Region Competition for Object Tracking by Using Kullback-Leibler Distance and Level Set Contours

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Motivation:

- Track simultaneously N different objects with non-rigid motion in a scene.
- Applications to video surveillance.

Assumptions:

- The tracking is performed on a non-static background.
- The object and background are represented by using mixture models.

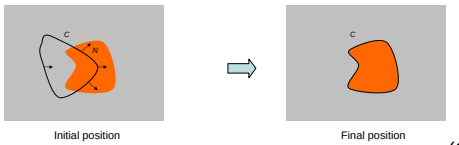
$$p(x/\Theta_{bck}) = \sum_{j=1}^{M_{bck}} \pi_j \cdot p(x/\theta_j) \qquad p(x/\Theta_{obj}) = \sum_{k=1}^{M_{obj}} \pi_k \cdot p(x/\theta_k)$$

The tracking method:

- Initialize the object contours manually by the user in the first frame of a video sequence.
- Use boundary, color and texture features to represent the objects and the background.
- Track simultaneously the moving objects by using active contours.
- Use level set formalism (Osher et al. 1988) to implement the object contours evolution (Level sets permit to handle automatically topology changes for the contours).

Principle of object tracking by using active contours:

Deform a planar curve $C(s,t)$ by a PDE to track an object on the image background.



Initial position — Final position

Motion Equation of the curve $C(s,t)$: $\frac{dC(s,t)}{dt} = \varphi(C)\cdot\vec{N}$

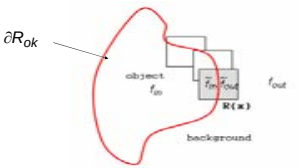
$\varphi(C)$: Curve velocity.

$\vec{N}$: normal vector.

Tracking model for N objects:

-Minimize the following energy functional according to the object contours by using Euler-Lagrange equations:

$$E(\partial R_{o1},\ldots,\partial R_{oN}) = \alpha\sum_{k=1}^{N}\underbrace{\oint_{\partial R_{ok}} g(|\nabla I|)ds}_{E_b} + \beta\sum_{k=1}^{N}\oint_{\partial R_{ok}}\underbrace{\left(\iint_{R(s)} D(\tilde{f}_{in}(x)\,||\,f_{in})\chi(R_{ok})dx + \iint_{R(s)} D(\tilde{f}_{out}(x)\,||\,f_{out})\chi(R_{bck})dx\right)ds}_{E_r}$$



$D(\tilde{f}_{in}(x)\,||\,f_{in})$: is the Kullback - Leibler distance.

$\chi(R)$: is the characteristic function of the region R.

$g(|\nabla I|)$: is the inverse of the image gradient magnitude.

Handling object collision and splitting:

During the tracking, fuse 2 objects R_{oh} and R_{ok} if the following conditions are satisfied:

$$\begin{cases}\exists x \in R_{oh}, \exists y \in R_{ok} : \Phi_h(x) \le 0 \text{ and } \Phi_k(y) \le 0 \\ D(f^h{}_{in}\,||\,f^k{}_{in}) \le \delta\end{cases}$$

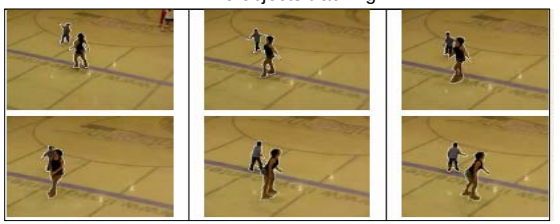
δ: is determined experimentally.

Φ_h and Φ_k: are the level set functions representing the contours of the objects R_{oh} and R_{ok}.

Examples:

One object tracking

Two objects tracking



Two objects tracking

One object tracking

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