A Biped Robot as a Gait Simulator for Cadaver Foot Study

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1 Introduction

Human foot has complex three dimensional structure consisting of 26 bones, ligaments, muscles, skin, and soft tissue. Mechanical characteristics of the structure changes according to the environmental conditions. Although the change of the characteristics greatly affects human walking behavior, the mechanism is not totally understood. For understanding the mechanism, some cadaver foot experiments have been conducted. To reproduce the constraints of the terrain against the cadaver foot, some robots, which are called gait simulators, are developed [1–3]. The tibia and fibula of a cadaver foot are fixed to the gait simulator, and some tendons were pulled from outside of the foot by actuators. The cadaver foot is pushed against the ground and the ground reaction force is measured. Since these gait simulators do not have an upper body, we do not know to what extent the simulators realize conditions of the environment to the foot during walking.

In this study, we develop a bipedal robot as a gait simulator that can walk and reproduce the ground reaction while bipedal walking. It has three characteristic: (1) the robot can be physically separated into two legs, one of which can be put in bi-plain X-ray fluoroscopic system, (2) it can be attached either an artificial model of a human foot or a cadaver foot, and (3) it has five joints and can walking in 3D.

2 Robot Design

The developed robot (a gait simulator) in this study is shown in Fig. 1. Its specification is shown in Table. 1. The leg of the gait simulator has knee and hip joints. The range of motion of each joint is shown in Fig. 2. Each joint has a potentiometer as a sensor and can be controlled based on the measured joint angle.

Table 1: Specification of a gait simulator.

Mass	19.4[kg]
Length of a	440[mm]
Length of b	350[mm]
Length of c	450[mm]
Length of d	350[mm]
Length of e	300[mm]

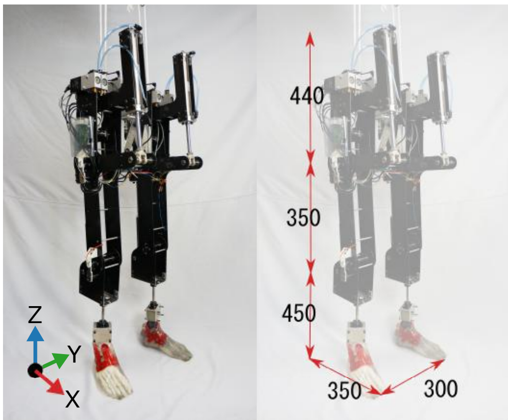


Figure 1: A biped robot as a gait simulator.

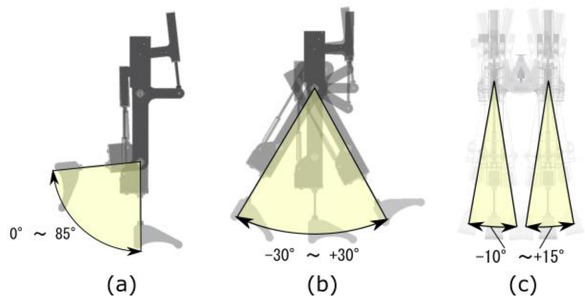
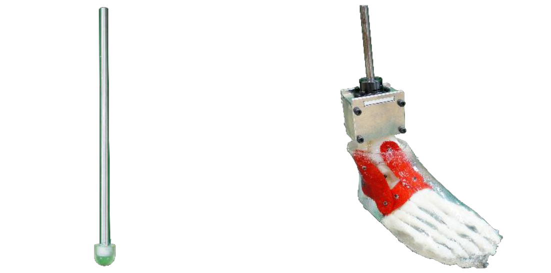


Figure 2: The angle range of a gait simulator.

3 Experiment and Result

We conducted walking experiments of the gait simulator and measured ground reaction force (GRF). We tested two types of foot for the simulator: a stick-like foot and the human foot model shown in Fig. 3. During the experiment, the gait simulator was hanged from the top with a rope in order to prevent the simulator from falling.

The gait simulator walked 4 steps with stick-like feet (Fig. 4). The ground reaction force (GRF) had the bimodal characteristics as shown in Fig. 5. Figs. 5 (a), (c), and (e) show the ground reaction force of a human in different directions. The Figs. 5 (b), (d), and (f) show those of the gait simulator in different directions.



(a) A stick-like foot (b) The human foot model

Figure 3: The tested foot

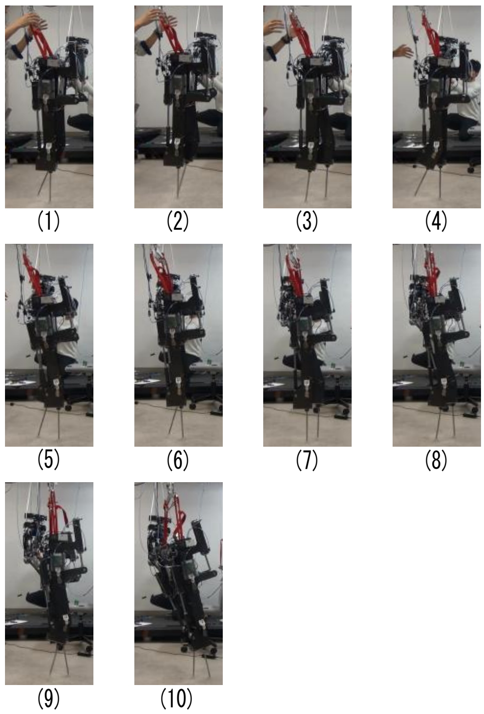


Figure 4: Snapshot series of a gait simulator walking 4 steps.

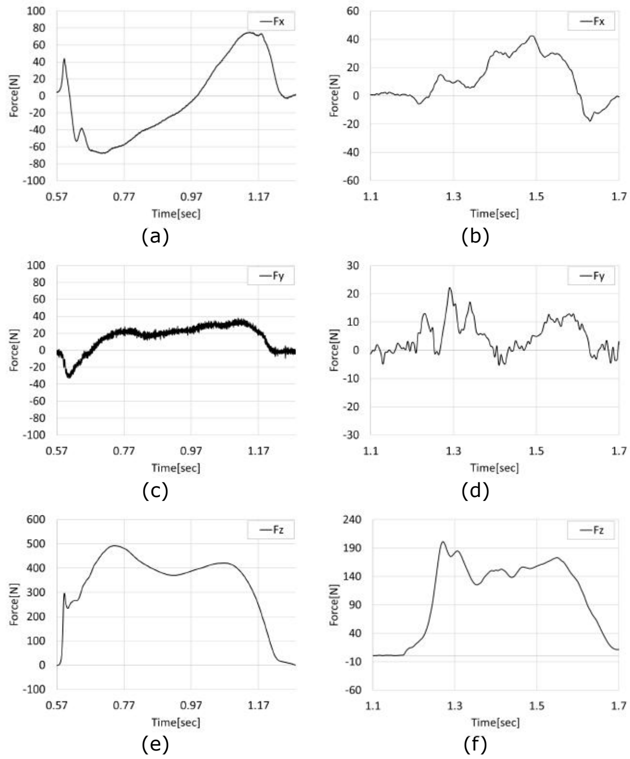


Figure 5: A ground reaction force (GRF) of human and a gait simulator. (a), (c), and (e) were obtained from a healthy male (22 years old, 164 cm, 55 kg) while walking at normal speed.

4 Future Works

In the future, we will let gait simulator can walk more stable and try to use different types foots and investigate these foot's characteristics to understand the mystery of human foot.

References

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