Gait Analysis for Recognition and Classification

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The Problem: Human gait is an identifying feature of a person that is determined by his/her weight, limb length, and habitual posture. Hence, gait can be used as a biometric measure to recognize known persons and classify unknown subjects. Gait can be detected and measured at low resolution, and therefore it can be used in situations where face or iris information is not available in high enough resolution for recognition. We have designed a representation for the dynamics of human gait that facilitates the recognition and classification of people by their gait.

Motivation: Gait is defined as "a manner of walking" in the Webster Collegiate Dictionary. We extend our definition of gait to include both the appearance and the dynamics of human walking motion. Johansson [3] had shown in the 1970's that observers could recognize walking subjects familiar to them by just watching video sequences of lights affixed to joints of the walker. Hence, in theory, joint angles are sufficient for recognition of people by their gait. However, recovering joint angles from a video of walking person is an unsolved problem. In addition, using only joint angles ignores the appearance traits that are associated with individuals, such as heavy-set vs. slim, and long hair vs. bald. For these reasons, we have included appearance as part of our gait recognition features.

Previous Work: Given the ability of humans to identify persons and classify gender by the gait of a walking subject, there have been a few computer vision algorithms developed for people identification and activity classification. Cutler and Davis [2] used self-correlation of moving foreground objects to distinguish walking humans from other moving objects such as cars. Polana and Nelson[6] detected periodicity in optical flow and used these to recognize activities such as frogs jumping and human walking. Bobick[1] used a time delayed motion template to classify activities. Little and Boyd[4] used moment features and periodicity of foreground silhouettes and optical flow to identify walkers. Nixon, *et. al.*[5] used principal component analysis of images of a walking person to identify the walker by gait.

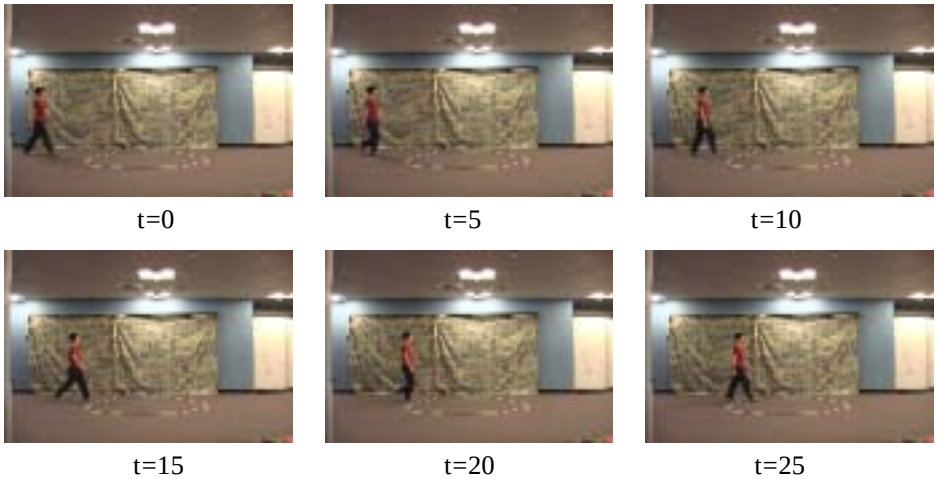

Figure 1: An example sequence of a walking person.

Approach: We assume that our walking subjects are viewed in the canonical direction, that which is perpendicular to the direction of walk(Figure 1). We showed in [7] that this assumption can be overcome using multiple calibrated cameras to synthesize the desired view. We also assume that the silhouette of the walker is segmented from the background (Figure 2) using a background subtraction algorithm such as [8]. To make our gait representation insensitive to changes of clothing and distance between the camera and the walking subject, we ignore the color of the foreground walker and use only the scale-normalized binary silhouette.

(a) t=1 (b) t=2 (c) t=3 (d) t=4 (e) t=5 (f) t=6 (g) t=7

Figure 2: A sample sequence of the silhouette of a walking subject after background subtraction.

Using the silhouettes of walking person, we compute a set of moment related features on 7 regions (see Figure 3) of the silhouette, and further compress the features across time. These regions are by no means meant to segment the arms and legs precisely. We are interested in a consistent method to divide the silhouette of a walking person into regions that will facilitate the person recognition task. These features are then used to recognize individuals by

Figure 3: The silhouette of a foreground walking person is divided into 7 regions, and ellipses are fitted to each region.

their walking appearances and to predict the gender of an unknown walker.

Future Work: Our future goals include evaluating gait features that support the tasks of people recognition and gender classification, and finding appearance based features that facilitate recognition of an expanded set of human action classes such as jogging, throwing a ball, etc.

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References:

[1] A. Bobick and J. Davis. The recognition of human movement using temporal templates. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 23(3), March 2001.

[2] Ross Cutler and Larry Davis. Robust real-time periodic motion detection, analysis, and applications. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(8):781 –796, 2000.

[3] G Johansson. Visual motion perception. *Scientific American*, (232):76–88, 1975.

[4] James Little and Jeffrey Boyd. Recognizing people by their gait: The shape of motion. *Videre*, 1(2), 1998.

[5] M.S. Nixon, J.N. Carter, J.M. Nash, P.S. Huang, D. Cunado, and S.V. Stevenage. Automatic gait recognition. In *Motion Analysis and Tracking (Ref. No. 1999/103), IEE Colloquium on*, pages 3 / 1–3 / 6, 1999.

[6] Ramprasad Polana and Randall Nelson. Detecting activities. In *CVPR*, 1993.

[7] G. Shakhnarovich, L. Lee, and T. Darrell. Integrated face and gait recognition from multiple views. In *CVPR*, 2001.

[8] C. Stauffer and W.E.L. Grimson. Adaptive background mixture models for real-time tracking. In *CVPR*, 1999.