K6-20

Development of Humanoid Robot with Stable Jump Capability

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Abstract: The humanoid robot with high capability for jump is proposed in this paper. Aluminum frames were used for the robot to reduce the weight and lower the position of the center of gravity. ABS (acrylonitrile butadiene styrene copolymer) resin was used for the exterior and the frame for weight saving and high strength. Human-like toe mechanism was introduced to the developed robot for stable landing. The height was 85 cm and the weight was 4.5 kg. As a result, 58 mm vertical jumping was achieved with small horizontal deviation of 2.3 mm. The vertical jump was stable.

1. Introduction

Humanoid robots have been studied in various research institutions widely. The research objective is usually large robots aiming for the cooperation work with humankind. Especially smooth locomotion is one of large concern among the research field. The locomotion of the robot is considered the convention of walking and jumping. And these motions have been discussed by many institutions. It is important that the humanoid robot is able to jump at the running motion. The large humanoid robot with many degrees of freedom carries an internal control unit and a battery. So the humanoid robot tends to be heavy. Therefore, achieving of the jumping motion is difficult. Conventionally, jumping robots studied in previous works required special mechanisms, for example one-legged robots[1]. The humanoid robot with special jumping mechanism isn't desirable for cooperate with human environment. The purpose of this study is made the humanoid robot without requiring special mechanisms and it is able to vertical jump.

2. Design concept and fabrication

The structure of the humanoid robot is reproducing human beings. The humanoid robot requires high torque and precise angle adjustment. So in this case, servo motors were used as actuators. Basic structure was the moving mechanism for biped walking, and working mechanism by two arms. The joint position of the robot was placed corresponding to the standard of joint human. Figure 1 shows the freedom degree of the humanoid robot in this study. The frame was made aluminum alloy A5024 for light weight and high strength. Aluminum alloy plates were processed for NC cutting machine. For the toe frame received load force, it was made from polyoxymethylene (POM) for obtaining high second moment of area (I). The exterior was considered not to reduce the range of movement, and achieve light weight and high strength simultaneously. The exterior was made from Styrofoam® and ABS resins that showed excellent impact resistance and processing. The part of the frame of the upper body was made from ABS resins. The ABS resin realized the center of gravity and light weight. The gyro sensor was used for stabilizing the position.

The dimensions of fabricated humanoid were 85, 33, 12 cm, height, wide and depth respectively. The weight was 4.5 kg. The freedom of the degree was 27.

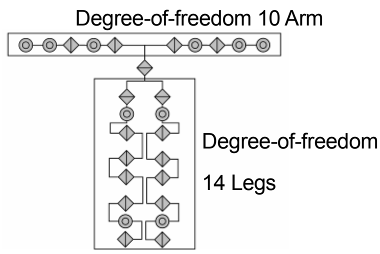

Figure 1. Schematic diagram of actuator layout.

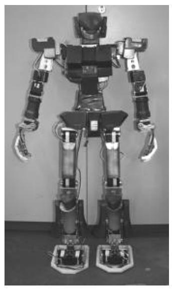

Figure 2. Fabricated humanoid robot.

3. Motion generation

The humanoid robot motion was generated by multiple consecutive positions. First, single position was generated. The multiple generated positions were connected and single motion was generated. During the motion, motion speed

1: Department of Precision Machinery Engineering was adjusted. In jumping motion, two pattern was examined. The deference of two motion was the movement of toes. These were fixed toes and active toes.

4. Experimental procedure

The jumping motions were observed by high speed camera of Vision Research Phantom. The reptation was 500 flame/sec and exposure was 200 μs. The jumping hight and horizontal deviation were measured by the movie image. The holizontal deviation was accumurated during three succesive jumps. 10 times of data was compared with the fixed toe and moving toe.

5. Result and discussion

Figure 3 shows the jumping motion of fixed toe. Figure 4 shows the motion of moving toe.

Figure 3. Jumping motion of fixed toe.

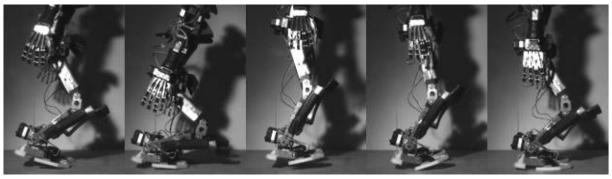

Figure 4. Jumping motion of moving toe.

The maximum amount jumping of fix toe was 5.3 cm and jumping of moving toe was 5.8 cm. Only 0.5 cm of the difference was observed. On the other hand, the horizontal deviation was affected by the toe mechanism. Figure 5 shows the horizontal deviation of landing.

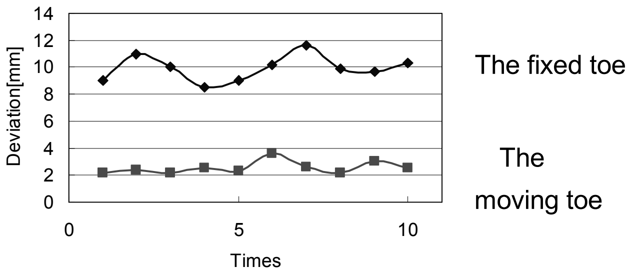

Figure 5. Horizontal deviation of landing.

10 times average of horizontal deviation of the landing after three jumping was 9.7 and 2.55 mm, in the case of the fixed toe and the moving toe, respectively. It is found that the moving toe suppressed deviation of the horizontal position.

Figure 6 shows the mechanism deviation of the horizontal position, in the case of fixed toe (a), and moving toe (b), respectively. *Fa* indicates forward force accompanied with backward movement of knee. *Fb* is counter force from the floor. Usually, *Fb* is smaller than *Fa*. Therefore, the jumping motion generates forward deviation. *Fc* is additional counter force by the moving toe. The moving toe pushes the floor during the jump, and then the backward force is generated. By adjusting the motion of moving toe realizes cancellation of forward force and the small horizontal deviation.

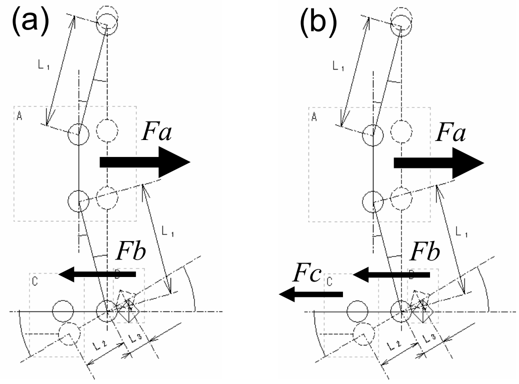

Figure 6. The mechanism deviation of the horizontal position (a) fixed toe; (b) moving toe.

6. Conclusion

The jumping humanoid robot with 85cm height was fabricated. For stable jumping behavior, moving toe was introduced. 5.8 cm of the vertical height was achieved. However a large difference was not observed among toe system differences. On the contrary, the deviation of the horizontal position after jumping was reduced considerably. The mechanism was discussed in this paper.

Acknowledgment

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Reference

[1] Ryosuke Tajima, Keisuke Suga “Motion having a Flight Phase: Experiments Involving a One-legged Robot”, Proc. of IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, pp. 860-866, 2007.