Accepted Manuscript

Decision-Level Fusion for Single-View Gait Recognition with Various Carrying and Clothing Conditions

Amer Al-Tayyan, Khaled Assaleh, Tamer Shanableh

PII: S0262-8856(17)30048-3
DOI: doi:10.1016/j.imavis.2017.02.004
Reference: IMAVIS 3601

To appear in: *Image and Vision Computing*

Received date: 17 March 2015
Revised date: 29 December 2016
Accepted date: 8 February 2017

Please cite this article as: Amer Al-Tayyan, Khaled Assaleh, Tamer Shanableh, Decision-Level Fusion for Single-View Gait Recognition with Various Carrying and Clothing Conditions, *Image and Vision Computing* (2017), doi:10.1016/j.imavis.2017.02.004

Decision-Level Fusion for Single-View Gait Recognition with Various Carrying and Clothing Conditions

Amer Al-Tayyan[a,*,1], Khaled Assaleh[b], Tamer Shanableh[c]

[a] *WSP | Parsons Brinckerhoff, Sharjah-UAE*
[b] *Department of Electrical Engineering, American University of Sharjah, Sharjah-UAE*
[c] *Department of Computer Science and Engineering, American University of Sharjah, Sharjah-UAE*

***Abstract*—Gait Recognition is one of the latest and attractive biometric techniques, due to its potential in identification of individuals at a distance, unobtrusively and even using low resolution images. In this paper we focus on single lateral view gait recognition with various carrying and clothing conditions. Such a system is needed in access control applications whereby a single view is imposed by the system setup. The gait data is firstly processed using three gait representation methods as the features sources; Accumulated Prediction Image (API) and two new gait representations namely; Accumulated Flow Image (AFI) and Edge-Masked Active Energy Image (EMAEI). Secondly, each of these methods is tested using three matching classification schemes; image projection with Linear Discriminant Functions (LDF), Multilinear Principal Component Analysis (MPCA) with K-Nearest Neighbor (KNN) classifier and the third method: MPCA plus Linear Discriminant Analysis (MPCA+LDA) with KNN classifier. Gait samples are fed into the MPCA and MPCALDA algorithms using a novel tensor-based form of the gait images. This arrangement results into nine recognition sub-systems. Decisions from the nine classifiers are fused using decision-level (majority voting) scheme. A comparison between unweighted and weighted voting schemes is also presented. The methods are evaluated on CASIA B Dataset using four different experimental setups, and on OU-ISIR Dataset B using two different setups. The experimental results show that the classification accuracy of the proposed methods is encouraging and outperforms several state-of-the-art gait recognition approaches reported in the literature.**

***Keywords*—Biometrics, Gait Recognition, Decision-Level Fusion, Accumulated Prediction Image, Accumulated Flow Image, Edge-Masked Active Energy Image, Multilinear Subspace Learning.**

* Corresponding Author. Tel: +971 50 4164716
[1] Present Address: WSP | Parsons Brinckerhoff in the Middle East, email: amer.altayyan@wspgroup.ae
E-mail addresses: b00038189@aus.edu (A. Al-Tayyan), kassaleh@aus.edu (K. Assaleh), tshanableh@aus.edu (T. Shanableh).

I. INTRODUCTION

GAIT is defined as "the *coordinated* and *cyclic* combination of movements that result in human *locomotion"* [1]. As such, and based on these repeated patterns, it can be used to identify people. The use of gait traits in biometrics is increasingly attracting researchers' interest. This is mainly due to its potential in identification of individuals at a distance. It can be also applied to subjects unobtrusively, without their cooperation or awareness. The application of gait in biometrics requires specific focus on some covariates like the view angle [2], [55], [60], [61] and [62], clothing [3], [4], [5], [6], [51], [52] and [53], footwear [2] and [7], time span [2], fatigue and muscle development [1] and carrying conditions [3], [4], [5], [6] and [52].

One important decision to make before testing any gait recognition algorithm is the selection of the database. The database should be suitable to the application under study, and is used to train, test and evaluate the system.

Gait analysis methods can be generally classified into Model-Free and Model-Based. Model-based methods use the parameters taken from the human body structure or its kinematic data to build a model. Parameters can be, for instance, taken from stride length, stride speed and cadence [8]. Lee and Grimson [9] modeled the human body into seven regions, and represented each region by an ellipse. Cunado *et al.* [10] used models of the legs, as they found harmonics in the legs motion. Yoo *et al*. [11] modeled the body's parts into sticks. Yam *et al*. [12] used the pendulum-like movement of the legs as a model. Dockstader *et al*. [13] used a model of thick lines connected with points for different parts of the body and made use of the pendulum motion of the lower part for feature extraction. Bobick *et al*. [14] and BenAbdelkader *et al*. [15] have adopted the structural model of stride parameters to extract gait features. Tanawongsuwan *et al*. [16] and Wang *et al*. [8] modeled the different joints trajectories in the upper as well as the lower parts of the body. Zang *et al*. [17] used five-link biped model of the upper and lower body parts. Recently, Guasch *et al*. [18] used radar techniques to create a model of the human body based on the Doppler frequency