2021 International Symposium on Advanced Technology (ISAT-19)

Extended Abstract

A study on motion measurement for early screening for neurological disease

Tatsuro Sato[1, a*], Shigeo Yamashita[2], Shinichiro Morichi[3], Hisashi Kawashima[3]
Gaku Yamanaka[3], Satoru Kizawa[4] and Ayuko Saito[1, b]
[1]Department of Mechanical Science and Engineering, School of Advanced Engineering, Kogakuin University, Tokyo, Japan
[2]nac Image Technology Inc., Tokyo, Japan
[3]Department of Pediatrics and Adolescent Medicine, Tokyo Medical University, Tokyo, Japan
[4]Department of Mechanical Engineering and Robotics, National Institute of Technology (KOSEN), Akita College, Akita, Japan.
[a]s518025@ns.kogakuin.ac.jp, [b]saito@cc.kogakuin.ac.jp

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 was 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 between the pelvis marker and the tibia marker, and between 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
Cerebral palsy, Motion measurement, Neurological disease, Robot, 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 was 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 used 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 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

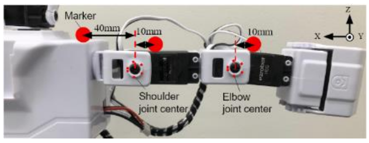


Fig.1 Reflective marker positions and laboratory coordinate system.

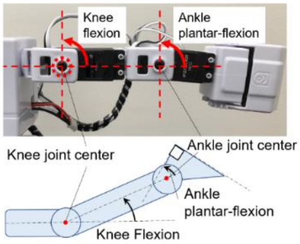
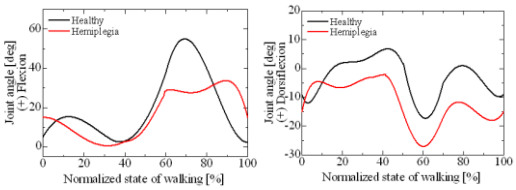


Fig. 2 Correspondence between robot and human lower limb joints.



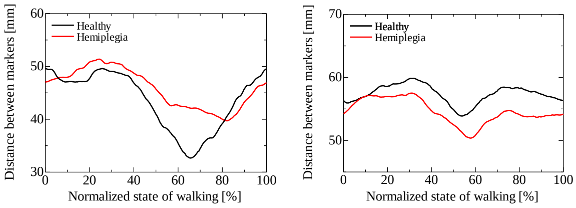
(a) Knee joint angles (b) Ankle joint angles

Fig. 3 Joint angles reproduced by the robot.

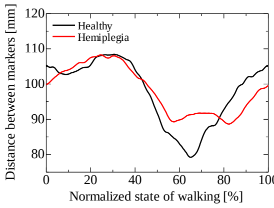
phase and swing phase is 100%. The black solid curves show motions in the normal gait, and the red solid curves show motions in the spastic gait of patients with hemiplegia. The sampling frequency of the three-dimensional optical motion analysis device was 100 Hz.

3. Result

Fig.4 shows the results of time series changes of the distances between markers. Fig. 5 (a) shows the distances between the robot's shoulder marker and upper arm marker, Fig. 5 (b) shows the distances between the upper arm marker and the forearm marker, and Fig. 5 (b) shows the distances 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



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



(c) Lower arm and shoulder

Fig.4 Time-series changes between markers.

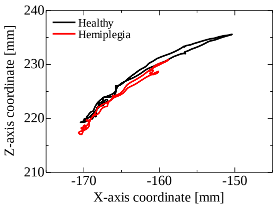


Fig. 5 Locus of the midpoint between markers.

significantly different between normal gait and spastic gait. Fig.6 shows the trajectory of the midpoint between the markers. 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.

References

[1] M. Nakajima et al., Developmental changes in the Collis horizontal reaction analyzed using a three-dimensional video motion analysis system, Japanese society of child neurology, 37(6), pp. 479-485, 2005(in Japanese).

[2] E. Suzuki et al., Evaluation on spastic gait caused by cervical myelopathy with gait analysis, Proceedings of Annual Meeting of Japanese Society for Clinical Biomechanics and Related Research, 23, pp. 447-451, 2002(in Japanese).

[3] T. Yanagizono, Pediatric abnormal gait by gait analysis, MB Medical Rehabilitation, 156, pp. 15-23, 2013(in Japanese)