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Giacometti Six-legged Walking Robot
- Giacometti Gait and Walking Experiment -

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This research presents Giacometti gait mechanism for the Giacometti robot. Motivated by the Giacometti structure, which is thin and long, the robot has leg design that is non-stiff and deformable which makes it difficult to walk with conventional walking gait. Using the proposed gait, walking experiment was conducted with various input pressure and gait frequency and could achieve stable walking at 0.05m/s.

Key Words: Giacometti, Hexapod, non-stiffness leg

1. Introduction

Most of the legged robots that are currently available nowadays have been inspired biologically from animals and human locomotion. The bio-inspired robot's design principles may come in various numbers of legs from quadruped [1,2] to hexapod [3,4] robots, which mimic the locomotion of the biological creatures. On the other hand, there are legged robots with morphologies that were principally inspired by certain mechanical principles such as ATRIAS [5], which were designed, based on 'spring-mass' model. We noticed that the bigger the robots, the higher the amounts of system weight as higher power to weight ratio actuators are required. Most of the robots used conventional DC motors, pneumatic and hydraulic actuators that carry most of the weight of the robot. They also have complicated control system with various sensors equipped for high performance and specification.

We developed a new concept of robot called Giacometti robotics, which aimed for large structure but having lightweight and simple system. The leg design mechanism using soft actuator design structure was presented in [6]. The concept is to keep the important and practical functions of the robot while eliminating unwanted advanced functions. Fig. 1 shows proposed Giacometti robot. The robot is 1.5 m in length, 1 m in height, 1.7 m in width and only 3.2 kg in weight.

In this paper, we propose a Giacometti gait, which was specially designed for Giacometti robot. Having thin and long leg design, which is non-stiff and deformable, it exhibits elastic deformation due to low stiffness leg structure. This makes it difficult to walk with conventional walking gait.

2. Giacometti gait and walking test

This Giacometti gait considers 4 legs as minimum number of legs during stance phase. The gait is divided into six phases and it will be repeated for walking motion. Fig. 2 (a) shows the leg assignment for the Giacometti gait from side view. '*a*' and '*f*' is the condition when the robot leg is in the air during swing phase, while '*b*','*c*','*d*','*e*' is the condition during stance where *a* = swing forward, *b,c* = stance forward, *d,e* = stance backward and *f* = swing backward. The leg assignment will be mapped to the leg coordination as in Fig. 2 (b) referring to Table 1. For example, in Phase 1, *L1* will perform 'swing forward' while *L2* will perform 'swing backward' motion as shown in Fig. 4.

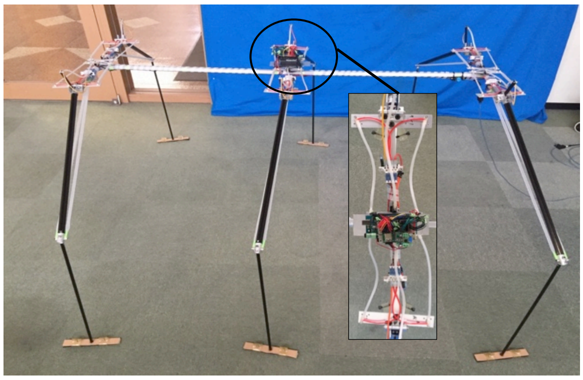
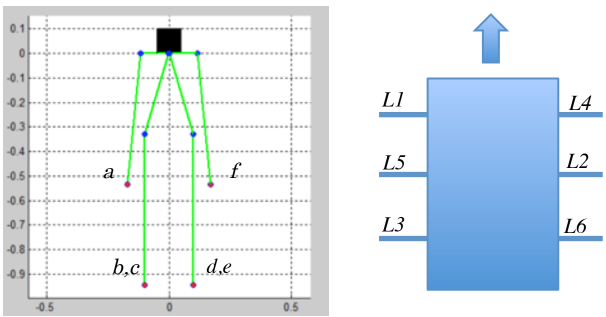


Fig. 1 Giacometti Robot with its control system



(a) side view of one leg　　(b) top view

Fig. 2 Leg assignment for Giacometti gait

Table 1: Giacometti Gait Leg Assignment

Phase	*Legs*					
	L1	***L2***	***L3***	***L4***	***L5***	***L6***
Phase 1	*a*	*f*	*e*	*d*	*c*	*b*
Phase 2	*b*	*a*	*f*	*e*	*d*	*c*
Phase 3	*c*	*b*	*a*	*f*	*e*	*d*
Phase 4	*d*	*c*	*b*	*a*	*f*	*e*
Phase 5	*e*	*d*	*c*	*b*	*a*	*f*
Phase 6	*f*	*e*	*d*	*c*	*b*	*a*

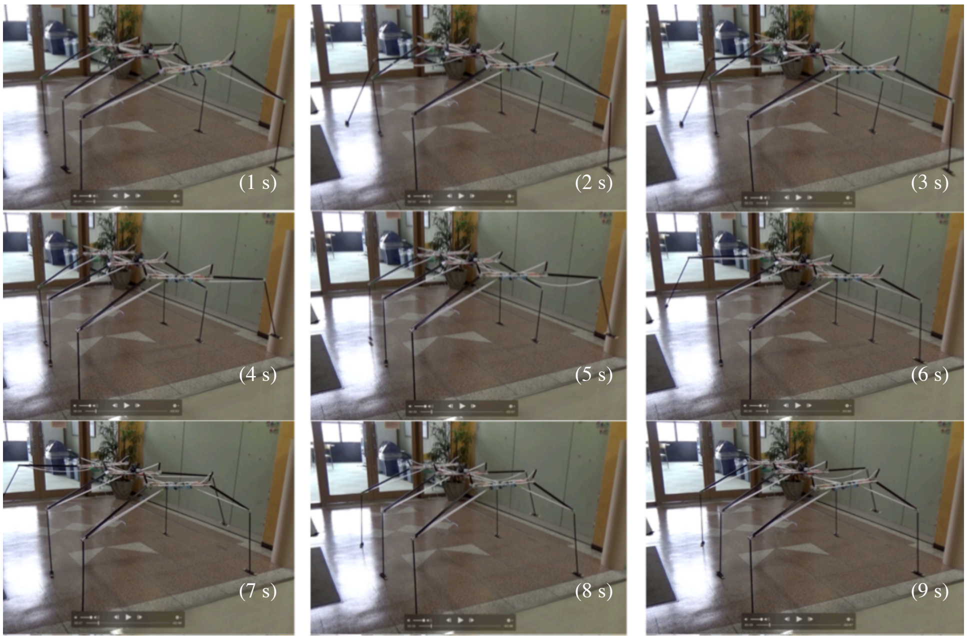


Fig. 3 Walking motion sequence using Giacometti gait as interval of 1 s

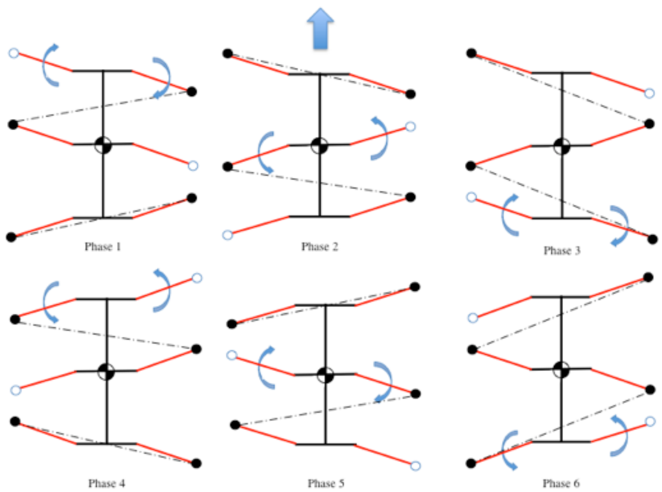


Fig. 4. Giacometti gait walking pattern

We conducted walking experiments for Giacometti gait to check the ability of the robot to perform walking motion. The biggest challenge for the Giacometti robot is to walk with its low stiffness leg structure due to small leg diameter. Fig. 3 shows the walking motion sequence using Giacometti gait at interval of 1s with walking speed of 0.05m/s. Fig. 4 shows the coordination of the walking phases. Phase 1 shows both front legs are in motion (left front, *L1* swings forward and right front, *L4* performs a backward stance). The right front leg, *L4*, which performs backward motion while in stance position, will produce forward body motion of the robot. However, as the other three legs are in contact with the ground in stance state, it prevents the robot body from performing any forward motion. This forces the right front, *L4* leg to store the elastic energy developed towards the surface by bending its structure. This phenomenon is possible as the leg has bending structure capability from the low stiffness property.

3. Conclusion

In this paper, a six-legged walking Giacometti robot and the Giacometti gait were presented. The robot leg structure, which consists of long, light and thin legs, has bending capability because of low stiffness property. Applying Giacometti gait, the robot successfully demonstrated basic walking motion. As an extension to the work, it would be interesting to assess the robot without pneumatic tether.

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