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Falling-Down Possibility of Wearing Lower Extremity Exoskeleton

Rong-Jer Lai* and Ting Tsai Hsu

National Kaohsiung University of science and technology, Taiwan

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***Corresponding author:** Rong-Jer Lai, National Kaohsiung University of science and technology, Taiwan

Abstract

Falling-down can result in serious injuries for a user of walking assist device. The shape and the area of support plane of lower extremity exoskeleton vary during walking and the falling-down possibility changes with the time. The critical moments to be falling down could be identified and the countermeasures be applied through simulation of walking motion.

Keywords: Lower extremity exoskeleton, Falling-down, Support plane

Introduction

A wearable walking assistive exoskeleton robot (2WA-EXO), one of 2016 R&D 100 Awards winners [1], was developed by Industrial Technology Research Institute (ITRI) [2], Taiwan in 2013 and launched in 2018. The features of the walking assistive device are light-weight (less than 20 kg), compact (thickness less than 7cm), high walking speed (maximum 100cm/sec, endurance 3.5hours) and easy-to-use (waist open/close mechanism and adjustable shank), as shown in Figure 1 [3].

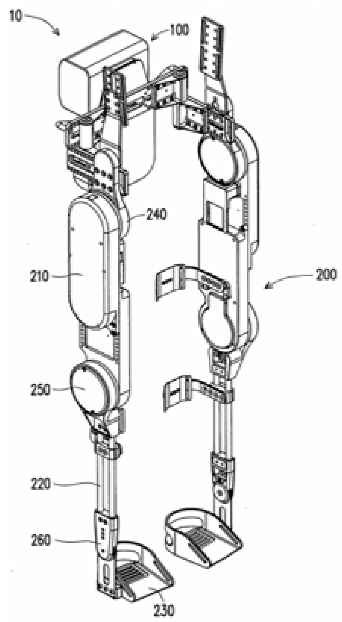

Figure 1: Lower extremity exoskeleton robot 2WA-EXO [3].

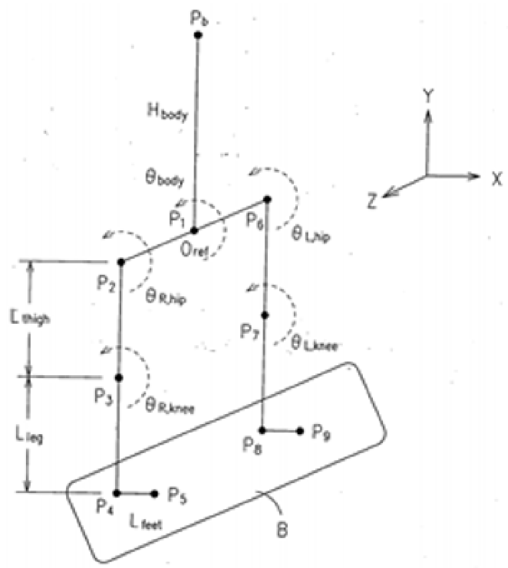

Figure 2: Simplified model of 2WA-EXO [4].

For a user of walking assistive device falling-down can result in serious injuries. Posture monitoring system and safety protection mechanism are usually proprietary rights, such as TW I564129 held by ITRI [4]. To investigate the falling-down possibility the device was simplified as an articulated object consisting of rigid links connected with joints, as shown in Figure 2, and a simulation program using MATLAB software was derived to track the motion of exoskeleton based on the theory of kinematics and transformation matrices [5]. On the sagittal plane the distance between the vertical projection of mass center and the intersection of the boundary line of support plane of lower extremity exoskeleton was calculated along the walking direction each time, where the support plane was defined as one formed by the vertical projections of end points of 2 feet links on the ground [6]. The shape and the area of support plane vary during walking and the falling-down possibility changes with the time. From the results the critical moments to be falling down could be identified, as shown in Figure 3 and the countermeasures be applied.

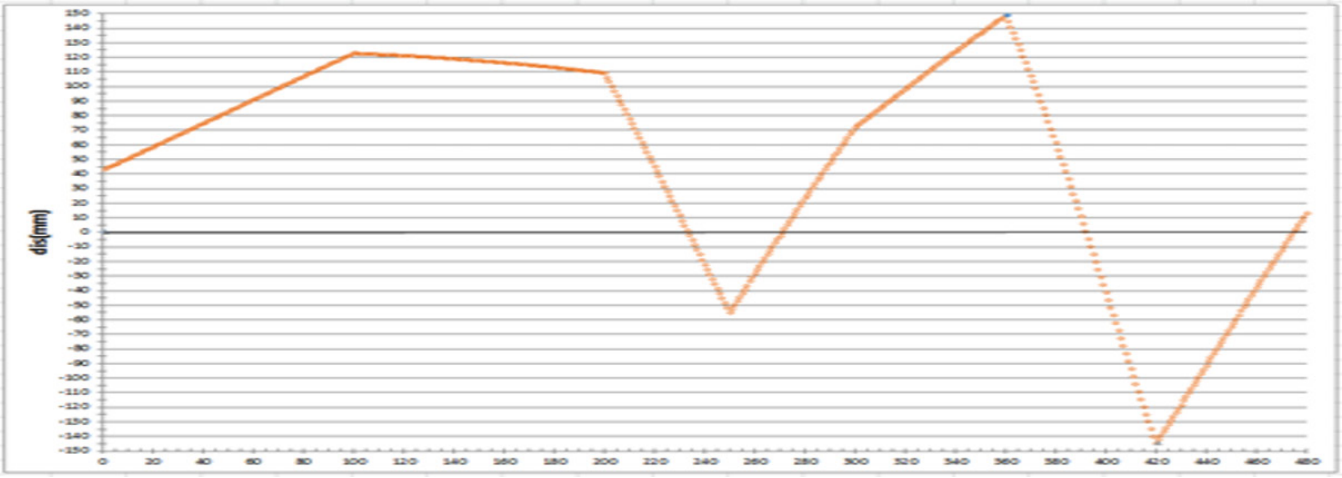

Figure 3: Variation of distance between the vertical projection of mass center and the intersection of the boundary line of support plane during walking.

Conclusion

Based on a mathematical model written in MATLAB program the motion of lower extremity exoskeleton was simulated to investigate the possibility and the critical moments to be falling down.

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