

Computer Vision for HCI

Covariance Tracking

Overview

- Real-time non-rigid object tracking
- Covariance Tracking
 - Covariance of spatial and statistical features

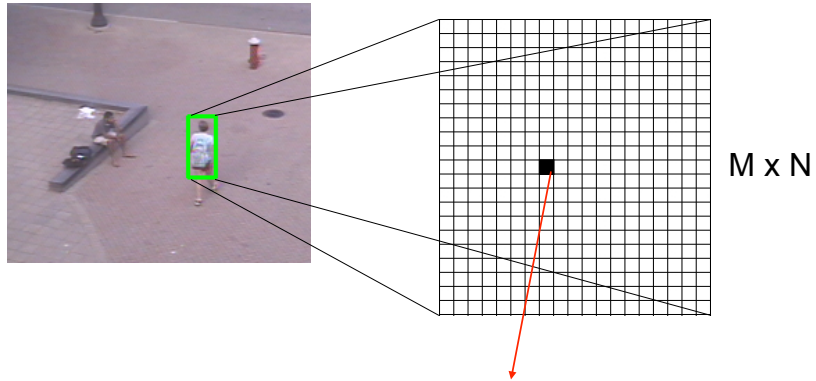
Covariance Tracking

Based on: "Covariance tracking using model update based means on Riemannian manifolds",
Fatih Porikli, Oncel Tuzel, Peter Meer, CVPR 2006

Motivation

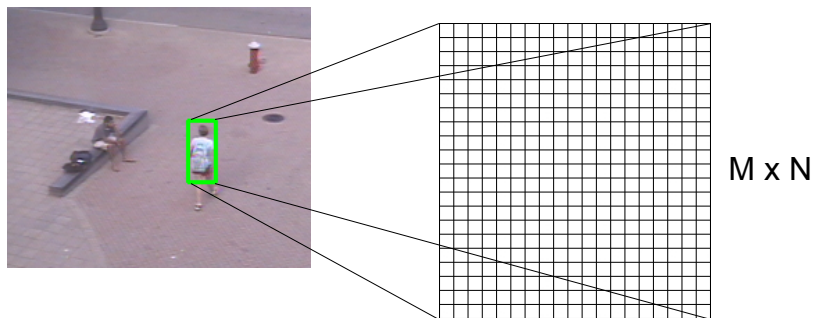
- Captures spatial and statistical properties, and their correlation
- Fuse different types of features
 - Location
 - Color
 - Edges
- Low dimensional representation (fast)
- Scale invariance

Covariance Descriptor



Feature vector (for each pixel) $f_k = [x \ y \ R \ G \ B]^T$
 $d \times 1$

Covariance Matrix



Person Model

$$C^{Model} = \frac{1}{MN} \sum_{k=1}^{MN} (f_k - \mu)(f_k - \mu)^T$$

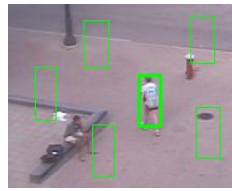
$d \times d$

mean f_k

Finding the best match



C^{Model}



Candidate matches

- For each patch region in the next image, find its covariance matrix
- Compare C^{Model} to all patch regions
- Find the patch whose distance from C^{Model} is minimum

Comparing Covariance Matrices

- Find the distance between 2 covariance matrices
- Space of covariance matrices is not vector!
 - Simple arithmetic matrix subtraction would not work
- The space of covariance matrices is a Riemannian Manifold
- Distance metric:

$$\rho(C^{Model}, C^{Candidate}) = \sqrt{\sum_{i=1}^r \ln(\lambda_i(C^{Model}, C^{Candidate}))^2}$$

λ_i - Generalized Eigenvalues [In Matlab: $eig(C_1, C_2)$]

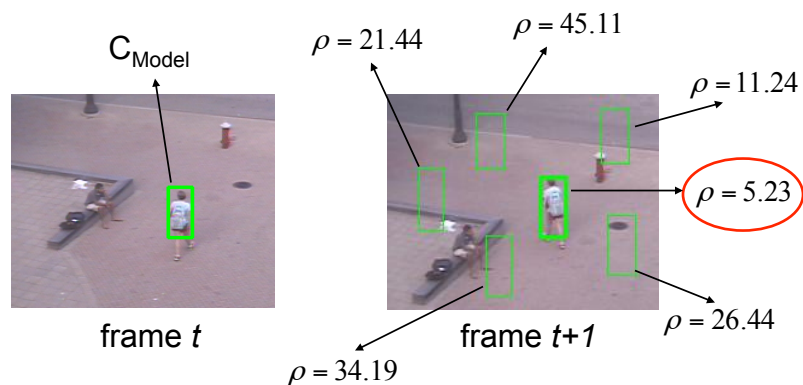
Algorithm

- Compute C^{Model} for known target
- Scan all patches in next image
 - For each patch compute covariance matrix $C^{Candidate}$
 - Find distance from C^{Model}

$$\rho(C^{Model}, C^{Candidate})$$

- Find patch region with minimum distance

Example



Results



Active Camera tracking
Feature space: [x y R G B]
Target: manually selected on 1st frame

Other

- Rotation invariance
 - Use radial distance instead of Cartesian
$$f_k = [r(x,y) \ R \ G \ B]^T$$
- Model Update
 - Calculate mean covariance matrix from a few previous frames and use as C^{Model}
 - Calculate mean on manifold (see paper)

Summary

- Algorithm for non-rigid object tracking
- Covariance Tracking
 - Covariance of spatial and statistical features
 - Low dimensional representation of object
 - Distances between matrices based on manifold distance