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MECHANICAL LEG GEOMETRY OF A WALKING ROBOTUSING DEGREES OF FREEDOM

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ABSTRACT

Walking robots use legs with from one to four degrees of freedom (DOF). There are so many varieties of layouts only the basic designs are discussed. It is hoped the designer will use these as a starting point from which to design the geometry and actuation method that best suits the application.

KEYWORDS: Leg Geometry, Degrees of Freedom (DOF), Intelligence System & Robotics.

INTRODUCTION

The simplest leg has a single joint at the hip that allows it to swing up and down (Figure 1). This leg is used on frame walkers and can be actuated easily by either a linear or rotary actuator. Since the joint is already near the body, using a cable drive is unnecessary. Notice that all the legs shown in the following figures have ball shaped feet. This is necessary because the orientation of the foot is not controlled and the ball gives the same contact surface no matter what orientation it is in.

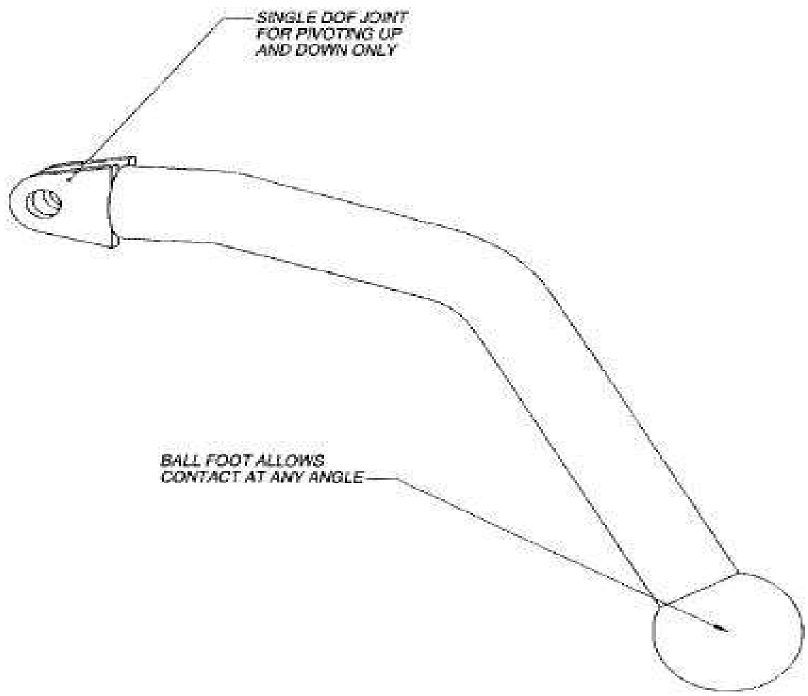

Figure 1.One-DOF leg for frame walkers

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A second method to surmount adding orientation controlled feet is to mount the foot on the end of the leg with a passive ball joint. The following four figures show two-DOF legs with the different actuation methods. These figures demonstrate the different attributes of the actuation method. Figure 2 shows that linear actuators make the legs much wider in one dimension but are the strongest of the three.

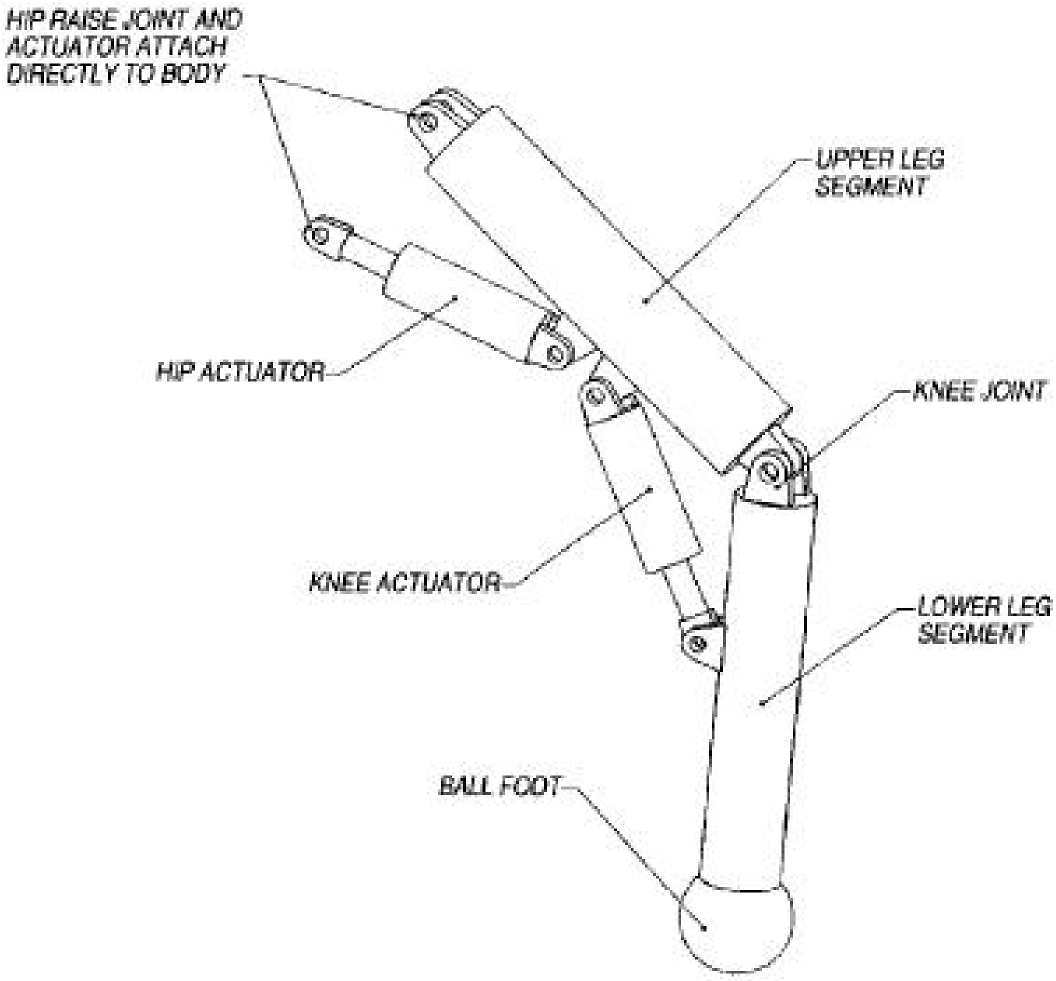

Figure 2.Two-DOF leg using linear actuators

Figure 3 shows a mechanism that keeps the second leg segment vertical as it is raised and lowered. The actuator can be replaced with a passive link, making this a one-DOF leg whose second segment doesn’t swing out as much as the leg shown in Figure 2.

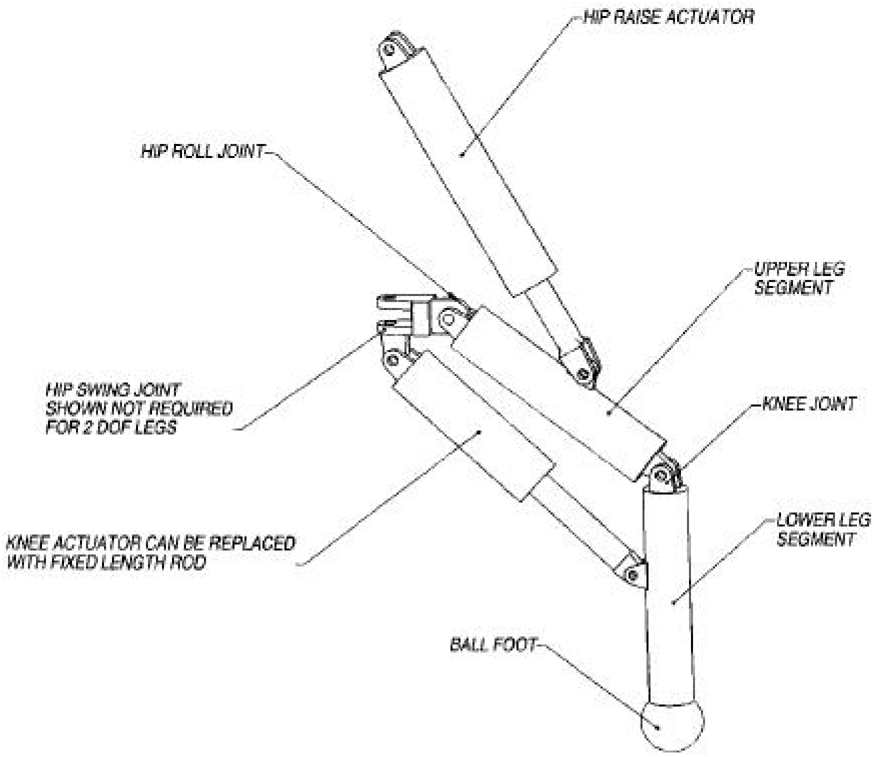

Figure 3.Two-DOF leg using linear actuators with chassis- mounted knee actuators

Rotary actuators (Figure 4) are the most elegant, but make the joints large. The cable driven layout (Figure 5) takes up the least volume and has no exposed actuators.

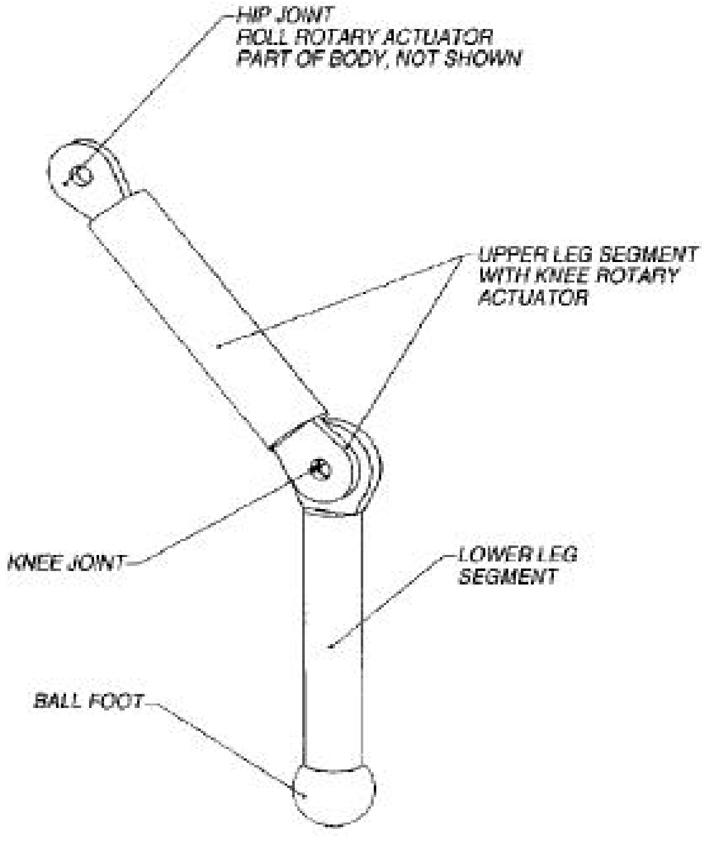

Figure 4.Two-DOF leg using rotary actuators

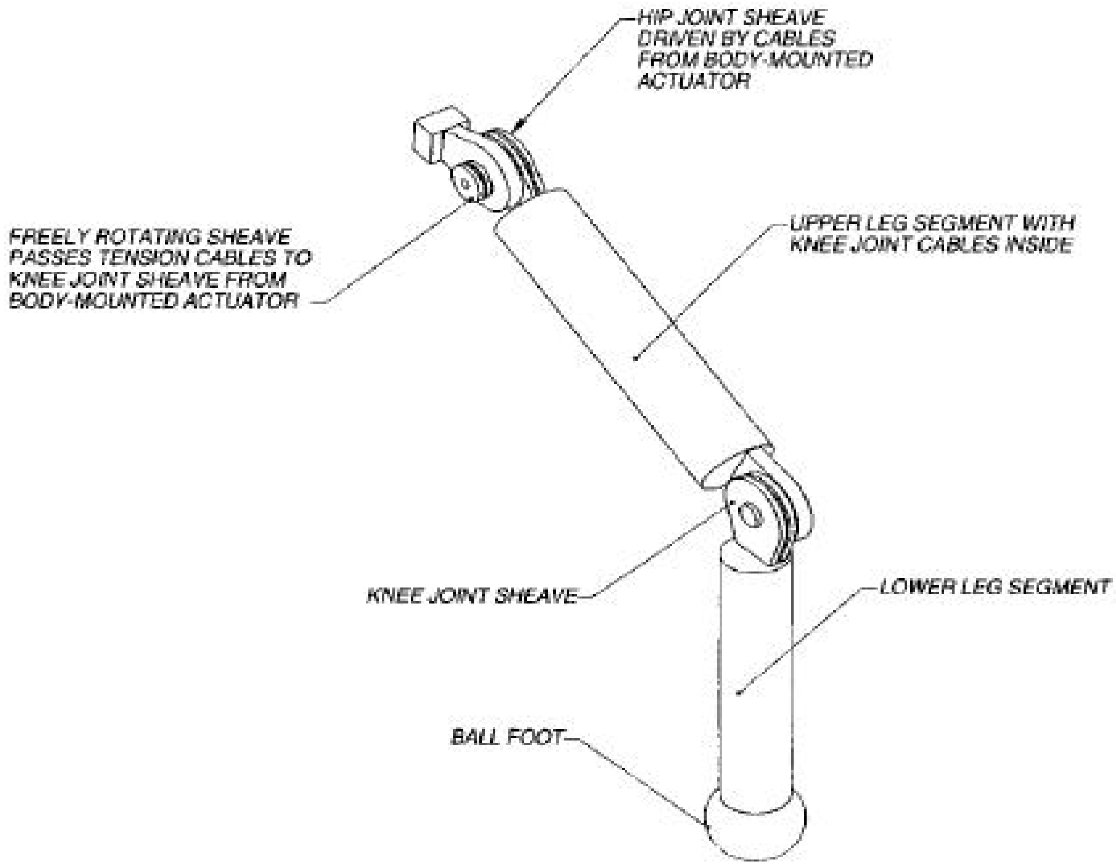

Figure 5.Two-DOF leg using cable driven actuators

Both of these methods are common, mostly because they use motors in a simple configuration, rather than linear actuators. Their biggest drawback is that they need to be big to get enough power to be useful. iRobot's Genghis robot used two hobby servos bolted together, acting as rotary actuators, to get a very effective two axis hip joint. This robot, and several others like it, uses simple straight legs. These simple walker layouts are useful preliminary tools for those interested in studying six-legged walking robots. To turn the two-DOF linear actuator layout into a three-DOF, a universal joint can be added at the hip joint. This is controlled with an actuator attached horizontally to the chassis. Figure 6 shows a simple design for this universal hip joint.

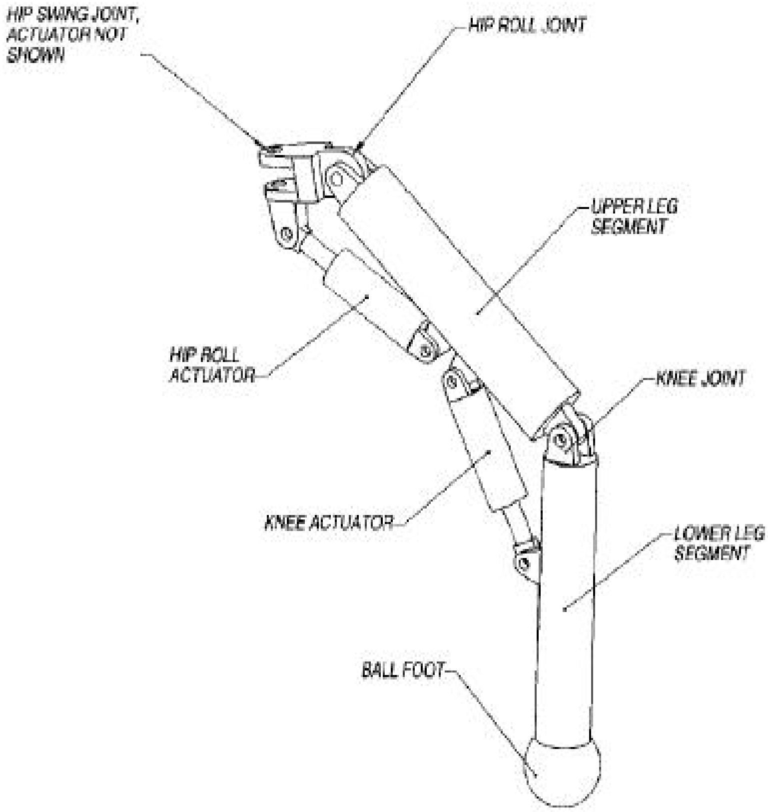

Figure 6.Three-DOF leg using linear actuators

The order of the joints (swing first, then raise; or raise first, then swing) makes a big difference in how the foot location is controlled and should be carefully thought out and prototyped before building the real parts. The three-DOF rotary actuator leg (Figure 7) adds a knee joint to the Genghis layout for improved dexterity and mobility.

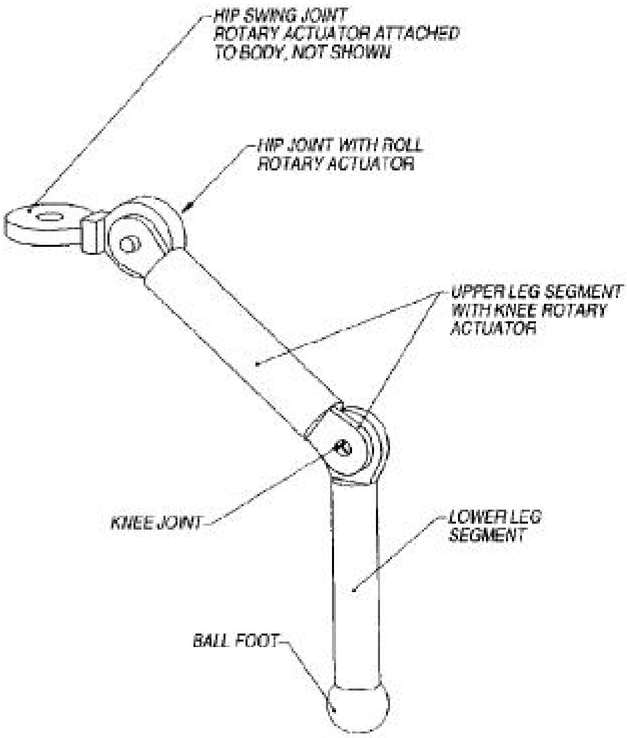

Figure 7.Three-DOF leg using rotary actuators

There are many varieties of this layout that change the various lengths of the segments and the relative location of each actuator. It is quite difficult to drive a two-DOF hip joint with cables, but it can be done. The general layout would look much like what is shown in Figure 7.

References

[1]. Gordon McComb, The Robot Builder's Bonanza, 2nd Edition, Published by McGraw-Hill.

[2]. Henry T Brown, Five Hundred and Seven Mechanical Movements, Published by Brown Coombs & Co. New-York.

[3]. Vol. 14, No. 2, IEEE Robotics and Automation Magazine, June 2007.

[4]. Ming Fai Fong, Mechanical Design of a simple Bipedal Robot, Massachusetts Institute of Technology, June 2005.

[5]. Mark Gerald Wagstaff, Mechanical Design for a Humanoid Robot, University of Queensland, October 2001.

