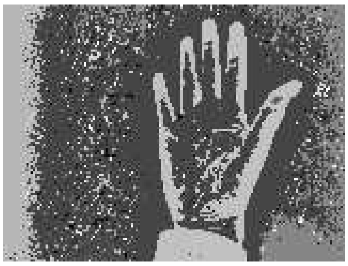
(e) the sign distribution of the relative potential in frame 5

(f) the sign distribution of the relative potential in frame 6

Fig. 7 The sign distribution of the relative potential values for the “clenching hand” video sequence

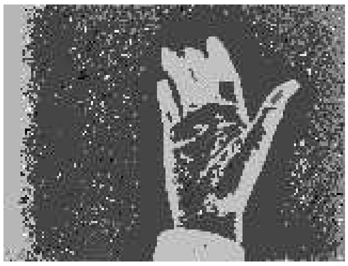


(a) the segmentation result on the plane of frame 1

(b) the segmentation result on the plane of frame 2

(c) the segmentation result on the plane of frame 3

(d) the segmentation result on the plane of frame 4



(e) the segmentation result on the plane of frame 5

(f) the segmentation result on the plane of frame 6

Fig. 8 The segmentation results for the “clenching hand” video sequence

Fig. 9 The sequence of clenching hand area segmented from the video

Fig. 10 is a sequence of the TV broadcaster, which has the size 176×144 for each frame. In the experiment, the sign distribution of the relative potential in the 3D space is recorded. The result is shown in a 2D form in Fig. 11, where the sign distribution in each frame is shown separately. According to Fig. 11, the main area of the broadcaster can be segmented as several connected regions including the face. Moreover, the tracking of the face is also possible based on the segmentation result because the result includes connected 3D areas through the whole sequence.

The segmentation result is shown in Fig. 12, where the 3D result is shown in a 2D form and different areas are represented by different gray-scale values. Especially, for the application of automatic expression recognition, in Fig. 13 the segmentation of the face on each frame are put together to show the tracking of the face in the sequence. The segmentations of the lip in each frame are also put together in Fig. 14. Based on the segmentation results, further recognition can be carried out.


(a) frame 1


(b) frame 2


(c) frame 3


(d) frame 4


(e) frame 5


(f) frame 6

Fig. 10 The video sequence of a TV presenter


(a) the sign distribution of the relative potential in frame 1


(b) the sign distribution of the relative potential in frame 2


(c) the sign distribution of the relative potential in frame 3


(d) the sign distribution of the relative potential in frame 4


(e) the sign distribution of the relative potential in frame 5


(f) the sign distribution of the relative potential in frame 6

Fig. 11 The sign distribution of the relative potential values for the “TV presenter” video sequence


(a) the segmentation result on the plane of frame 1


(b) the segmentation result on the plane of frame 2


(c) the segmentation result on the plane of frame 3


(d) the segmentation result on the plane of frame 4


(e) the segmentation result on the plane of frame 5


(f) the segmentation result on the plane of frame 6

Fig. 12 The segmentation results for the “TV presenter” video sequence

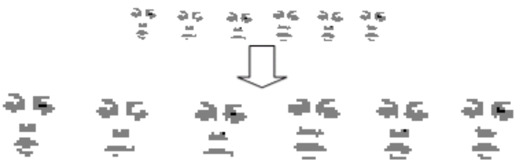


Fig. 13 The sequence of the face (including eyebrows, eyes, nose and lip) segmented from the video of the TV presenter

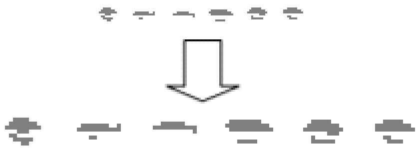


Fig. 14 The sequence of the moving lip segmented from the video of the TV presenter

Fig. 15 is the sequence of a person raising his arms, which has the size 160×120 for each frame. In the experiment, the sign distribution of the relative potential in the 3D space is recorded. The result is shown in a 2D form in Fig. 16, where the sign distribution in each frame is shown separately. According to Fig. 16, the main area of the person can be segmented as a connected region with the same sign of the relative potential value. Moreover, the tracking of the person’s action is also possible based on the segmentation result because the result includes connected 3D area of the person through the whole sequence. The segmentation result is shown in Fig. 17, where the 3D result is shown in a 2D form and different areas are represented by different gray-scale values. For the application of automatic posture and behavior recognition, in Fig. 18 the segmentation of the person on each frame are put together to show the tracking of his action in the sequence. Based on the segmentation results, further recognition can be carried out.


(a) frame 1

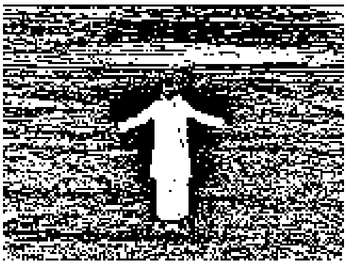

(b) frame 2

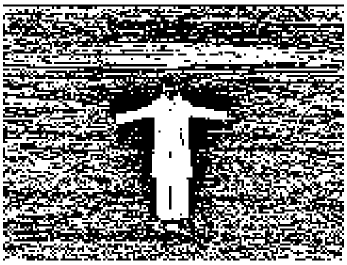

(c) frame 3

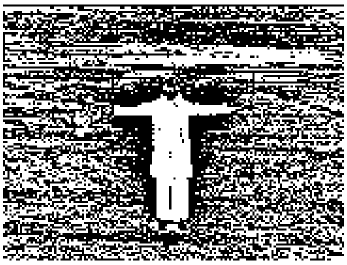

(d) frame 4

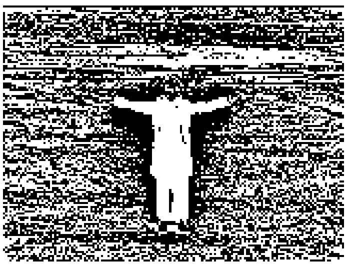

e) frame 5

Fig. 15 The video sequence of a person raising the arms


(a) the sign distribution of the relative potential in frame 1


(b) the sign distribution of the relative potential in frame 2


(c) the sign distribution of the relative potential in frame 3


(d) the sign distribution of the relative potential in frame 4

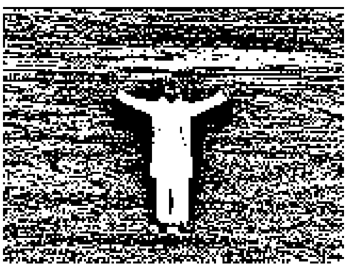
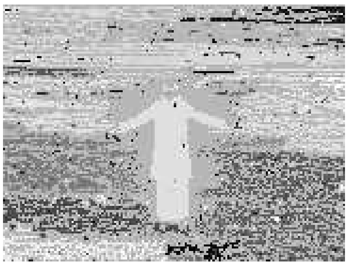
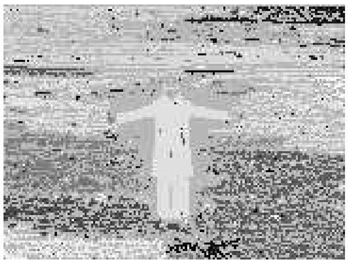
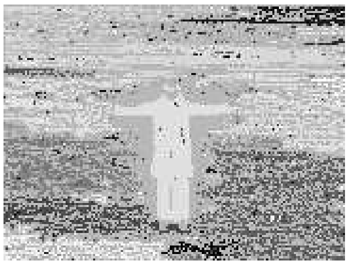
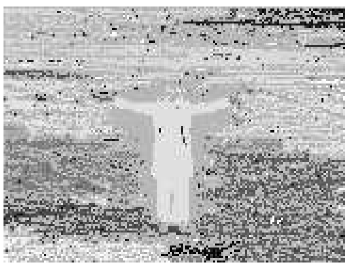

(e) the sign distribution of the relative potential in frame 5

Fig. 16 The sign distribution of the relative potential values for the “raising arms” video sequence


(a) the segmentation result on the plane of frame 1


(b) the segmentation result on the plane of frame 2


(c) the segmentation result on the plane of frame 3


(d) the segmentation result on the plane of frame 4

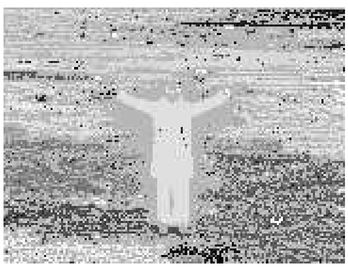

(e) the segmentation result on the plane of frame 5

Fig. 17 The segmentation results for the “raising arms” video sequence

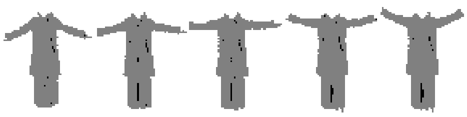


Fig. 18 The sequence of the “raising arms” action segmented from the video

Fig. 19 is a traffic sequence, which has the size 160×120 for each frame. In the experiment, the sign distribution of the relative potential in the 3D space is recorded. The result is shown in a 2D form in Fig. 20, where the sign distribution in each frame is shown separately. According to Fig. 20, the main area of the car at the front can be segmented as a connected region with the same sign of the relative potential. The tracking of the front car is possible based on the segmentation result because the result includes connected 3D area of the car through the whole sequence. The segmentation result is shown in Fig. 21, where the 3D result is shown in a 2D form and different areas are represented by different gray-scale values. For the application of automatic car tracking, in Fig. 22 and Fig. 23 the segmentations of the front car in each frame are put together to show the vertical and horizontal movement respectively. In Fig. 22, the vertical positions of the car in each frame are kept unchanged to show the vertical translation through the sequence. In Fig. 23, the horizontal positions of the car in each frame are kept unchanged to show the horizontal translation through the sequence. Then the movement of the car can be estimated for further analysis.

(a) frame 1

(b) frame 2

(c) frame 3

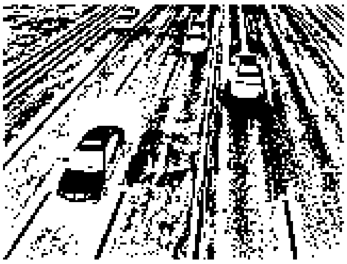
(d) frame 4

Fig. 19 A traffic video sequence

(a) the sign distribution of the relative potential in frame 1

(b) the sign distribution of the relative potential in frame 2

(c) the sign distribution of the relative potential in frame 3



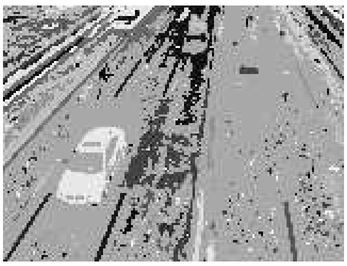
(d) the sign distribution of the relative potential in frame 4

Fig. 20 The sign distribution of the relative potential values for the traffic video sequence

(a) the segmentation result on the plane of frame 1

(b) the segmentation result on the plane of frame 2

(c) the segmentation result on the plane of frame 3



(d) the segmentation result on the plane of frame 4

Fig. 21 The segmentation results for the traffic video sequence

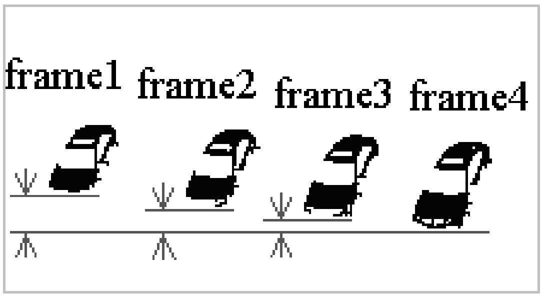


Fig. 22 The segmented car and its movement on the vertical direction in the image sequence

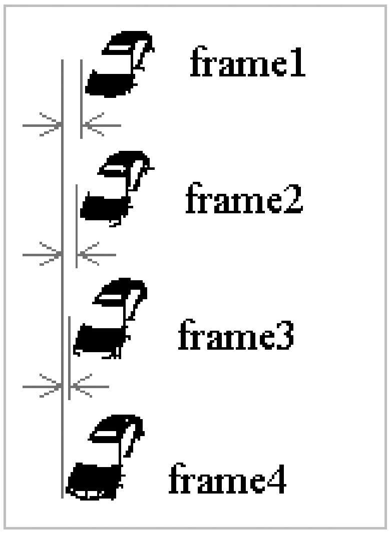


Fig. 23 The segmented car and its movement on the horizontal direction in the image sequence

5 Conclusion

In this paper, a novel method of image sequence analysis is presented inspired by physical electro-static field. The spatial property of the 3D relative potential field is studied, based on which the segmentation of image sequences in the 3D signal space is proposed. The experimental results indicate that the 3D relative potential field of image sequences can serve as a natural representation of 3D region border for object segmentation. Moreover, the segmented 3D bodies from the sequence provide a convenient way for object tracking and analysis. The effectiveness of the relative potential method is based on some unique characteristics of its mathematical form, which serves as a suitable model for the representation of the local-global relevance between image points. The structure information of the sequence can be revealed by the relative potential transform. The sign distribution of the relative potential values can serve as the feature of 3D region border, based on which image sequence segmentation can be performed. Further work will study detailed properties of the 3D relative potential field for image sequences, and its application on other tasks of image sequence processing will also be investigated.

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