Motion control of biped robot by using simulation

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Abstract

Recent years, researches about biped robot are extensively studied at the enterprise and the university. The purpose is human assistance, but it aims entertainment now.

Modern society is created for human to live easily. Therefore, to assist human, we need robot that is suitable for life space.

The vertical projection area of biped robot on the floor side is small, therefore, biped robot can move crooked road and narrow road. So we think it is best system on life space that has many irregular ground.

In this paper, we calculate Center of Gravity and Zero Moment Point by simulation.

1. Introduction

Recent years, researches about biped robot are extensively studied at the enterprise and the university. The purpose is human assistance, but it aims entertainment now.

Modern society is created for human to live easily. Therefore, to assist human, we need robot that is suitable for life space.

In the past research, wheel type robot was a mainstream. As a reason, the major factor is easy and steady to control. But, the fault is not able to move at irregular ground.

The vertical projection area of biped robot on the floor side is small, therefore, biped robot can move crooked road and narrow road. So we think it is best system on life space that has many irregular ground. But, it is difficult to control.

In this paper, we made the biped robot with servomotor to generate walking motion by application software, and calculate Center of Gravity and Zero Moment Point by simulation.

2. Theory

2.1 ZMP (Zero Moment Point)

ZMP is a point to replace the floor reaction force of the normal element that joined on the backside of the foot.

Support polygon is shown in Fig.1. Left square shows the footprint of the left leg, and Right square shows the footprint of the right leg.

Operation that ZMP is not in support polygon cannot be achieved.

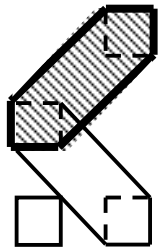


Fig.1 Support polygon

2.2 Rate of stance phase

Human's walking consists of state of one leg and state of both legs. State of one leg calls single stance phase, and state of both legs calls double stance phase.

Single stance phase is a period standing with one leg, and goes ahead. Double stance phase is a period standing with both legs, and switches axopodium.

Static walking cycle is always to keep balance. Dynamic walking cycle is presupposes to keep motion.

Human’s walking cycle (static and dynamic) are shown in Table 1 and Table 2.

Table 1 Human’s walking cycle (static)

Double stance phase	Single stance phase
40%	60%

Table 2 Human's walking cycle (dynamic)

Double stance phase	Single stance phase
20%	80%

3. Specific of biped robot and simulation

Specific of biped robot is shown in Table 3. Setting of simulation is shown in Table 4.

Table 3 Specific of biped robot

Actuator	Servomotor
Computer	Intel Pentium Ⅲ 487MHz
Mother board	HSWB-01
Application software	HSWB-01C
Size	Height 449[mm] × Width 200[mm] × Length 120[mm]
Degree of Freedom	Hip joint 3×2 Knee joint 1×2 Ankle joint 2×2

Table 4 Setting of simulation

Language	Borland C++ Builder5
Length of thigh Length of shin	0.145[m] 0.155[m]
Degree of Freedom	Hip joint 3×2 Knee joint 1×2 Ankle joint 2×2

We made Setting of simulation same as Specific of biped robot.

4. Experiment

4.1 Experiment of biped robot

We use HSWB-01C to control the biped robot. This application software is to control servomotor equipped in the biped robot.

First of all, we set home position to create motion of the biped robot. Next, we create the position of servomotor by the hour.

We can create various motions by the position of the servomotor. We set position by the trial and error.

In this paper, we use this method shown in Fig.2 to move biped robot.

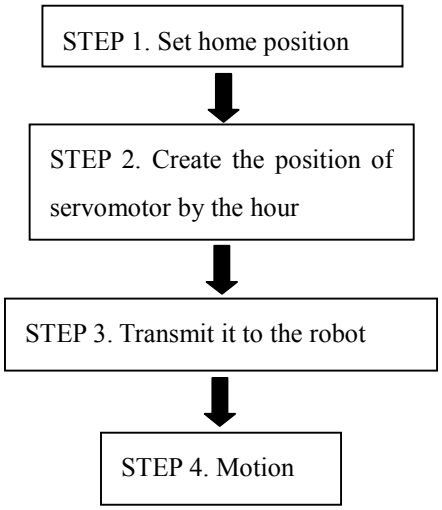


Fig.2 Method of motion creation

Figure of biped robot's joints are shown in Fig.3.

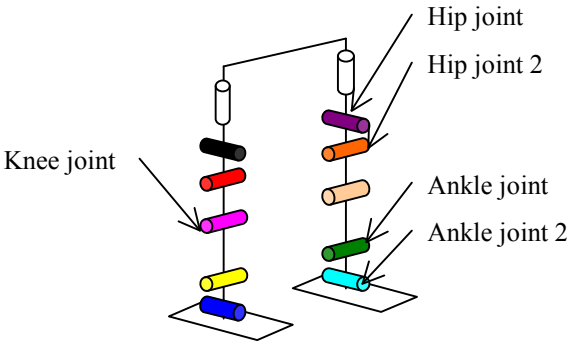
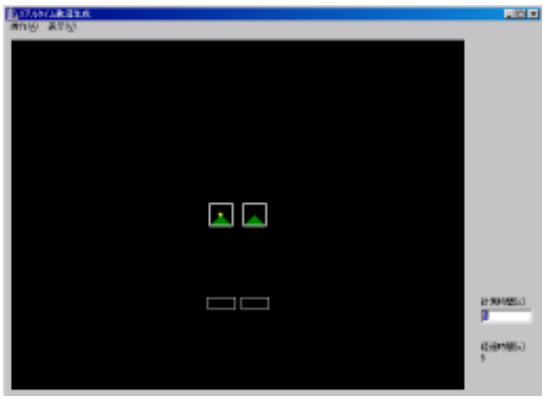


Fig.3 Figure of biped robot's joints

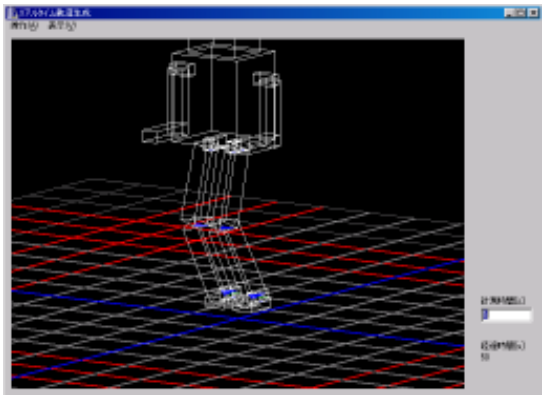
4.2 Experiment of simulation

Size and Degree of Freedom are done as well as biped robot, and perform the advancement operation for 5 seconds. We gain the result of ZMP and Center of Gravity, in that time.

Screen of simulation is shown in Fig.4.



(a) Top view



(b) 3D view

Fig.4 Screen of simulation

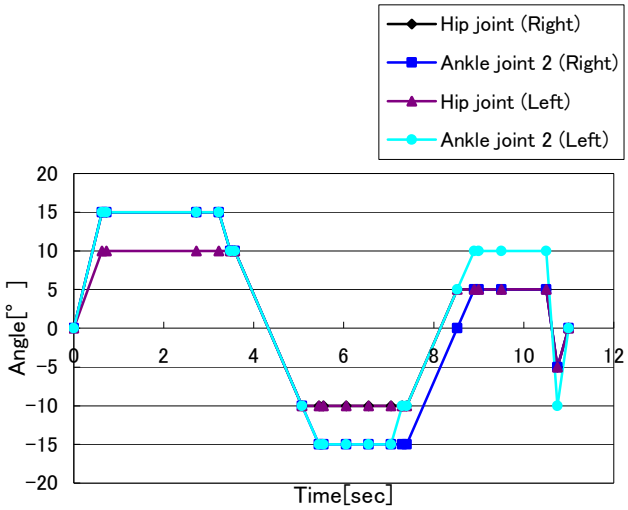
5. Result

5.1 Result of biped robot

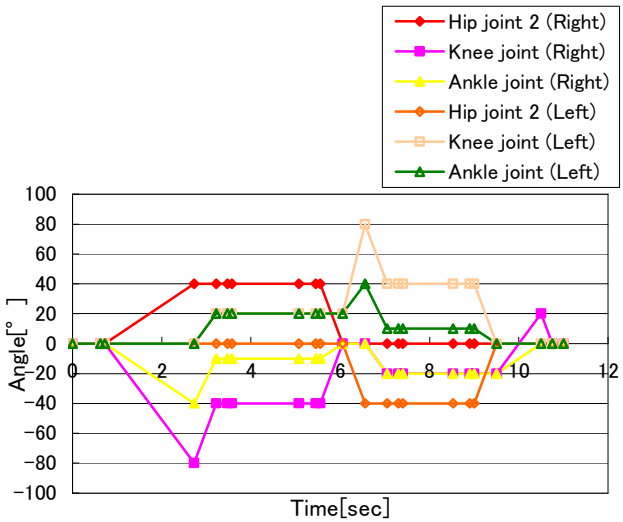
Angle change graph of Right-and-Left (Hip joint, Ankle joint 2) and Angle change graph of Backward-and-Forward (Hip joint 2, Knee joint, Ankle joint) are shown in Fig.5.

Position of servomotor (Fig.3) and the color of graph (Fig. 5) are corresponding.

Fig.5 (a) shows the change in Right-and-Left. Fig.5 (b) shows the change in Backward-and-Forward.



(a) Right-and-Left



(b) Backward-and-Forward

Fig.5 Angle change graph

Table 5 Robot's walking cycle result

Double stance phase	Single stance phase
41%	59%

The result of this experiment is similar to the ratio of double stance phase and single stance phase in human's static walking.

5.2 Result of simulation

Result of simulation is shown in Fig.6.

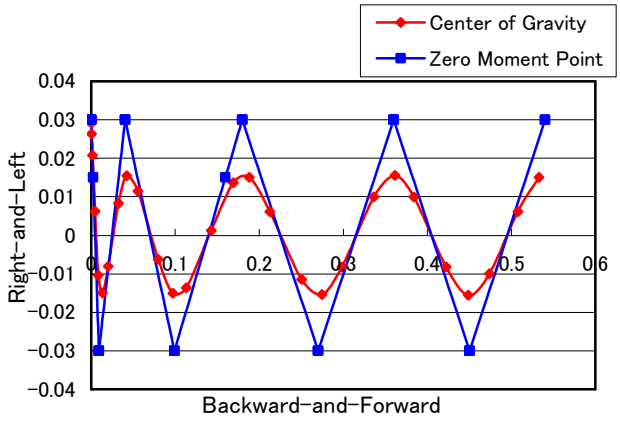


Fig.6 Result of simulation

6. Conclusions

In this paper, we researched about walking motion. We transmit instruction value to the biped robot, and generate walking motion by application software. And, we perform walking simulation.

Comparing with human walking motion and biped robot's walking motion, the ratio of this result is similar to the ratio of double stance phase and single stance phase in human's static walking.

It is necessary to research about Center of Gravity and Zero Moment Point more.

In the future, we complete motion of biped robot by using these results.

Reference

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