Object Categorization with SVM: Kernels for Local Features

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Introduction

The performance of an object categorization system depends mainly on **two ingredients:**

- a suitable representation of the image (pixel values, color histogram, etc.)
  $\Rightarrow$ traditionally main focus in Computer Vision

- a powerful classification algorithm (Nearest Neighbour Classifier, Bayes classifier, etc.)
  $\Rightarrow$ core topic of Machine Learning

The Best of Both Worlds

What representation?

$\Rightarrow$ **invariant local image descriptors**

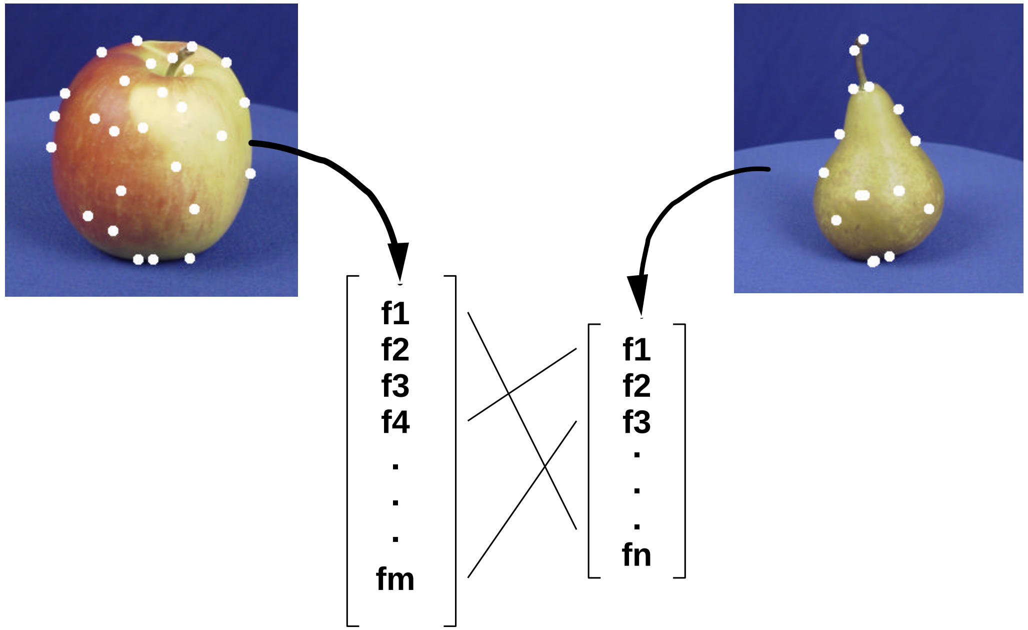
- invariant to transformations (translation, scaling, etc.)
- have proven to be very successful in Object Recognition

Which classifier? $\Rightarrow$ **Support Vector Machine**

- improved performance (e.g. over generative models)
- ability to control generalization

How to do it?

SVM needs a **kernel function** on sets of local features



Problem:

- local features are not ordered
- images have different number of interest points

Existing Approaches

- **Wallraven** et.al.[a]: average over the distance to the best match
  ⇒ match individual features

- **Kondor** and Jebara[b]: compute similarity of two distributions
  ⇒ compare statistics

[a] C. Wallraven et al, *Recognition with Local Features: the Kernel Recipe*, Proc. of ICCV'03

[b] R. Kondor and T. Jebara, *A Kernel between Sets of Vectors*, Proceedings of the ICML, 2003

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A Kernel between Sets of Vectors

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Bhattacharyya kernel on distributions:

$$K(p, p') = \int \sqrt{p(x)}\sqrt{p'(x)}\,\mathrm{d}x$$

- naïve approach: histograms of local features
  $\Rightarrow$ impractical because of dimensionality
- fit a Gaussian and use sufficient statistics (μ, Σ)

to capture more structure $\Rightarrow$ map local features to some feature space (kernel trick)

Experimental Setting

Experiments

were performed using the ETH-80 database[a]:

- local descriptors: SIFT-features (D. Lowe), JET-features (C. Schmid)
- kernel-functions: Kondor's kernel, Wallraven's approach
- SVM + one-vs-rest multi-class scheme

[a] B. Leibe and B. Schiele, *Analysing Appearance and Contour Based Methods for Object Categorization*, CVPR'03

Results

Leave-one-out performance on a subset of ETH-80
(5 out of 41 views, grayvalues)

	SIFT	JET
Kondor	**71%**	**75%**
Wallraven	**74%**	**63%**

compare to:

kNN + χ^2 on color histogram: **68%**

SVM + χ^2 on color histogram: **77%**

SVM + RBF-kernel on raw pixels: **84%**

Discussion and Future Work

Discussion

- results still preliminary
- parameters have to be tuned (e.g. minor kernel in Kondor-kernel)
- promising approach

Future work

- include spatial information
- other kernels on sets

Detailed Results

	Wallraven	Kondor	Wallraven	Kondor
apple	84%	86%	56%	72%
pear	90%	86%	70%	90%
tomato	90%	88%	70%	92%
cow	64%	52%	60%	64%
dog	58%	52%	54%	56%
horse	32%	26%	48%	46%
cup	80%	82%	62%	82%
car	90%	94%	82%	98%
mean	**74%**	**71%**	**63%**	**75%**
	SIFT-features of D.Lowe		JET-features of C.Schmid	