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The study of walking control with plural cylinder leg robots

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Abstract: Our goal of this research is to develop a working robot which has a medium level of power and walks with four legs. In our experiment, we used the robot which has two cylinder legs under the concept of multi-cylinder leg. It has very strong structure and it can endure and keep motion under heavy load. Multi-cylinder leg robot can walk any direction and draw any radius circle. In case of two cylinder leg, it can walk forward and backward on a straight or curved course. We are studying the control scheme of walking for this robot, which is put mind especially on smooth and steady movement without rolling, pitching, yawing or heaving motion and keeping the body horizontally. We confirmed the validity of control scheme with experiments.

Keywords: Walking control. Working robot. Cylinder leg.

1 INTRODUCTION

Now, the study of working robot becomes active because there exist very urgent request that robot should be applied, instead of human being to the work at the Fukusima atomic energy generating station where has the high nuclear level and complicated terrain. However, the current technology of crawler-type or wheel-type robots cannot fully work in such condition. Our goal of this research is to develop a working robot which has a medium level of power and walks with four legs. It is thought that the working robot should equip special functions such as for maintenance, management or setting of equipments with using tools. We thought that it was desirable to give robots the function changing their form suitably for work environment and work kinds to get high work performance and suggested the method to environment and the work kinds. In this paper, we refer to the moving mechanism and control of the robot. As well known, robot faces to big reactive force when it is working and it should move stably, carrying heavy goods. We thought a quadruped walking robot which has cylinder for the leg structure is adequate ,and confirmed the basic performances keeping prescribed posture and smooth movement by using the experiment. In the previous paper by Yaginuma[1], He performed a study of geometry and experimental confirmation about the type of the moving cylinder leg for assumed constant speed walking with keeping velocity contour. In this study, based on the results of the previous study we have carried out actual walking with the large scale robot.

2 ROBOT FOR EXPERIMENTS

We constructed each leg with two cylinders. The exper imental apparatus is shown in Fig.1. We equipped this type of leg for front leg of the robot and fixed leg with caster for aft-leg. Although in the previous study, it was a combination of the electric cylinder, we used DDVC hydraulic cylinder for pivoting the main leg and electric cylinder for rocking it. The specifications of the robot are shown in Table.1and Table.2 and Table.3.

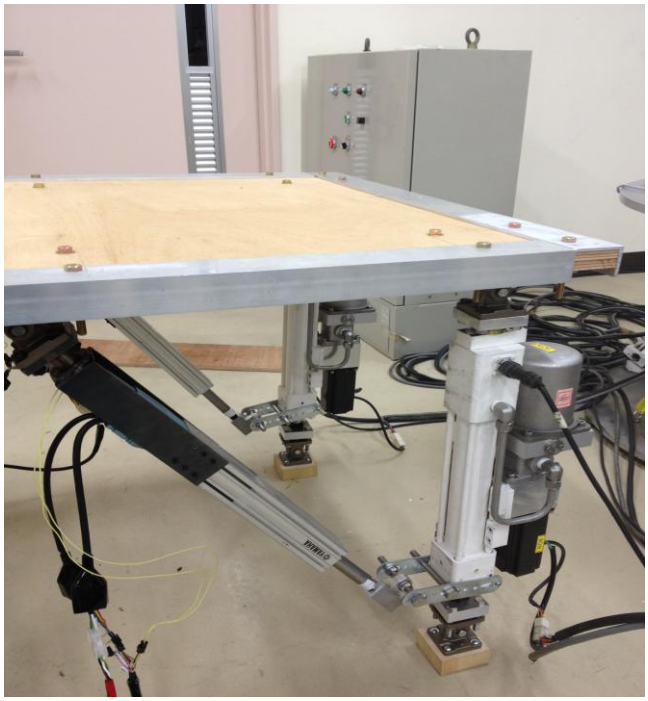

Fig.1 The experimental apparatus

Table1. The main leg cylinder specification

Motor output (kw)		0.4
Speed	Push(mm/sec)	6～75
	Pull(mm/sec)	9～112
Propelling power(N)		1.0
The diameter of a boa		φ40

Table2. Cylinder specification for rocking

Motor output(W)	30
Speed(mm/sec)	300
Propelling power(N)	64

Table3. The performance of the legs

Height legs(cm)	72
Stride (cm)	12
Cycle(s)	28

2.2 System Configuration

The command signal from a computer is changed into an analog signal through DA board, and is outputted to a driver. Through a driver, Actual speed/position of a cylinder is measured with a sensor and feed-backed to the computer through AD board.

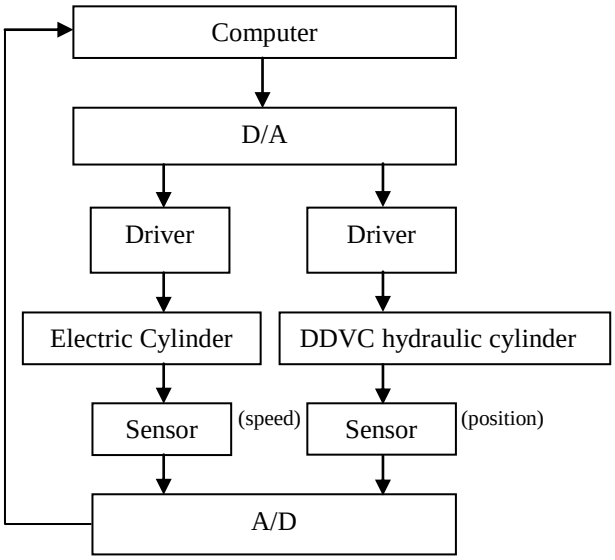

Fig.2 System configuration

3 Walking

3.1walking process

In this study, we assumed constant speed walking with keeping horizontal posture of body plane on a horizontal flat ground as a basic walk.

However we cannot avoid yawing motion caused of the structure.

As shown in previous study, the walking pattern has three mode of walking start, continuous walking and stopping.

3.1.1 Walking start mode

①When it starts walking, lift up the left leg and , move it to the traveling direction with half pitch of walk and lift down on the surface.

②. When left leg land, lift up the right leg and move it to front direction with half pitch of walk. At the same time, move the left leg backward to half pitch of walk.

3.1.2 Continuous walking

After, start motion, the front left leg and a front right leg repeat full pitch motion mutually.

③Stopping

When it stops walking, the landing leg stop the motion at the center of pitch and another leg also moves to center of pitch.

3.2 Walking locus

The human has various walking behavior according to a ground state, when walking on the land. For example, abo ut the motion of leg such as landing-backward moving-floating

forward moving, we set some basic patterns so that a walk of constant speed, horizontal posture and constant height ca n perform smoothly. The pattern is shown in Fig.3.

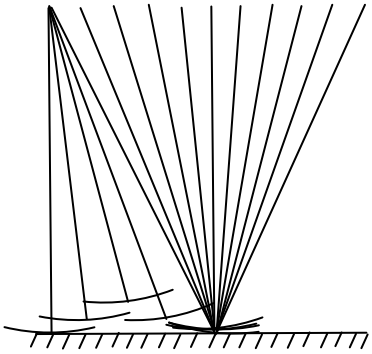

Fig.3 Walking pattern

4 CONTROL

4.1 Walking control

The legs structure of the robot proposed in this study as described above are all the same and same control scheme is applied to both legs. Operation of each leg is determined according to the type of motion of the body.

In this walk control, a speed of operation and locus were patterned from a rising to a start and landing, and the thing which makes a leg expand and contract in the shape of a sine wave was considered. The signal shown in Fig.4 and 5 are the operation of the left leg. With the combination of the signals, the left leg will be lifted in first two(2) seconds, and two cylinders will start motion and reach the peak value in three(3) seconds. Right leg will start motion with the same method at this timing. Continuous walk is performed with this way.

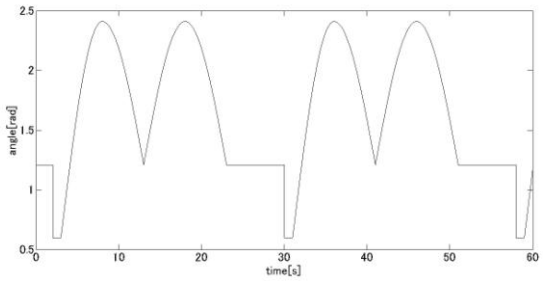

Fig.4 Motion of main cylinder (left leg)

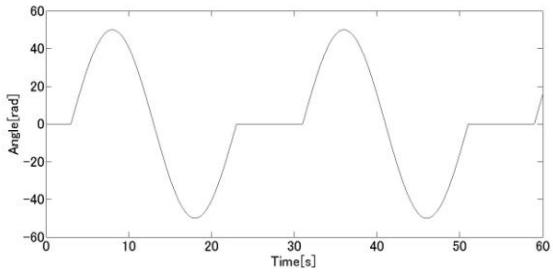

Fig.5 Motion of support cylinder (left leg)

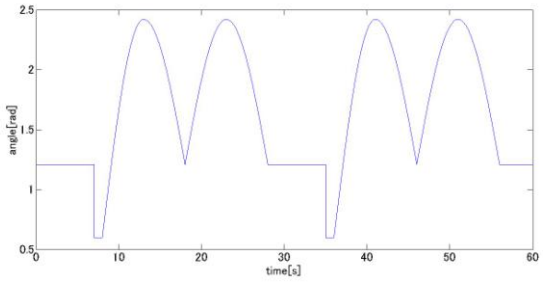

Fig.6 Motion of main cylinder (right leg)

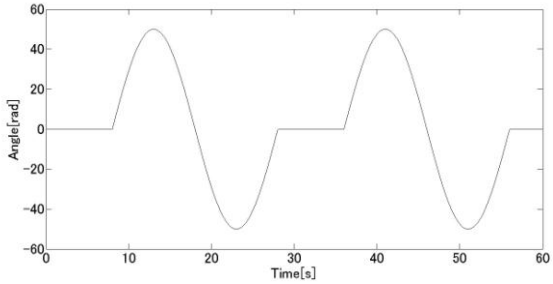

Fig.7 Motion of support cylinder (right leg)

4.2 Control method

When the robot is applied to a constant speed move with a horizontal posture，according to the purpose of the study, the moving pattern of the four (4) legs should be designed in different ways. As a result, the different methods of control are necessary.

In this experiment, PI control was adopted to confirm the walking pattern such as constant velocity contour walk. This control results are shown in Fig.8 and 9.

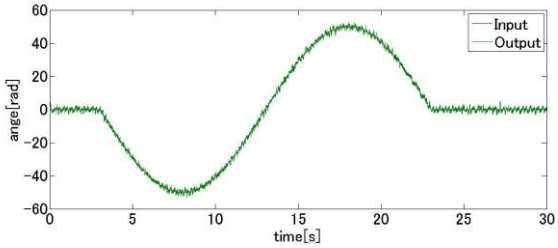

Fig.8 Control result of the left leg

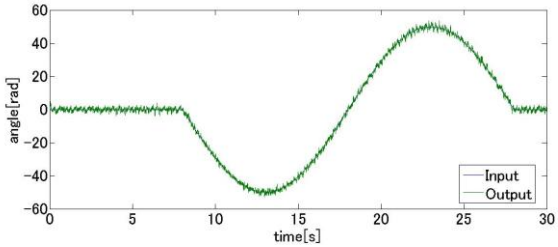

Fig.9 Control result of the right leg

5 CONCLUSION

In this study, we confirmed the results of previous study with actual walking robot. Although there is a little difference on the structure, two cylinder leg worked smoothly and made precise walking following to the pattern. However this is a basic walk and we are thinking to try the walking in actual situation such as not leveled ground, step or place filled with obstacles.

6 REFERENCES

[1] Yaginuma T(2010),Quadruped walking with parallel link legs. Artif Lift Robotics(2010)15:555-559 DOI 10.1007/s10015-010-0868-6