Human Identification Using Gait Skeletal Joint Distance Features

Md Wasiur Rahman, Department of Computer Science, University of Calgary, Calgary, Canada
Marina Gavrilova, Department of Computer Science, University of Calgary, Calgary, Canada

ABSTRACT

Gait not only defines the way a person walks, but also provides insights on an individual’s daily routine, mental state or even cognitive function. The importance of incorporating cognitive behavior and analysis in biometric systems has been noted recently. In this article, authors develop a biometric security system using gait-based skeletal information obtained from Microsoft Kinect v1 sensor. The gait cycle is calculated by detecting the three consecutive local minima between the joint distance of left and right ankles. Authors have utilized the distance feature vector for each of the joints with respect to other joints in the gait cycle. After mean and variance features are extracted from the distance feature vector, the KNN algorithm is used for classification purpose. The classification accuracy of the authors’ approach is 93.33%. Experimental results show that the proposed approach achieves better recognition accuracy then other state-of-the-art approaches. Incorporating gait biometric in a situation awareness system for identification of a mental state is one of the future directions of this research.

KEYWORDS

Biometric System, Cognitive Function, Feature Distance Vector, Gait, Gait Cycle, K Nearest Neighbors (KNN), Kinect Sensor, Pattern Recognition

INTRODUCTION

Biometric technologies are considered to be a more convenient and secure way of user authentication, as compared to traditional identification and verification methods (ID, cards or passwords). It is well known that human biometric identifiers can be divided into two categories: physiological biometrics, which may relate to parts of the body (face, ear, palm, fingerprint, iris), and behavioral biometrics including voice, signature, handwriting and gait (Gavrilova, & Monowar, 2012). There is also an emerging area of biometric domain, that uses social on-line interactions and aesthetics for biometric recognition (Sultana, Paul, & Gavrilova, 2017; Azam, & Gavrilova, 2017). Some biometric identifiers require person cooperation because it is difficult to obtain a person’s face, fingerprint, iris or voice from a location (Munsell, Tumlyakov, & Wang, 2017). Some others biometric identifiers require high quality of an image or a video for accurate person identification and feature extraction. Gait is one of the few biometric identifiers where person cooperation is not needed, and person can be identified using even a low-quality image or a video (Das, Guang, & Cheng-Tsun, 2014). Thus, the recent popularity of gait biometric can be attributed to its unobtrusiveness, universality and non-vulnerability in the case of a spoof attack, as gait is difficult to hide or imitate. As a result, gait analysis has been conducted in various applications such as video surveillance systems (Cucchiara,Grana, Pretti, & Vezzani, 2005), 3D human body modeling (Bae, & Park, 2013), forensic science (Bouchrika, Goffredo, Carter, & Nixon, 2011), and elderly population health assessment (Kressing, & Beauchet, 2006).

DOI: 10.4018/IJSSCI.2017100102

Copyright © 2017, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
Gait can not only define the way a person walks, but also provides interesting cues on individuals' daily routine, mental state, health state or even cognitive function (Wang, 2011). The importance of incorporating cognitive behavior and analysis in biometric systems has been noted recently (Wang, Widrow, Zadeh, Howard, Wood, Chan, & Gavrilova, 2016). One of the early works conducted in BT lab demonstrated that combining auxiliary cues from the gait videos in addition to extracting traditional gait features can significantly enhance the accuracy of subject identification (Bazazian, & Gavrilova, 2015). An interesting link between gait and cognition has been observed recently (Wang, Fariello, Gavrilova, Kinsner, & Shell, 2013). Normally, gait and cognitive function of a person are being evaluated independently; however, the strong correlation between changes in walking style, for instance, and some mental illnesses or cognitive impairments have been noted and investigated (Montero-Obasso, Verghese, Beauchet, & Hausdorff, 2012). Gait skeletal information can not only be used for person identification, but also for other applications, including gender detection (Kastaniotis, Theodorakopoulos, Theoharatos, Economou, & Fotopoulos, 2015). It can also be used to recognize actions of a person from recorded sequences or in real-time (Ahmed, Paul, & Gavrilova, 2016).

Another issue impacting gait recognition is the source of the data. In the past, standard video camera had been used for capturing and recording the gait pattern of a person. But there are quite a few limitations with this approach. It is expensive and time consuming to extract gait features from video sequences, as it usually involves background segmentation, image enhancement and noise removal. An advent of Microsoft Kinect sensor allows to easily bypass these difficulties. Kinect is inexpensive, and features can be extracted easily in a form of a silhouette and as 3D skeletal joint coordinates. The Kinect is a very popular device for gait researchers. The name Kinect comes from the word “Kinetic. Initially it has been used for gaming purposes. Nowadays it is used for many applications such as video-activated console for video capturing, face recognition, motion recognition and biometric systems. It can represent the data in various forms such as grayscale depth, infrared and skeleton, and also overcomes the limitations of a standard video camera. Kinect consists of an RGB camera with the depth sensor. The camera generates a moving image of the objects from the field and sensor tries to detect the human from the objects by transmitting an invisible near-infrared light. It measures the “time of flight” from object reflection. The time of flight acts as a sonar to detect the distance to the objects. Kinect can differentiate the depth of the object to 1 cm. Kinect also has a monochrome CMOS sensor that helps to obtain the dot arranged 3D skeletal joint information. The API of Kinect is more convenient for feature extraction in gait recognition than the other traditional approaches like the standard video camera. Thus, Kinect is utilized in various real-world problems: healthcare, house monitoring, surveillance or physiotherapy. There are two versions of Kinect: v1 and v2. Kinect v2 is an updated version of v1 by improving few features of v1 such as the increase in a number of skeletal joints from 20 to 25, camera resolution, depth distance and horizontal and vertical fields of view. In this article, we use skeletal data of Kinect v1 and v2 sensors which consists of 20 and 25 joints for each person. Figure 1 shows various forms of data collection using Kinect v2 sensor.

This article makes the contribution to the Kinect gait research domain. The novelty of this work lies in the way the joint distance features are being calculated. The mean and variance between all pairs of joints are considered cumulatively in our approach, while the distance from the fixed reference point in the middle of the human torso was considered previously. This provides more flexibility to examine the relative relationship between various joints and use these discriminating features to increase accuracy of identification. This work is an extended version of our previous work which has been presented at ICCI*CC’17 (Rahman, & Gavrilova, 2017).

RELATED WORK

Existing approaches to gait recognition can be divided into two categories. One is model-free approach (Wang, Nahavandi, & Kouzani, 2010) and another is model-based approach (Ahmed, Paul, & Gavrilova, 2016).
A Biologically Inspired Neural Network Approach to Real-Time Map Building and Path Planning
[www.igi-global.com/chapter/biologically-inspired-neural-network-approach/6831?camid=4v1a](www.igi-global.com/chapter/biologically-inspired-neural-network-approach/6831?camid=4v1a)

Smart City Portals for Public Service Delivery: Insights From a Comparative Study
[www.igi-global.com/chapter/smart-city-portals-for-public-service-delivery/189435?camid=4v1a](www.igi-global.com/chapter/smart-city-portals-for-public-service-delivery/189435?camid=4v1a)