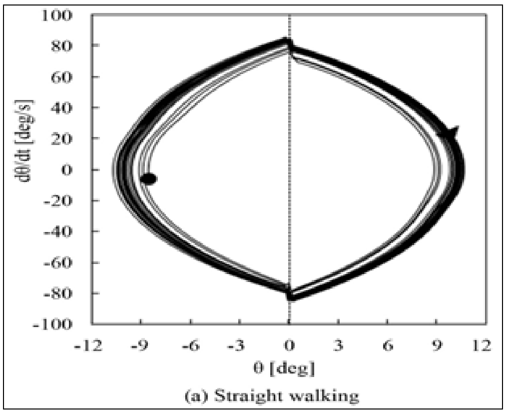
The biped is capable of taking turns.

This action is accomplished by making different angles at the two ends of the motor. A plotted graph explains how the turn is achieved.



Graph 1: *Angular Velocity Curve Plotted between rpm of Motor and Degree Motion of Legs for Right Turn*[7].

Where as to maintain a straight walk, the motor has to rotate equal angles at both ends of the mean angle.



Graph 2: *Plot between rpm of Motor and Degree Motion of Legs for Straight Walking*[7].

REFERENCES

1. En.wikipedia.org/wiki/Humonoid_Robot
2. Tatsunori Hirai, Nobutaka Isiki, Yuji Kawabe, *et al*. *Effective Development of Biped Robots by CAE*. Kijiro Watanabe Hosei University, 3-7-2 Kanjino-cho, Koganei, Tokyo 184-8584, Japan.
3. Jong Hyeon Park, Ohung Kwon. *Reflex Control of Biped Robot Locomotion on a Slippery Surface*. School of Mechanical Engineering, Hanyang University, Seoul, 133-791, Korea.
4. Amirhossein Karmi, Mohammad Danesh, Ashkan Tabibian, *et al*. *Dynamic Analysis and Path Planning for a Redundant Actuated Biped Robot*.
5. Jin'ichi Yamaguchi and Atsuo Takanishi. Development of a Biped Walking Robot Having Antagonistic Driven Joints Using NonLinear Spring Mechanism. Weseda University.
6. Hiroki Yamamoto. An Approach to Stable Walking on Unknown Slippery Floor for Biped Robot. Kouhei Ohnishi, Keio University, Japan.
7. Sangwan V., Taneja A., Mukherjee S. Design of a Robust Self-Excited Biped Walking Mechanism. Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India.