Feature Detection of Moving Images Using a Hierarchical Relaxation Method

3B−1

Dingding CHANG Shuji HASHIMOTO Sadamu OHTERU
Waseda University

1. Introduction

In this paper, we present a hierarchical method for detecting local features in moving images. The relaxation processes are performed on the temporal-spatial pyramid, which is a multiresolution data structure of moving images. Therefore, it becomes possible to obtain the accurate detection by using information in other frame images and the processing results in high layer of the pyramid while it is difficult by using only one frame image.

2. Relaxation Method

Suppose that we have a set objects (A_1, A_2, ...,A_n) that we want to classify into m classes (B_1,B_2,...,B_m), and let Pih be the estimate of probability that A_i belongs to B_h, $1 \leq i \leq n$, $1 \leq h \leq m$. Thus for each i we have $0 \leq P_{ih} \leq 1$, and $\Sigma_h P_{ih}=1$. At the same time, we have the quantitative measure of a compatibility of Ai∩Bh with Aj∩Bk denoted by C(i,j,h,k), and C(i,j,h,k) always lie in the fixed range [-1, 1]. The relaxation iteration process is defined by[1]

$$P_{ih} = P_{ih} (1+Q_{ih}) / \Sigma_h P_{ih} (1+Q_{ih})$$

$$Q_{ih} = \Sigma_j D_{ij} \Sigma_k P_{jk} C(i,j,h,k).$$

The weighted coefficients D_{ij} can be defined by experiments, and $\Sigma_j D_{ij} = 1$.

3. Hierarchical Process

The research for the visual system of human beings shows that the retina is a array structure composed of a lot of receivers with different resolution. When we search for some objects in a scene, the interesting area and global structure in the scene will be rapidly detected by the low resolution receivers around the retina at first. Then, using these information, required details will be detected by the high resolution receivers at the concave center of retina. Based on the fact of hierarchical process of human vision system, the multiresolutional data structure and hierarchical method has become a interesting subject in the field of image processing[2].

4. Hierarchical Relaxation Method

4.1 Previous Works

Schatcher et al proposed a relaxation method for edge detection[3]. In the method, initial edge probabilities and no-edge probabilities can be estimated from the digital gradient at each point, and the compatibilities can be based on the edge probabilities and directions of neighboring points.

We find some unnecessary even contradictory computations were done in definition of the probability and compatibility in this method. This does not only make operating times longer but also affects the detected results. An improved method was proposed by considering the edge probability only, choosing simple operation instead of operation of trigonometric function, and using computation of probability increment instead of iteration process of probability. A hierarchical method was also proposed by defining weighted coefficients based on information in high hierarchy, and by interpolating processing results in low resolution image to high resolution image[4,5].

4.2 Temporal-Spatial Hierarchy

To extend the hierarchical relaxation method to detect edges in moving images, we build temporal-spatial pyramid, which is formed hierarchically not only on spatial directions but also on temporal direction.

$$H_k(x,y,t)= \Sigma \Sigma \Sigma\ H_{k-1}(2x-i,2y-j,2t-k).$$

$$(i,\ j,\ k = 0,\ 1)$$

4.3 Temporal-Spatial Relaxation

When relaxation process is performed in temporal direction, it should be considered to establish motion correspondence for different frames. Relaxation process in a cubic neighbour region is described as below, assuming that the motion compensation has been performed so that the corresponding edges are included in the region.

(1) Compatibilities are defined by

R_1 = -1; for $90° < | a-b | < 270°$
1; others.

$R_2 = 1/(1+B)$; for $0° \leq | a-c | < 90°$
$1-1/(1+B)$; for $90° \leq | a-c | < 180°$.

$B = \mathrm{mod}(| a-c | ,90°)/45.$

Here compatibilities R_1, R_2 represent the effect between the central point (x,y,t) and neighbour point (u,v,w), a, b, c are the edge directions at the central point and neighbour point, and the direction of connected line of these two points, respectively.

階層的弛緩法による動画像の特徴抽出

張 汀汀 橋本 周司 大照 完
早稲田大学

(2) Iteration computation is defined by

P_{new} = max [0, P(1+Q)]; for Q≧0

min [1, P(1+Q)]; others.

$Q = \Sigma\ D_{xyt}\ P(u,v,w)\ R_1\ R_2$.

Here PQ is the probability increment, and D_{xyt} is the weighted coefficient which can be decided by the detecting result in the high layer of the temporal-spatial pyramid.

4.4 Motion Estimation

Motion estimation should been done for motion correspondence. A method to estimate two dimension translation will be described below, which can be extended to estimate general three dimension motion.

Let $F_1(x,y)$ and $F_2(x,y)$ be the gray levels at point (x,y) in two successive frames. The time lapse Δt between the two frames is assumed small so that the amount of motion is also small. At any given spatial location (x0,y0) the time difference is

$\Delta F(x0,y0) \fallingdotseq F_2(x0,y0) - F_1(x0,y0)$.

Assume the amount of two dimension translation is $\Delta x = x_0' - x_0$, $\Delta y = y_0' - y_0$. Then, we have

$\Delta F(x_0,y_0) = F2(x_0,y_0) - F2(x_0'-y_0')$.

We expand $F_2(x_0',y_0')=F_2(x_0+\Delta x,y_0+\Delta y)$ in the above equation into a Taylor series and take only up to linear terms and get

$\Delta F(x_0,y_0) = -\Delta x\ \delta F/\delta x - \Delta y\ \delta F/\delta y$.

If we have two points which we can assume to have the same motion, then by calculating ΔF, $\delta F/\delta x$ and $\delta F/\delta y$, we can get two linear equations. A unique solution to (Δx, Δy) will be then obtained, if the two equations are independent.

5. Experiments and Results

The experimental result is shown in Fig.1. Three frames in a image sequence, which are shown in Fig.1 (a), (b) and (c), were taken in the experiment. The detecting results by Sobel operator, hierarchical relaxation method using one frame only, and the method presented in this paper using three frames are shown in Fig.1 (d),(e) and (f), respectively. We see the better detection can be obtain by the proposed method.

6. Conclusions

We have developed a hierarchical relaxation method for edge detection of moving images. Using information in multiresolution images and frames front and back, the edges of objects in a scene and their time-variant locations can be detected with high speed and high accuracy by the method. It can be expected to extend it to detect other features in moving images, and to find use in future research of segmentation, modelling and understanding of moving images.

7. References

[1] A.Rosenfeld, A.C.Kak, "Digital Image Processing", Academic Press, New York, 1982.

[2] R.M.Haralick (ed.), "Pictorial Data Analysis", Springer-Verlag, Berlin, 1983.

[3] B.J.Schatcher, et al, "An application of relaxation method to edge reinforcement", IEEE Trans. Syst., Man & Cybern., Vol. SMC-7, 1977. pp.813-816.

[4] D.D.Chang, et al, "A hierarchical relaxation method for edge detection", Proceedings of the IEEE 1988 International Conference on Syst., Man & Cybern., Beijing/ Shenyang, CHINA. August 8-12,1988. pp906-908.

[5] D.D.Chang, et al, "Multiresolution relaxation: experiment and evaluation", Proceedings of the 9th International Conference on Pattern Recognition, Rome, ITALY, November 14-17, 1988. pp712-714.

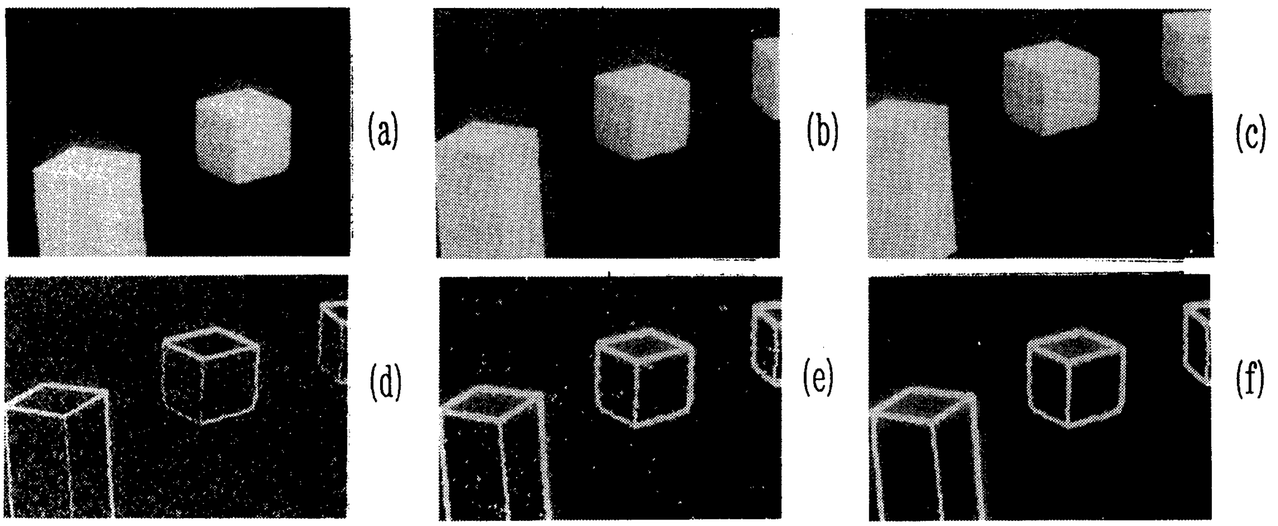

Fig.1 Edge detection for moving images. (a), (b) and (c) are 3 frames in an image sequence, (d), (e) and (f) are the detecting results by Sobel operator, the hierarchical relaxation method using one frame only, and the proposed method using three frames respectively.