Motion control of biped robot bending the knee

Koji Umezaki Masanori Sugisaka
Dept. of Electrical and Electronic Engineering, Oita University.
700 Dannoharu Oita 870-1192 Japan.
E-mail:msugi@cc.oita-u.ac.jp

Abstract

In this research, it experiment about the stable walk by leveling by a static walk. The robot manufactured this is the biped robot without the portion of the upper half of the body, such as an arm, of only a lower half of the body.

Then, walk operation using center of gravity movement with a crotch and an ankle was created, and angle change of the servomotor in this mechanism on either side was compared. The large step and walk was able to be obtained by carried out moveable of the knee this time.

A future problem is to raise the biped robot's stability from now on, and to enable it to perform various operation.

1. Introduction

In these years, the humanoid robot which can harmonize with a life of human attracts attention many biped robots are studied developed. Those many think entertainment nature as important. In future it live together and cooperates with human in activity of human's ever day, and it is thought that the demand of a robot with the practicality which can perform work and support increases.

In this research, in order to perform a walk on step or slope, it amide at performing walk motion which separated the leg from the floor certainly.

The walk preformed this is static walk. With static walk, it progresses in front little by little, maintaining "static balance" in every moment. Therefore, in static walk even if it stops walk operation on the way it is possible to maintain balance and to continue stopping at a state as it is. On the other hand, dynamic walk carries out maintaining "dynamic balance" on the assumption that it moves. If dynamic walk is stopped during walk operation for movement which will be the requisite, balance will be broken down and it will fall.

2. Structure of biped robot

2. 1 Specific of biped robot

Size and degree of freedom of biped robot are shown in a Table1.

Table1 Specific and degree of freedom

size	height449[mm]×width 200[mm] ×length 120[mm]
degree of freedom	hip joint 3×2 knee joint 1×2 ankle joint 2×2 (Total 12)

2. 2 Structure and system of biped robot

The biped robot manufactured for the first time at this laboratory had attached the upper half of the body. However, load was applied and damaged to the servomotor of knee joints for weight. Then, biped robot which removed fixation of knee joint was manufactured last year. However, in order to mitigate the burden of a knee joint, the upper half of the body is removed.

The biped robot manufactured this time is shown in Fig.1.

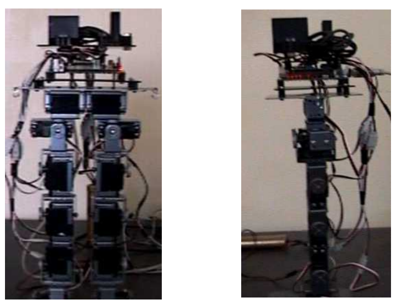


Fig.1 Photograph of developed robot

3. Experiment of walking cycle

3. 1 The experiment method

The motion which a robot is made to perform was created using the manufactured biped robot. In creation to each servomotor was determined by trial and error. The flow of motion creation is shown in Fig.2.

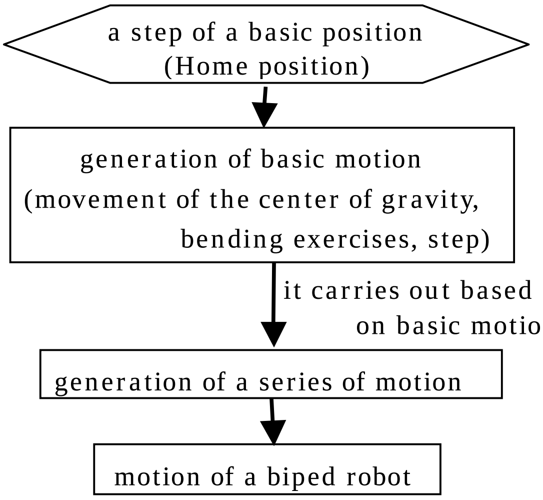
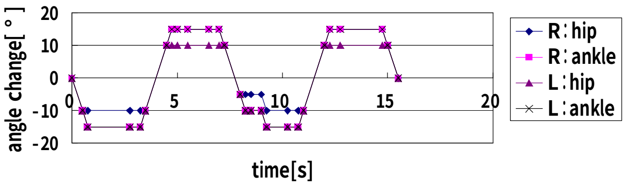


Fig.2 The creation of the motion

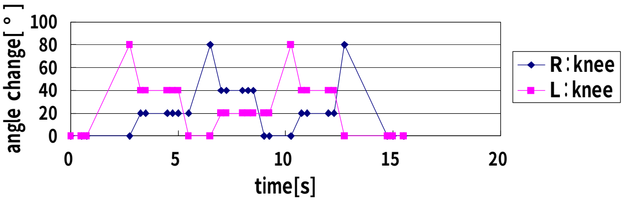
3. 2 Walk operation of biped robot

The rate of double stance phase and single stance phase in a biped robot's walking cycle is shown in Table2. Angle change of the instruction value of the servomotor of each joint is shown in Fig.3.

Double stance phase is a period which stands both legs, arriving at the ground and switches a leg. Moreover, single stance phase is a period which stands by one leg and carries idling leg in front from back.



(a) the thigh and an ankle



(b) a knee

Fig.3 Servomotors value of each joints

Table2 Robot walking cycle

double stance phase	37%
single stance phase	63%

Fig.3 shown that the knee joint on either side is performing symmetrical change. However, at a hip joint and ankle joint on either side, the instruction value is not change symmetrical. This is because it will have fallen if the center of gravity is moved to right-and-left symmetry. The following thing can be considered as this reason. It is that the interval of a leg on either side becomes narrow for a robot's weight , when performing walk operation.

Moreover, in walk operation, it turns out that the knee joint is performing operation to bend and operation to lengthen by a unit of two times.

3. 3 Walking analysis of human

The rate of double static phase and single static phase in human walking cycle is shown in Table.3.

Table3 Human walking cycle

double stance phase	20%
single stance phase	80%

Human walking cycle, the hip joint is operation to bend and operation to lengthen by a unit of one times. Moreover, the knee joint and the ankle joint are performed by a unit of two times.

3. 4 Comparison of a robot and human being in a walking cycle

From Table2 and Table3, biped robot walking cycle is understood the rate of double stance phase is long as compared with human thing. This is because walk operation of biped robot is static walk. Usually, by comparison of dynamic walk which human is performing this thing for time to movement of the center of gravity as a reason. Dynamic walk is taken out with the leg near at hand simultaneously with movement of the center of gravity. However, static walk is performing separately operation issued before movement and the leg of the center of gravity.

4. Up rise of step

4. 1 Relation between a step and the sole

In order for me to make it go up a step, biped robot's sole and position of a step were considered. The model and size of a sole of biped robot are shown in Fig.4 and Table4.

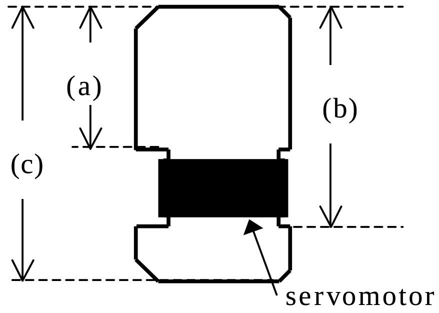


Fig.4 The model of sole

Table4 The size of sole

part	size [mm]
(a)	65
(b)	100
(c)	125

The following thing was considered from this. However, it is the case where both legs are placed just before a step. When a pace less than 100[mm], it become like Fig.5.

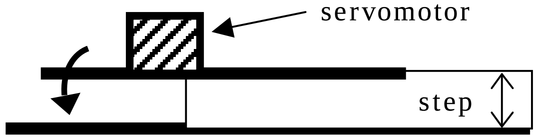


Fig.5 A pace less than 100[mm]

I thought that there may be no center of gravity on step, and it might fall back for this. Moreover, when a pace is larger than 100[mm], it is become like Fig6. I thought that there may be center of gravity on step and it could be a step.

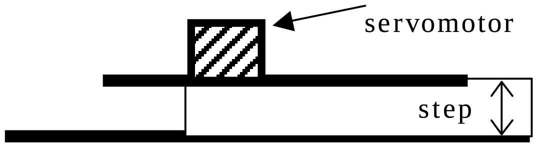


Fig.6 A pace larger than 100[mm]

4. 2 Motion which go up to step.

Biped robot shows the angle change of each servo motor in operation which reaches a step in Fig8. It is the hip joint and the ankle joint on either side which are shown in Fig8. Moreover, link mechanics of biped robot is shown in Fig.9.

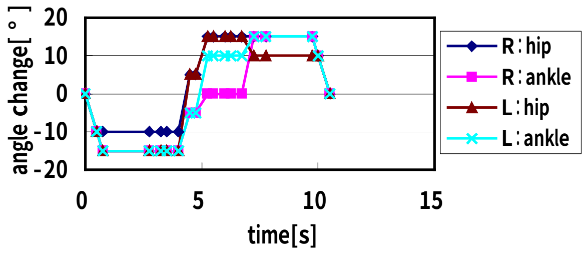


Fig.8 Servomotors value of each joints (a step)

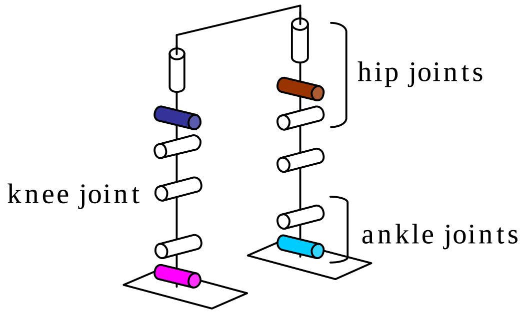


Fig.9 Link mechanics of biped robot

There servo motors are mainly used for movement of the center of gravity on either side. Fig shows moving the center of gravity finely, when moving the center of gravity to the leg before being on a step. This is because movement of the center of gravity on either side and center of gravity of order are moved separately. From this, it seldom needs to maintain balance by movement of the center of gravity of order by the case of the flat ground at the time of movement of the center of gravity on either side. However, in the case of a step, I thought that it was required to maintain balance at movement of the center of gravity of order.

5. Conclusion

Walking motion which separated biped robot's leg from the floor completely was able to be made to perform this time. It become possible to make a step reach by this, and operation was generated. However, many condition are required in order to operate.

6. Challenges for the future

The environment which can be operated for the influence of friction with the sole and a floor is limited. Moreover motion is generated by trial and error this time. Therefore, the position of the center of gravity cannot be grasped. In order to act, the center of gravity is important. From now on, it is necessary to consider move transition of the position of the center of gravity. As for the rest, stable operation is aimed at by using technology, such as a sensor and image processing.

Reference

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[2] Ryuichi Nakamura, Hiroshi Saito "Basic Kinematics" Isiyaku publication Co. Ltd p.334〜342 2002