Validity of Real Time Gait Analysis Using a Single Head-Worn IMU

Tong-Hun Hwang(tonghun.hwang@sportwiss.uni-hannover.de)[1], Julia Reh[2], Alfred Effenberg[2]
Hoger Blume[3]
[1]Instutue of Microelectronic systems, Leibniz University Hannover, Germany; 2. Institute of Sports Science, Leibniz University Hannover, Germany, [2]Institute of Sports Science, Leibniz University Hannover, Germany, [3] Instutue of Microelectronic systems, Leibniz University Hannover, Germany

Abstract

Walking is a basic movement pattern, which plays a critical role in the maintenance of one's health by sustaining an adequate level of physical activity [1]. Promotion of physical activity with healthy walking has positive effects on the human body; however, asymmetric or abnormal walking causes pain, injury, or even bigger health problems in short and long term period. In terms of maintaining healthy walking, gait analysis is of interest for researchers and practitioners because it contributes not only to prevent injuries [2], but also to rehabilitate patients and seniors to walk healthy again [3]. With today's up-to-date mobile technology, engineers and application developers have shown an increased interest to gait analysis [4, 5] because of growing demands for a mobile health monitoring devices, such as earbuds [6], pedometers, smart watches and smart phones [4]. However, most of these devices for gait analysis provide a limited number of gait parameters. On the other hand, advanced gait parameters, such as foot-ground contact time (CT), can be obtained normally in laboratory settings or at high costs. Previous researchers have reduced the number of sensors to reducing cost, by using one-sensor solutions with smart phones [4] and ear-worn sensors [7]. However, they have struggled to detect toe off (TO) with single-sensor solutions in real time. Nevertheless, a head-worn sensor succeed to detect heel strike (HS) and TO without the aid of other sensors [8].

This work describes a real time gait event detection algorithm in detail using a head worn inertial measurement unit (H-IMU) used in Hwang et al. (2018). Authors focused on describing the validity of measuring CT that starts at HS and ends at TO, which are the most important events in gait analysis. A real time low-pass filter for HS and a robust detection method for TO were introduced. One participant walked on a 400-m track and on the grass of a football field with constant speed. Head kinematic data were collected to detect HS and TO with a professional IMU-based motion capture system, XSENS MVN System. The validity was shown by comparing to a foot-worn IMU-based gait analysis, which is regarded as a valid approach by previous studies [3, 9]. Results demonstrated that 95% confidence interval of mean absolute errors (95CI-MAEs) of CT was 12.7 ±2.49 ms (HS: 9.55 ±1.80 ms, TO: 7.67 ±2.09 ms) on the track, and 19.33 ±3.14 ms (HS: 13.30 ±2.36 ms; TO: 12.41 ±2.59 ms) on the grass. With a minimal delay of CT detection, the real-time analysis would be applied to auditory-motor feedback to accelerate learning and relearning process [10], supporting the maintenance and rehabilitation of symmetric and healthy gait patterns [3] in the future.

Keywords: *Biomedical monitoring, gait analysis, inertial measurement unit, smart devices, wearable sensors*

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Biography

Tong-Hun Hwang was received the B.S. and M.S. degree in electrical and computer engineering from Hanyang University, Seoul, South Korea, in 2008 and 2010, respectively. From 2010 to 2013, he joined the Multimedia Platform Group, System LSI Division, Samsung Electronics, Suwon, South Korea. Since 2015, he has been a research assistant at the Institute of Sport Sciences, and a phD Student at the Institute of Microelectronic Systems in Leibniz University Hannover, Germany.