IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 40-45

Progression of Quadruped Robot: A Review

HarshalRewatkar, Krishna Limbad, Krishna Sharma,PriyankaNandurkar,TejaswiniKhobragade, ShubhamThaware,AbhayKasetwar
Department Of Electronics and Telecommunication Engineering
S.B. Jain Institute of Technology, Management and Research
Nagpur Maharashtra 441501
INDIA

Abstract: *Legged robots are now one of the most trending fields of research in robotics. The ability of legged animals to loco mote through different terrains is the key behind the efforts in such research. As traditional wheeled vehicles are restricted to provide universal locomotion due to challenges faced in different terrains, these legged robots provide solutions for the same challenges. Legged robots can provide mobility in adverse conditions such as elevated, swampy or potholed province.This universal accessibility is possible due to various proximity sensors, breakthrough actuators and refined computing. Here in this paper we aim to investigate distinct progressions in making of quadruped robots [1].*

I. Introduction

The worldwide interest in developing a quadruped robot to achieve animal like mobility was first experienced nearly five decades ago. In the year 1967 McGhee and Frank were the one who started to operate a computer controlled autonomous four legged robot, Phony Pony (*fig 1*), the first of its kind. For the next 50 years the world has witnessed various other modals and trends so as to ensure the desired traits in the robot. These works were truly dedicated to control the robot with relatively easier approach than the ones before it.In 2004, Pfeifer and Iida established a research line based on framework of a dog. They developed a Puppy robot which dwell eight passive joints, each able to achieve 1 degree rotational freedom. The structure of this robot was almost in conjunction with that of a dog. This robot turned out to be complicated when it came to its mechanical design [2].

Increase in Degree of Rotational freedom

1999 to 2004 validated another research line for four legged robot. It was named as Tekken I (*fig 2*), II and IV. This line was designed by Fukuoka and Kimura which ensured greater degree of freedom legs. Due to increased freedom of legs, the robot attained docile walking in resemblance to animal motion.

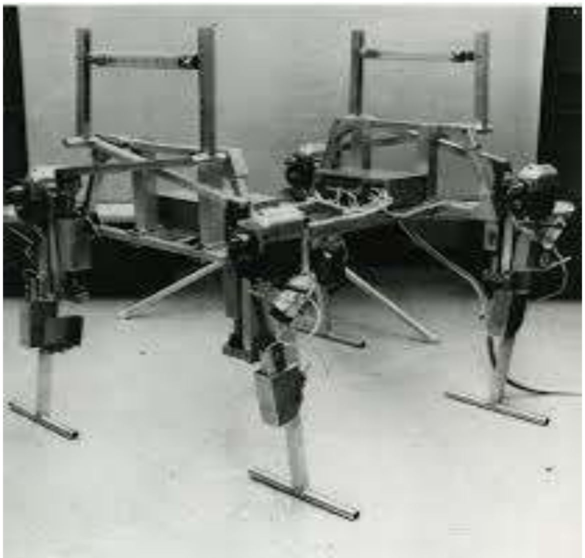

Fig.1 McGhee and Frank's Phony Pony (1968)

Each leg consisted hip pitch joint, a hip yaw joint, a knee pitch joint, and an ankle pitch joint. This increment in degree of rotational freedom resulted in increased weight and capacity of battery, complex leg execution, elevated cost, demanded high functioning controller and special sensors.

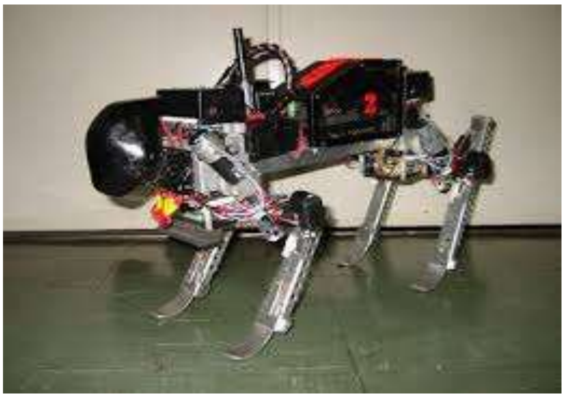

Fig.2 Tekken I

Decrease in Degree of Rotational Freedom

Poulakakis, Smith, and Buehler (2003) advanced to develop Scout II (*fig 3*). The concept of this research line was opposite to the one practiced by Tekken series. Here, the degree of rotational freedom was reduced in comparison to Tekken series. This robot was able to overcome the drawback of functional perplexity as it possessed simple mechanical design. Each leg assembly was divided as upper and lower, both connected through a spring. Thus Scout II had 2 degrees of freedom per leg but involved only a single actuator. Despite, the mobility was not very much the same as it was desired to be.Iida proposed another design of quadruped robot which had less degree of rotational freedom. This robot possessed a slider-crank mechanism which decreased one degree of freedom. However, the leg contained only one link, therefore, the mobility of robot failed to achieve periodicity

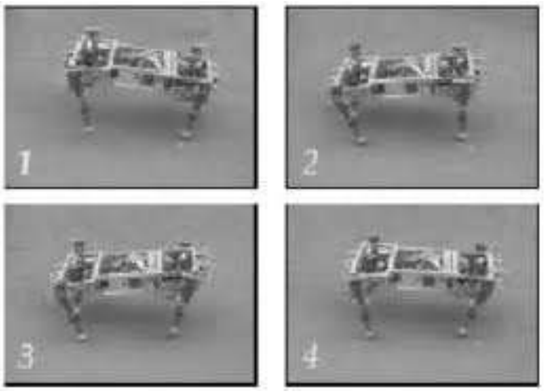

Fig.3 Scout II

AIBO: The Toy Robot

Fujita andKitaro constructed AIBO in 1998. Even though AIBO is a toyed robot, it is one of the most interesting robots ever. Its uniqueness was due to its large variety of sensors and 20 DOF which made it considerably perplex. The AIBO has seen as an inexpensive quadruped robot for research, because it has standard interface, and integrates a computer, vision system, and articulators in a package vastly cheaper than conventional research robots [7].

Fig.4 AIBO

II. Inspection of Quadruped Robot Design Ideas

Reduced DOF

In order to rotate the tip of the leg along oval trajectory, lida reduced a degree of freedom of each leg by slider-crank mechanism*(fig 5*), which is driven by an actuator. The tip of leg rotates along the arc trajectory. Thus, with this structure, one degree of freedom is decreased [8].

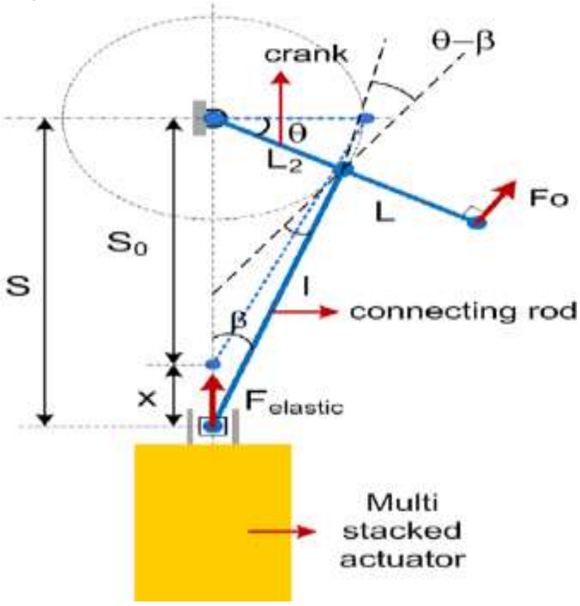

Fig. 5 Slider crank mechanism

B. Structure of leg to resemble musculoskeletal framework of a dog

All the animals have similar leg-joint physiology. The front leg is same similar to the rear leg. The motivation behind this legged design is to obtain flexibility and rhythm for leg mobility shown by the animals. A leg consists of three major segments: pelvis, femur (segment 1), tibia-fibula (segment 2), tarsal (segment 3), and toes. A dog's walk is referred as a diagonal walk i.e front left and right back legs move forward then the front right and left back legs move and so on. When the walk of dog is investigated, segment 1 and segment 2 nearly stay beeline, equivalent to one segment, and only the rotation at knee joint of segment 3 is observable. Therefore, the legs of dog in walk gait can be modeled by two links. The first link comprises of segment 1 and segment 2, and the second link is segment 3. Note that, the first link includes two degree of freedom. Based on these concepts, the various designs intended to have the body of robot more upright than previous quadruped robots [3].

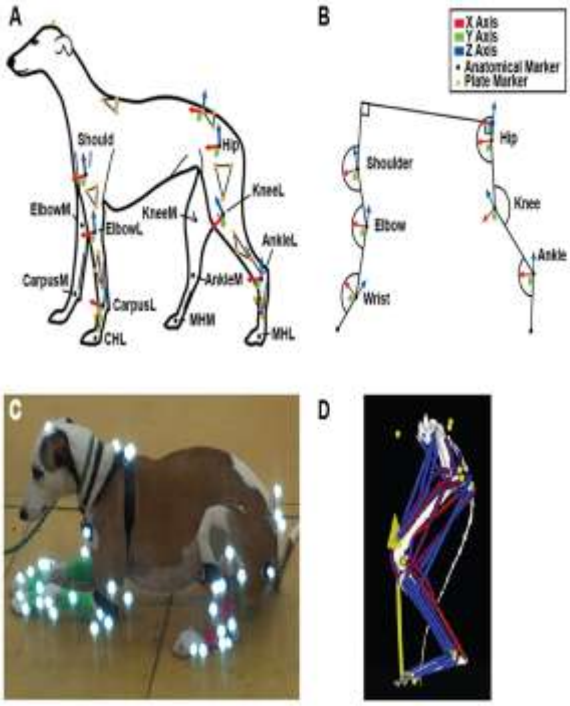

Fig.6 Musculoskeletal framework of a dog

III. Overview of the Quadruped Robot Control Ideas

A. Locomotion in Quadruped Robot

There are two primary stages of each step cycle: support stage (foot on ground) and transfer stage (foot in air). In this section, support stage is considered. Since leg geometry for 4 legs is similar, themovement for all of them is the same except for the fact that diagonally opposite legs are used during locomotion. Therefore, the strategy of control is established by modeling of each leg as a planar two link manipulator. Hence, if one assumes a path for quadruped robot, this robot is controlled to walk along a straight line, therefore, the 2 dimension is used [4].

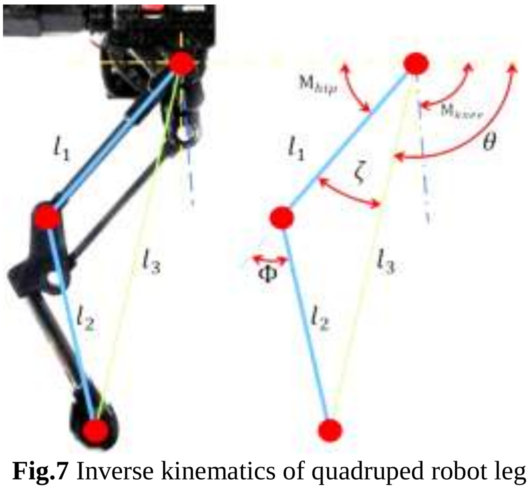

Fig.7 Inverse kinematics of quadruped robot leg

B. Bounding in Quadruped Robot

By sticking to the slider-crank mechanism, each leg of quadruped robot is oscillated by only constant voltage supplied for motor of hip joint; therefore, the controller needs no to use oscillatory position control in bounding gait [4].

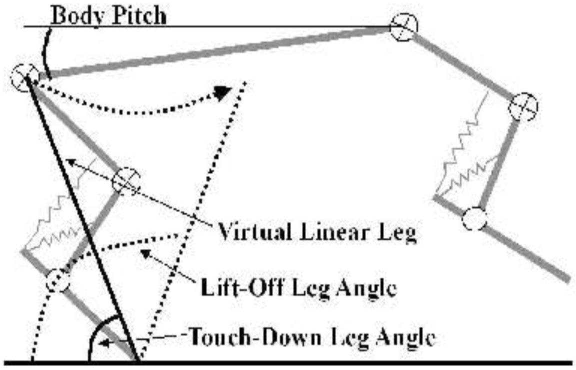

Fig.8 Bounding in quadruped robot

IV. Big Dog

Big dog is a legged robot which weighs about 109 Kgs, is about 1 meter tall, 1.1 meters long, and 0.3 m wide. It is regarded as one of the most revolutionary design in the world of four legged robot development. This ideal system is capable of travelling anywhere a person or animal could use their legs. It's capable of running for several hours while carrying its own fuel and payload. It requires very less human interaction to manage its motion in different and difficult terrains. Big Dog has about 50 sensors which help it to anticipate its surrounding and work accordingly. This giant robot has also jumped about 1.1 meters and carried various loads. On flat terrain Big Dog has carried 154 kg, although loads of 50 kg are more typical. Big Dog has onboard systems that provide actuation, power, sensing, controls and communications. The power supply is a water-cooled two-stroke internal combustion engine that delivers about 15 hp. Hydraulic pump is droved by this which delivers high-pressure hydraulic oil through a system of filters, manifolds, accumulators and other plumbing to the robot's leg actuators. The actuators are low-friction hydraulic cylinders regulated by two-stage aerospace-quality servo valves. Each actuator consist sensors for joint position and force. Each leg possesses four hydraulic actuators that power the joints, as well as fifth passive degree of freedom [6].

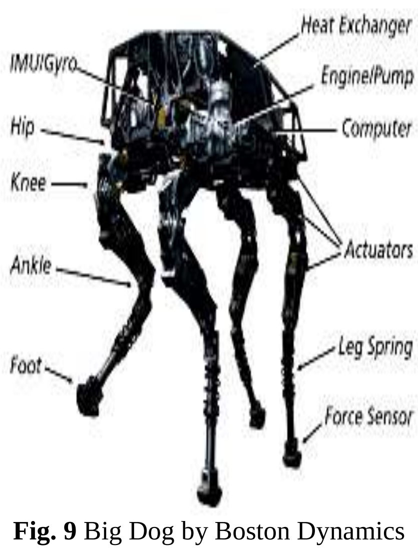

Fig. 9 Big Dog by Boston Dynamics

V. Conclusion

Legged robots display significant advantages over wheeled and tracked vehicles because they allow locomotion in terrain inaccessible to these traditional vehicles, since they do not need a uniform and continuous support surface. This paper has presented a survey of several strategies, biological animals characteristics, the use of evolutionary computation for the optimization of the legged structure parameters. Although the referred aspects indicate that legged locomotion is advantageous when compared with traditional locomotion systems, it should be kept in mind that, in their present state of development, these vehicles still suffer from huge limitations, since they exhibit low speeds, are difficult to build and need complex control algorithms. It is expected that in the future vehicles adopting locomotion through artificial legs may become an efficient transportation mode that can compete with other classical transportation means. However, as stated previously, in their present state of development, there are several aspects that have to be improved and optimized.

References

[1]. M.G.Bekker"*Introduction to Terrain Vehicle Systems"*inUniversity of Michigan Press (1969).
[2]. Buehler, M.Battaglia, R.Cocosco, A.Hawker, G.Sarkis, J. Yamazaki *"Simple Quadruped That Walks, Climbs and Runs"*.in ICRA (1998).
[3]. Albiez, J & K. Berns "*Biological Inspired Walking – How Much Nature Do We Need?"(2006).*
[4]. Dunn, E.R. & R.D. Howe *"Foot Placement and Velocity Control in Smooth Bipedal Walking" inIEEE International Conference(1996).*
[5]. Garcia, E., J. Estremera, & P. Gonzalez de Santos*"A Classification of Stability Margins for Walking Robots, Climbing and Walking Robots" (2002)*.
[6]. *M*. Raibert ,*"BIG DOG: The quadruped robot" (2008)*.
[7]. MM Viloso, "*Creating an intelligent AIBO robot" (2006)*.
[8]. Y Geva, *"Anovel design of quadruped robot" in SAGE Journals (2014).*