Visual Preserving Video Retargeting with Deformable Shape Consistency

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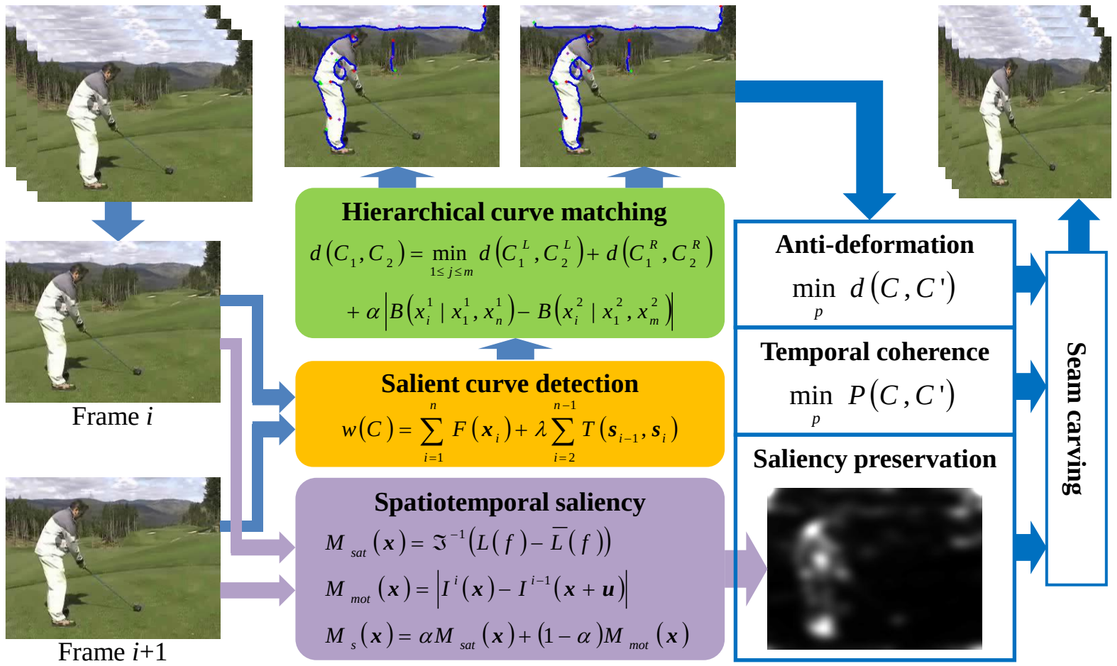
1. Introduction

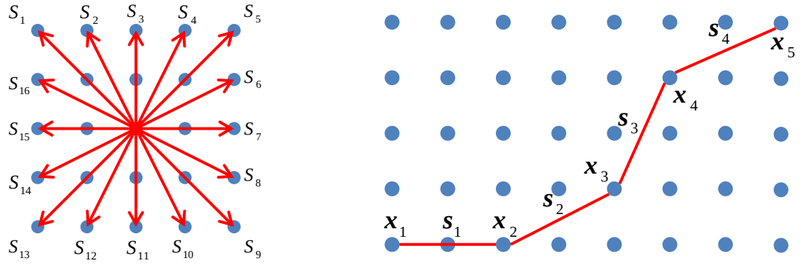
Video retargeting is a technique that resizes the aspect ratio and resolution of a video in a content aware manner. In this paper, we propose a novel shape preserving video retargeting method to reduce deformations and maintain temporal consistency via matching salient curves in the video frames. Our method transforms the anti-deformation and temporal consistency problems in video retargeting into a curve matching cost minimization problem. By incorporating a deformation cost and temporal inconsistency cost into the seam carving framework, the quality of the retargeted videos can be significantly improved.



System framework

2. Salient curve detection

A curve is represented as a sequence of oriented segments $c=(x_1,x_2,\cdots,x_n)$, where $s_i=x_{i+1}-x_i\in S$



Oriented segments Curve representation

The weight of a curve is defined as

$$W(c)=\sum_{i=1}^{n}F(x_i)+\lambda\sum_{i=2}^{n-1}T(s_{i-1},s_i)$$

where $F(\boldsymbol{x})$ is the saliency map, and $T(\boldsymbol{u},\boldsymbol{v})$ is a smoothness term that encourages consistent orientations of consecutive fragments $\boldsymbol{u}$ and $\boldsymbol{v}$. Salient curves can be extracted by detecting curves with large weights and sufficient lengths.

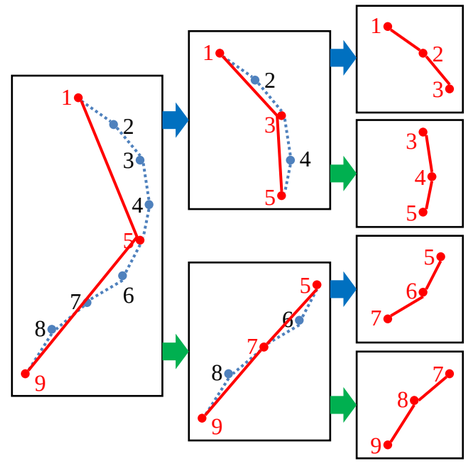
3. Hierarchical shape matching

A curve is represented by a binary shape tree. Each node in the shape tree stores the relative location of the midpoint with respect to the two endpoints of a sub-curve. The left child of the node stores the first half sub-curve and the right child stores the second half sub-curve in the same manner.

Given two endpoints $x_1=(x_1,y_1)$ and $x_n=(x_n,y_n)$ of a curve, the relative location of the midpoint $x_i=(x_i,y_i)$ is represented in the Bookstein coordinate

$$x_i'=\frac{(x_n-x_1)(x_i-x_1)+(y_n-y_1)(y_i-y_1)}{(x_n-x_1)^2+(y_n-y_1)^2}-\frac{1}{2},\ y_i'=\frac{(x_n-x_1)(y_i-y_1)+(y_n-y_1)(x_i-x_1)}{(x_n-x_1)^2+(y_n-y_1)^2}$$

Matching two curves in the Bookstein coordinate is invariant to translation, rotation and scaling.



Shape tree

To match curve $c_1=(x_k^1)_{k=1}^n$ and $c_2=(x_k^2)_{k=1}^m$, we fix the shape tree of $c1$, and look for a mapping from the points in $c2$ to the points in $c1$, which minimizes the deformation cost

$$d(c_1,c_2)=\min_{1<j<m}\left\{d(c_1^L,c_2^L)+d(c_1^R,c_2^R)+\alpha\left|B(x_i^1\mid x_1^1,x_n^1)-B(x_j^2\mid x_1^2,x_m^2)\right|\right\}$$

where x_i^1 is the midpoint of $c1$, x_j^2 is the midpoint of $c2$, $d(c_1^L,c_2^L)$ is the matching cost of the left subtrees of $c1$ and $c2$, and $d(c_1^R,c_2^R)$ is the matching cost of the right subtrees of $c1$ and $c2$.

3. Shape preserving seam carving

The energy of a seam is

$$E(\boldsymbol{p})=E_s(\boldsymbol{p})+\beta E_d(\boldsymbol{p})+\gamma E_t(\boldsymbol{p})$$

where *Es* is the visual saliency term, *Ed* is the deformation term and *Et* is the temporal term.

Visual saliency term *Es* is the sum of the saliency intensities of seam $\boldsymbol{p}$ in the saliency map *Ms*:

$$E_s(\boldsymbol{p})=\sum_{j=1}^{H}M_s(p_j,j)$$

The deformation term *Ed* is the sum of deformation costs of corresponding curves after removing seam $\boldsymbol{p}$:

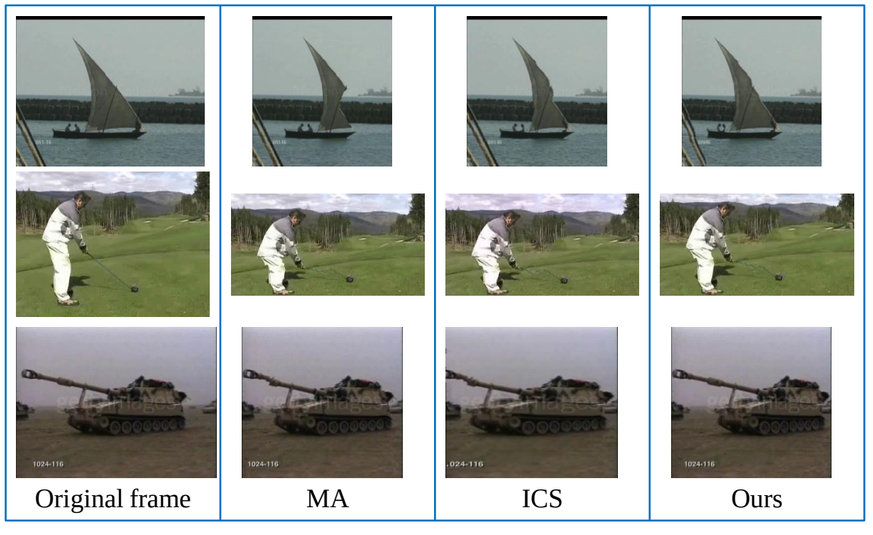
$$E_d(\boldsymbol{p})=\sum_{i=1}^{N}d(c_i,c_i')$$

where c_i' is the deformed curve of c_i. The temporal term *Et* penalizes the variation of relative positions of curves.

The optimal seam is obtained via dynamic programming.

$$\boldsymbol{p}^*=\arg\min_p\ E_s(\boldsymbol{p})+\beta E_d(\boldsymbol{p})+\gamma E_t(\boldsymbol{p})$$

4. Experimental results



Original frame MA ICS Ours

Psycho-visual evaluation result

	Ours	ICS	MA
Ours	-	17	15
ICS	59	-	31
MA	61	45	-
Total	120	62	46
Prefer	78.9%	40.8%	30.3%

ICS: M. Rubinstein et al., "Improved seam carving for video retargeting," SIGGRAPH, 2008.
MA: Y. Bo et al., "Matching area based seam carving for video retargeting," *TCSVT*, 2008.