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Minimum number of inertial measurement units needed to identify significant variations in walk patterns of overweight individuals walking on irregular surfaces

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Gait data collection from overweight individuals walking on irregular surfaces is a challenging task that can be addressed using inertial measurement unit (IMU) sensors. However, it is unclear how many IMUs are needed, particularly when body attachment locations are not standardized. In this study, we analysed data collected from six body locations, including the torso, upper and lower limbs, to determine which locations exhibit significant variation across different real-world irregular surfaces. We then used deep learning method to verify whether the IMU data recorded from the identified body locations could classify walk patterns across the surfaces. Our results revealed two combinations of body locations, including the thigh and shank (i.e., the left and right shank, and the right thigh and right shank), from which IMU data should be collected to accurately classify walking patterns over real-world irregular surfaces (with classification accuracies of 97.24 and 95.87%, respectively). Our findings suggest that the identified numbers and locations of IMUs could potentially reduce the amount of data recorded and processed to develop a fall prevention system for overweight individuals.

An irregular surface is a potential risk factor of falling while walking for all body weights[1]. In fact, half of the fall-related events (e.g., tripping, slipping, and stumbling) occur while walking on uneven or irregular surfaces such as paved and sloped surfaces and staircases[2–4]. In general, overweight (body-mass-index [BMI] > 25.0[5]) individuals, including young, middle-aged and older adults, are likely to fall more than normal-weight individuals[1,6–8]. In addition, falls in the overweight population (both male and female) are linked to an altered gait, postural instability, significant postural sway, and inability to adjust the corresponding walk pattern while walking on irregular surfaces[9–13]. Unfortunately, the characterization of the walk patterns of the overweight population in a real-world scenario is a challenging task due to the limited number of suitable devices for recording gait data. In this scenario, wearable sensors such as an inertial measurement unit (IMU) could be an advantage for recording gait data from overweight individuals to analyze their walk patterns in a range of irregular surfaces[14,15]. A comprehensive analysis of walk patterns defined by IMU data may help us better explain the underlying mechanism of falling because IMU data are able to reveal the kinematic variability during walking in real-world irregular surfaces[16–18]. However, the number and location of IMUs are two important metrics that might restrict the data recording and subsequent application of IMUs for fall prevention.

The identification of appropriate body locations (e.g., upper limbs, lower limbs and torso) for IMUs is needed because using the minimum number of wearable devices is preferred by individuals across different ages[19,20]. One approach to identify the minimum number of IMUs is exploring the IMU data recorded from a combination

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