

A study on motion measurement for early screening for neurological disease

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ABSTRACT

Spastic gait caused by central nervous system diseases in infants is not easy to distinguish from internal rotation gait. In this study, we caused a humanoid robot that is driven by servomotors to reproduce the characteristic motion of lower limb joints in the spastic gait. The characteristic motion of lower limb joints of the spastic gait and the gait of the healthy persons were compared. As the result, it was shown that the state of changing distance of the pelvis marker and the tibia marker, and the pelvis marker, and the foot marker may be significantly different between normal walking and spastic gait. The proposed method is expected for a screening of pediatric patients with cerebral palsy.

KEYWORDS

Infant, Muscle tension, OpenSim, Scaling, Spastic gait

1. Introduction

Movement disorders in pediatric patients with cerebral palsy would change due to growing up. Cerebral palsy is occasionally diagnosed by detecting gait abnormalities [1]. Evaluation of gait abnormalities including spastic gait from the viewpoints of kinematics and kinetics enables to determine the presence or absence of disease [2]. However, spastic gait caused by central nervous system diseases in infants is not easy to distinguish from internal rotation gait. A simple motion measurement that detects the characteristics of spastic gait can provide more children early screening of diseases.

Therefore, in this study, we caused a humanoid robot that is driven by servomotors to reproduce the characteristic motion of lower limb joints in the spastic gait. We developed an analytical method that could relatively easily extract the characteristics of spastic gait using the information obtained from the robot's motion measurement. Specifically, the characteristics of spastic gait were obtained from the trajectory of

a small number of reflective markers attached to the robot. The proposed method is useful for giving opportunities for screening for children with central nervous system diseases and is expected to contribute to early treatment.

2. Measurement experiment

The humanoid robot (JD Humanoid, EZ-Robot Inc.) was measured in the experiment. The robot motion was measured using a three-dimensional optical motion analysis device (MAC3D System, MOTION ANALYSIS Inc.).

Fig.1 shows the reflective marker positions. The markers were attached to the shoulder, upper arm, and forearm of the robot. In the experiment, the shoulder joint and elbow joint of the robot were treated as human knee joint and ankle joint (Fig. 2). The robot reproduced the joint movements in the normal gait and spastic gait shown in Fig. 3 by referring to the previous study [3]. The knee joint angle and ankle joint

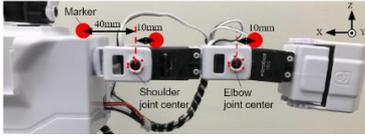


Fig.1 Reflective marker positions and laboratory coordinate system

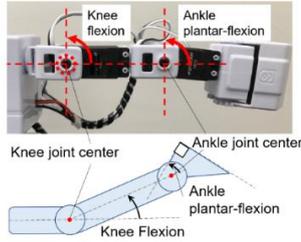
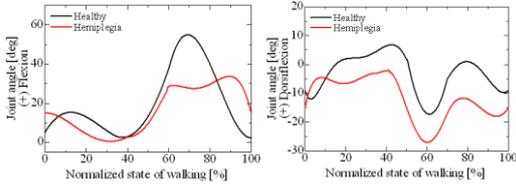


Fig. 2 Correspondence between robot and human lower limb joints



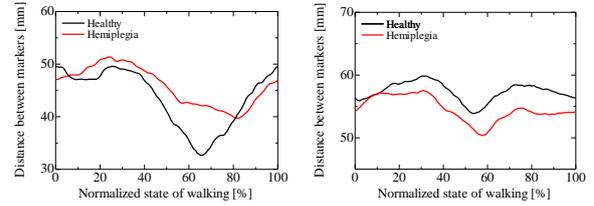
(a) Knee joint angle (b) Ankle joint angle
Fig. 3 Joint angles reproduced by the robot

angle of the sagittal surface in spastic gait of paralyzed patients were reproduced. The horizontal axis in Fig. 3 shows the normalized time, where one gait cycle including a stance phase and swing phase is 100%. The black solid curves show motions in the normal gait, and the red solid curves show motions in the spastic gait of patients with hemiplegia. The sampling frequency of the three-dimensional optical motion analysis device was 100 Hz.

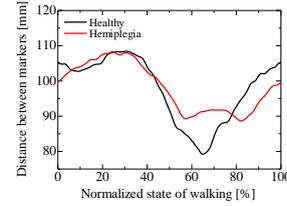
3. Result

Fig.4 shows the results of time series changes of the distances between markers. Fig. 5 (a) shows the distance between the robot's shoulder marker and upper arm marker, Fig. 5 (b) shows the distance between the upper arm marker and the forearm marker, and Fig. 5 (c) shows the result of the distance between the forearm marker and the shoulder marker. The horizontal axis shows the normalized time, where one gait cycle including a stance phase and swing phase is 100%. The black solid curves show motions in the normal gait, and the red solid curves show motions in the spastic gait of patients with hemiplegia. The results indicate that the variation in the distance of the pelvis marker and

the tibia marker, and the pelvis marker, and the foot marker may be significantly different between normal walking and spastic gait. Fig.6 shows the trajectory of the midpoint between the



(a) Shoulder and upper arm (b) Upper and lower arm



(c) Lower arm and shoulder

Fig.4 Time-series changes between markers

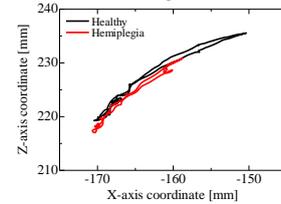


Fig. 5 Locus of the center between markers

cycle. From the result, the trajectory of the midpoint between markers obtained from the spastic gait data has a shorter range than that obtained from the normal gait data, although the shapes of the trajectories of the midpoints between markers of the two types gait data are similar. It may not use to distinguish normal gait and spastic gait.

References

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