Video Segmentation with Motion Smoothness

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(a) (b) (c)

Figure 1: *In traditional 3D Graph Cuts, due to the color similarity, there are cases that no matter what smoothness weighting is, artifacts would be produced as shown in (a) and (b). Hence, we combine color and motion information to improve the result greatly as shown in (c).*

1 Introduction

In this extended abstract, we propose a novel approach for video segmentation by utilizing motion information. Recently, graph-cut-based segmentation methods became popular in this domain but most of them dealt with color information only. Those methods possibly fail if there are regions similar in color between foreground and background. Unfortunately, it is usually hard to avoid, especially when objects are filmed under a natural environment. For instance, Figure 1(a) shows a result of graph cut with a small smoothness weighting, and hence some background regions are incorrectly labeled. On the contrary, if a larger smoothness weighting is used, some background regions near the foreground will be merged as shown in Figure 1(b). To improve those drawbacks, we propose a method based on both of color and motion information to conduct the segmentation. The method is useful because foreground and background usually have different motion patterns as shown in Figure 1(c).

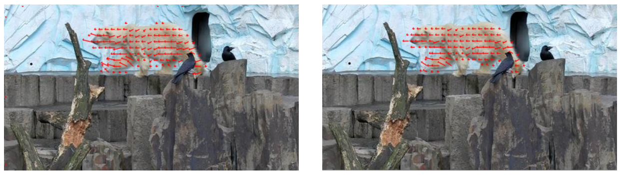
2 Video Segmentation

In traditional video segmentation, such as [Li et al. 2005], the segmentation problem is usually formalized into an energy minimization with the following objective function: $E = E_d + \alpha E_s + \beta E_t$, where E_d is color similarity, E_s and E_t are penalty terms for color differences among neighboring pixels that have different labels, in the same frame and neighboring frames, respectively. In our system, we extend the energy function by further incorporating the motion information E_m: $E = E_d + \alpha E_s + \beta E_t + \gamma E_m$. where the motion difference E_m is calculated according to the inner product of normalized motion vector v_p and v_q of the neighboring pixels p and q:

$$E_m = \sum_{(p,q)\in\mathcal{N}} |f_p - f_q| \cdot g(v_p \cdot v_q),$$

where f_p and f_q are given labels, and $g(X) = \frac{1}{X+1}$ is implemented inverse relation.

All the motion vectors are pre-calculated by a revised version of the optical flow algorithm proposed by Brox *et al.* [2004], which can produce much denser optical flow information. However, since the raw optical flow has some noises, we further conduct color-guided weighting average:



(a) (b)

Figure 2: *(a) Before refinement, there are some noises in the boundary region. (b) After refinement, some noises are removed.*

$$v_p = \frac{\sum_{(p,q)\in\mathcal{N}} v_q \cdot w(p,q)}{\sum_{(p,q)\in\mathcal{N}} w(p,q)},$$

where the weighing $w(p,q)$ is in an inverse proportion to geometric distance and color difference. After the refinement, the quality of the optical flow information is improved as shown in Figure 2.

3 Conclusion and Future Work

A new video segmentation method is proposed in this paper. We do not only utilize the traditional spatial color smoothness and temporal coherence, but also encode the motion smoothness into a 3D temporal-spatial graph. In many cases, our method outperformed traditional ones taking only color information into account. In the future work, we will try to automatically adjust the weighings by the statistics of color and motion of the input video. Secondly, we will improve the user interface to let user provide additional strokes and utilize the optical flow information to propagate the strokes.

References

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