Object Tracking with Radical Change of Color Distribution Using EM algorithm

황인택[O] 최광남
중앙대학교 컴퓨터공학과
sitdown@vim.cau.ac.kr[O], knchoi@cau.ac.kr

Object Tracking with Radical Change of Color Distribution Using EM algorithm

In Teck Whoang[O], Kwang Nam Choi
School of Computer Science & Engineering, Chung-Ang University,

요 약

This paper presents an object tracking with radical change of color. Conventional Mean Shift do not provide appropriate result when major color distribution disappear. Our tracking approach is based on Mean Shift as basic tracking method. However we propose tracking algorithm that shows good results for an object of radical variation. The key idea is iterative update previous color information of an object that shows different color by using EM algorithm. As experiment results, we show that our proposed algorithm is an effective approach in tracking for a real object include an object having radical change of color.

1 Introduction

Object tracking requires model about variation of illumination, view-point, scale, occlusion of object and also complexity of background. The important key issue of the all is how we can remove predictable or unpredictable noise while maintaining update between prior knowledge and new observed data of the target object.

All of object tracking system requires robustness about arbitrary noise and tolerance to spacious variation of observation data. We can realize the requirements through prior knowledge and proper processing of a target. However there are vary circumstances thatmake object tracking hard. For example, the color of target object can be changed. Therefore many algorithms using color distribution is based on assumption that the color of target object is not changed during tracking. However this assumption is not true in real world. For example, in people tracking, the color of target object is changed when someone change one's clothes during tracking time. In face tracking, color distribution based algorithms have similar problems. For example, when a person shake or raise and hang his head, the view-point of the face is changed and color distribution have radical variation.

Comaniciu suggested Mean Shift algorithm thatis based on color distribution [4]. Although this paper showsexamples as color distribution of target is changed radically during tracking. In this paper, we suggest the algorithm that is based on Mean Shift have a robustness of color changes. Our approach is that: First, we obtain the color distribution of a target object. Then for all of each frame, we find position of the target by using color distribution. This processing is similar with Mean Shift. After finding the object, we recalculate and update color distribution for object which is found. By using EM algorithm as iterative method for updating density functionfor tracking, we obtain robustness for radical change of color distribution.

We first describe the Mean Shift algorithm as basicmethod. We represent the tracking system based on EM algorithm. We experiment on an artificial object and a human. We also show the results of experiment. We explain results and compare suggested algorithm with Mean Shift.

2 System Design

2.1 Mean Shift

The Mean Shift algorithm is introduced in Fukanaga and Hostetler 1975 as a non-parametric clustering [8]. This algorithmis extended to image processing by taking into account the spatial neighborhood of the samples in Commaniciu and Meer [9]. Mean Shiftis based on kernel density estimation that converges a location by moving from current to highest probability location iteratively. We must define appropriate kernel function in Mean Shift. In this paper, we exploit radically symmetric kernel as following Comanicu's proposal [3]. Two usual symmetric kernels are Epanechnikov kernel and multivariate normal [10].

$$K_E(x)=\begin{cases}\frac{1}{2}c_d^{-1}(d+2)(1-\|x\|^2) & \text{if } \|x\|<1\\ 0 & otherwise\end{cases} \quad (1)$$

c_d : the volume of the unit sphere in R^d

$$K_N(x)=(2\pi)^{\frac{-d}{2}}\exp(-\frac{1}{2}\|x\|^2) \quad (2)$$

We can define the estimate of the density gradient as the gradient of the kernel density estimate

$$\hat{\nabla}f(x)\equiv\nabla\hat{f}(x)=\frac{1}{nh^d}\sum_{i=1}^{n}\nabla K\left(\frac{x-x_i}{h}\right) \quad (h:\text{window radius}) \quad (3)$$

and we can obtain sample Mean Shift by

$$M_h(x)\equiv\frac{1}{n_x}\sum_{x_i\in S_h(x)}x_i-x \quad (S_h(x):\text{hypersphere of radius } h)$$
(4)

and then we can compute Mean Shift vector

$$M_h(x)=\frac{h^2}{d+2}\frac{\hat{\nabla}f(x)}{\hat{f}(x)} \quad (5)$$

We can obtain direction of maximum increase in the density from current position x by the Mean Shift vector. Therefore we repeat this procedure until estimated location be converged by transferring to increasing direction of local density. Initial location be adjusted as local density maximum. Mean Shift algorithm be implemented by above these procedures. The Mean Shift procedure requires recursive computation to be obtain Mean Shift vector. To guarantee finite computation time, we must prove that this sequence $\hat{\nabla}f(x)$ is convergent. This convergence condition is sufficient by a proof of [9].

2.2 EM algorithm

In this paper we exploit EM algorithm for tracking a object having large variation of color. EM algorithm is a method that be obtained maximum likelihood estimates of parameters in probability model depends on latent variables by iterative Maximum likelihood estimation. In expectation step of EM we obtain estimated location of local density maximum as above processing of Mean Shift vector. Proposed algorithm is as follows:

1. Initialize search window as density function of target object and other parameters.
   T : threshold of difference between updated estimated location and estimated current location of target object.
   i : count of iteration
2. i ← i + 1
3. Expectation Step : compute $Q(\theta;\theta^i)$
   θ : obtained previous location of estimated by Mean Shift
   θ^i : obtained i-th candidate location of estimated by Mean Shift
   $Q:\|\theta-\theta^i\|$
4. Maximization Step : $\theta^{i+1}\leftarrow\arg\min Q(\theta;\theta^i)$
   Search minimize between candidate and previous location.
5. Repeat Steps 2, 3 and 4 until θ^i converges
6. Update density function as new density function.

When we denotes m-feature space as following Target model : (6)

3 Experiment Results

This experiment is performed with human and artificial object and in interior illumination. The artificial object has two different colors having a long distance between each other in color space. The object shows explicit difference of results between conventional Mean Shift and proposed tracking algorithm. We use normal PC webcam. This camera has 320 * 200 resolution, 15 frame per a second.

Figure 1 and 2 shows the experimental results of Mean Shift and proposed algorithm. Both of two experiments have identical condition of environmental variable including drifting of target object. In this sequence, the target object has large variation of color by temporal flow. As the results of Figure 1, we can obtain that conventional Mean Shift estimates incorrect position of the artificial object in last result frame. Mean Shift has a limitation as estimate highest probability position only for initial probability distribution by the algorithm. Initial density function in Mean Shiftis very useful information for supporting coherence of tracking. However usability of the initial function depends on variation of an object. An example of the cases is an artificial object in Figure1 and 2. This object has two different colors by temporal flow. As second and third frame of result in Figure1, Mean Shift obtainsthe middle position of only initial colors. Figure2 shows results are processed by our proposed tracking algorithm. All frames of the sequence show robust results about large variation of color. To maintain correct result, conventional approaches based on color information exploit the other data for example around background or shape data of a target. However this approach involves probability of incorrectness by using inaccurate features that the object does not have in itself. Our proposed algorithm using EM do not consider another data except information that a target has. Therefore we reduce the probability of incorrectness. Results of Figure 2 show a evidence of that.

Figure 3 and 4 show results of human tracking in real world. In this experiment, a target is a human head. Tracking is performed in identical environment as same a human, background and internal illumination. A problem of human head tracking is that someone has different color in face and hair. When someone turn around one's head on the opposite side of camera, a traditional tracking system based on color data will lose a target depend on situation. Because they lose coherence between front view with mainly skin color and backward view with black hair. Figure3 shows a case of above situations. Other frames except final frame in Figure 3 represent good result. When a target has another pose of different color against initial pose as end frame of Figure 3 and 4, they will lose their target. Figure 4 by using proposed algorithm has different results in final frame. Figure4 proves that proposed algorithm also has a good performance for natural object in real world as well as Figure 2.

When we exploit relative extra information of a target in future, we will obtain more robust tracking system has a good performance about both problems of occlusion in each objects and color variation of an object.

4 Conclusion

In this paper, we represent a robust system for radical change of color distribution as an issue of object tracking researches. Conventional tracking system based on color information requires a target that maintains the minimum of initial color information for tracking. However this requirement depends on an object and environmental elements. When an object has large variation, they will lose a target.

We provide robust tracking system for this problem by combining EM algorithm and Mean Shift. As experiment results, the proposed algorithm shows a good performance for an object with radical variation of color in both experimental environment and real world. We showed that our proposed algorithm is an effective approach in tracking for a real object include an object having radical change of color.

References

1. D. Comaniciu, V. Ramesh, P. Meer: Kernel-Based Object Tracking, IEEE Trans. Pattern Analysis Machine Intell., vol. 25, no. 5, pp. 564-575, 2003.

2. Fukanaga, K. and Hostetler, L., The estimation of the gradient of a density function, with applications in pattern recognition, IEEE Transactions on information theory, vol. 21, no. 1, pp. 32-40, 1975.

3. Comaniciu, D. and Meer, P., Mean Shift : a robust approach toward feature space analysis, IEEE Transactions on Pattern Analysis and Machine Intell., vol. 24, no. 5, pp. 603-619. 2002.

4. D. Comaniciu and P. Meer, Mean Shift analysis and applications, in Proc. 7th Intl. Conf. on Computer Vision, Kerkyra, Greece, pp. 1197-1203, 1999.

5. D.W. Scott, Multivariate Density Estimation, New York: Wiley, 1992.

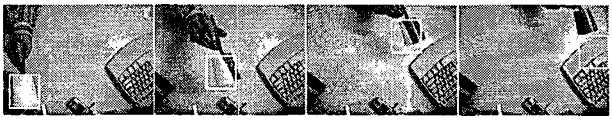

Fig. 1. Experimental result of conventional Mean Shift (left-right). All of frames have about 90 frames interval to previous.

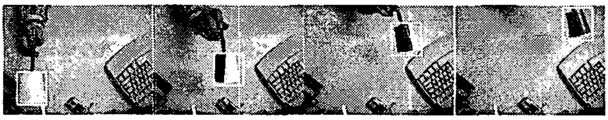

Fig. 2. Experimental result of proposed tracking algorithm for object with radical change of color distribution (left-right). All of frames have about 90 frames interval to previous.

Fig. 3. Human tracking result by Mean Shift in real world(left-right). All of frames have about 90 frames interval to previous.

Fig. 4. Human tracking result by proposed algorithmin real world(left-right). All of frames have about 90 frames interval to previous.