Detection of Gait Characteristics for Scene Registration in Video Surveillance System

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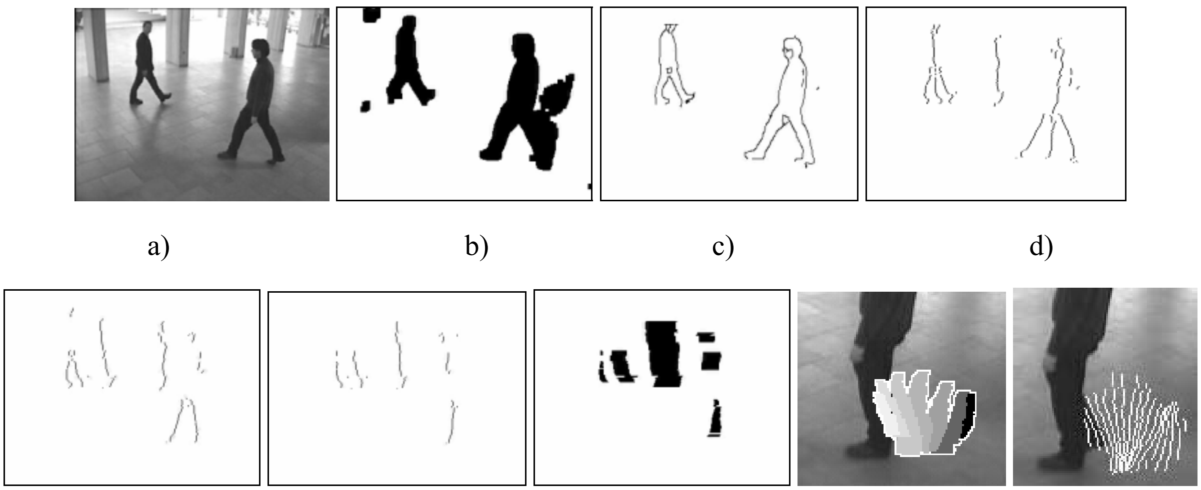
Abstract

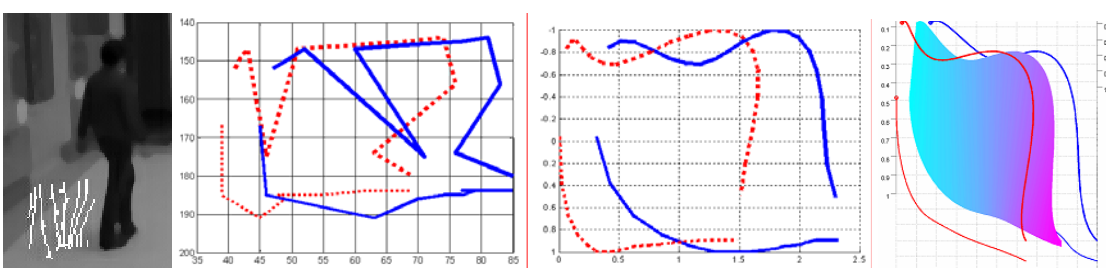
The paper presents a robust walk detection algorithm, based on our symmetry approach which can be used to extract gait characteristics from video image-sequences. To obtain a useful descriptor of a walking person, we temporally track the symmetries of a person's legs. Our method is suitable for use in indoor or outdoor surveillance scenes. Determining the leading leg of the walking subject is important and the presented method can identify this from two successive walk-steps (one walk cycle). We tested the accuracy of the presented walk detection method in a possible application: image registration methods are presented which are applicable to multi-camera systems viewing human subjects in motion.



a) b) c) d)

e) f) g) h) i)

Fig. 1. Overview of feature extraction steps: a) Image from input sequence. b) Result of change-detection. c) Filtered Canny edge map. d) First level symmetries. e) Second level symmetries. f) Third-level symmetries (L3S). g) Reconstructed masks from symmetries. h) Tracking, showing coherent masks in the sequence (of 7 representative frames). i) Symmetry pattern (of the total 25 frames).



a) b) c) d)

Fig. 2. a) original symmetry pattern and the trajectories of 9 frames. The four curves in b) (trajectories) are the upper and lower – both left and right - end points of the symmetry sample expanded with its radius. Interpolated trajectories of 100 points by using Bezier splines in c) and the numerically integrated surface of the pattern in d). The surface is formed from the interpolated upper and lower end points of symmetries which represents the height of the visible area of leg-opening.

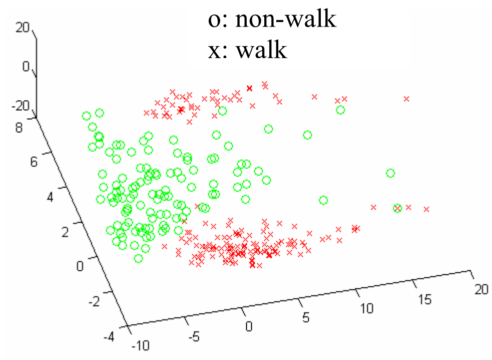


Fig. 3. “Walk” and “non-walk” patterns in the eigenspace.

Leading Leg Identification: According to our terminology, the leading leg is the “standing” leg, which at that instant carries the person’s weight (see Figs. 4b and 4c). In this section we present a method to determine, from one detected walk cycle (two consecutive steps), whether the leading leg is the right or the left leg by estimating 2D direction of walk and the “ratio” of consecutive walk patterns. The 2D motion vector on the image-plane, and the walker’s gait-period, can be extracted directly from the detected patterns: we estimate the motion vector by fitting a regression line to the last half-trajectory of the lower two points of the pattern.

a) b) c) d) e)

Fig. 4. a) An image showing the location of the derived symmetry pattern (marked with white border; “x” marks a feature-point, see Section V). b), c) Illustrations of our definition of “leading leg”; the “standing” or leading leg is the right leg in b), and the left leg in c) (legs highlighted manually). d), e) The detected patterns for the same steps as shown in b) and c); the 2D direction is bottom-left to upper-right (case 2 in Table I).

TABLE I

SURFACE DEPENDENCIES ON 2D WALK-DIRECTION AND LEADING LEG.

Case	2D Dir	Leading Leg	Ratio
1	↗	Right	>1
2		Left	<1
3	→	Right	≈ 1
4		Left	≈ 1

5	↘	Right	<<1
6		Left	>>1
7	↖	Right	<1
8		Left	>1
9	←	Right	≈ 1
10		Left	≈ 1
11	↙	Right	>>1
12		Left	<<1

Fig. 5. Detection of symmetry patterns in various outdoor videos.

Fig. 6. Detection of symmetry patterns in indoor video.

TABLE II

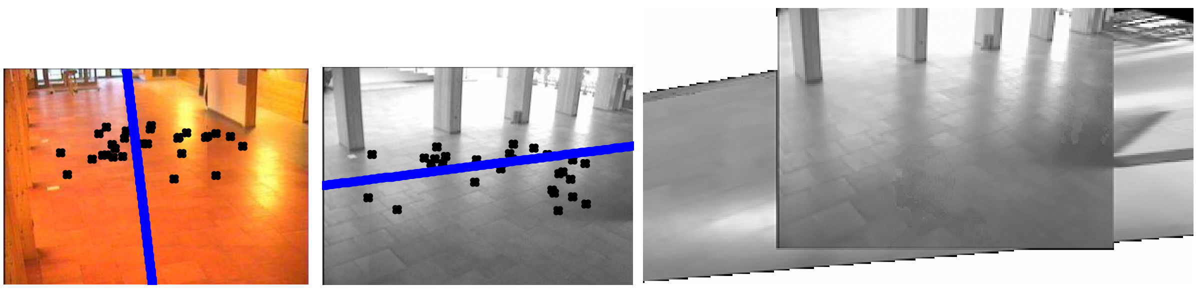
EXPERIMENTAL RESULTS ON DETECTION OF WALK PATTERN

Method	Data set	Detection Rate	False-Positive	False-Negative
KFDA [8] (Gaussian kernel)	Training	89.2%	8.2%	2.6%

SVM	Training	93.8%	5.2%	1%
(Gaussian kernel)				
KFDA [8]	Indoor test	75.7%	15.3%	9%
SVM	Indoor test	89.5%	8.9%	1.6%
SVM	Outdoor test	78.1%	14.1%	7.8%

A. Registration of camera-views

We evaluated the registration algorithm by using surveillance cameras placed in a public area located in the university building. The angle between the view-axes of the two overlapping cameras employed was nearly 90° (hence, to detect corresponding points using standard optical methods would be difficult). In the non-overlapping layout the two cameras are placed oppositely to each other.



a) b) c)

Fig. 7. Transformation from the first-camera view (left) to the second (right): Detected corresponding points, and a synthetic line-trajectory in a) and b) and alignment of views in c).

TABLE III

EXPERIMENTAL RESULTS ON DATA FROM "ENTRANCE" CAMERAS

(RANSAC DISTANCE THRESHOLD IS T=0.01)

Case	Input	Points	Correct points	Detected outliers	Avg. error in pixel
Method: DLT					
1	S2	8	8	-	6.4
2	S1+S2	54	39	-	250.2
Method: RANSAC+DLT					
3	S2	8	8	4	12.5
4	S1+S2	54	39	25	7.8
5	S1	46	31	28	6.2

a) b) c)

Fig. 8. Images of “Main hall” and “Entrance” cameras with control lines on the ground (marked with two long paper tapes) for verification. Result of alignment of **non-overlapping views** with the highlighted control lines in c).