Medical Image Processing

Erkennung, Analyse und Suche von Bildern

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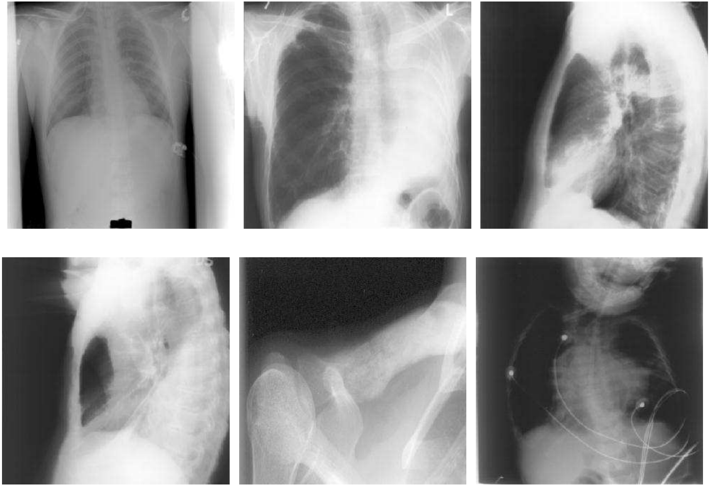
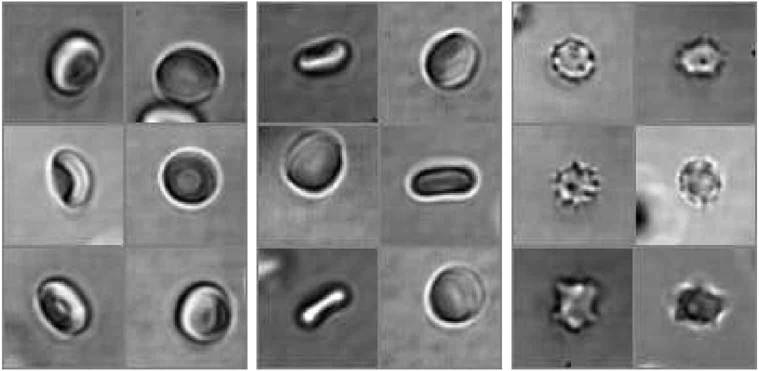
Medical Images

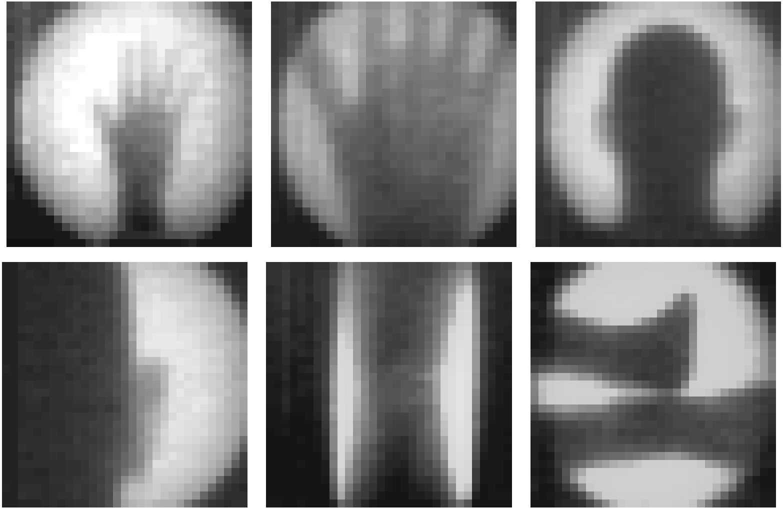
High intra-class variability



Blood Cell Data



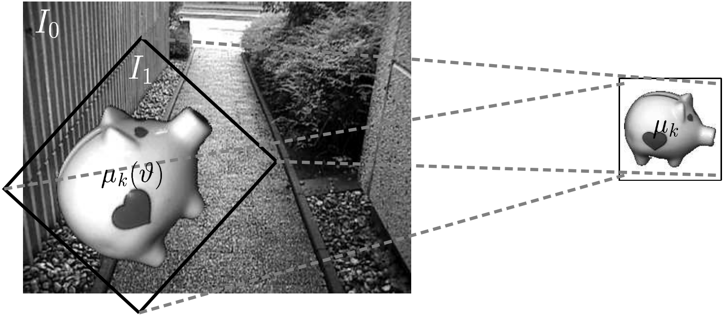
Application: X-Ray Dose Estimation



Object Recognition

Object Recognition / Scene Analysis

Scene Analysis


I_0
I_1
$\mu_k(\vartheta)$
μ_k

Object Recognition using Image Patches

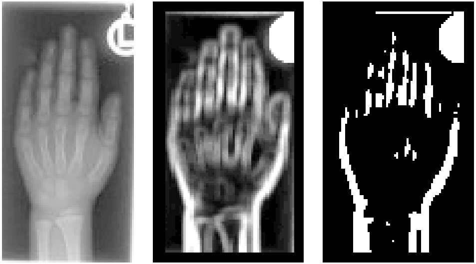
idea:

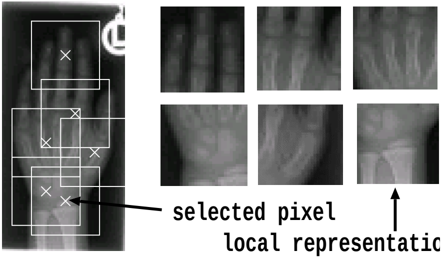
- small sub images extracted at different relevant positions of original image
- position determined e.g. by local variance, entropy, or salient points
- known to achieve good results in various classification tasks: face recognition, optical character recognition

advantages:

- different objects with same parts: allow for learning about one type of object from other objects
- changes in geometrical relation between image parts can be modelled
- can handle occlusions well

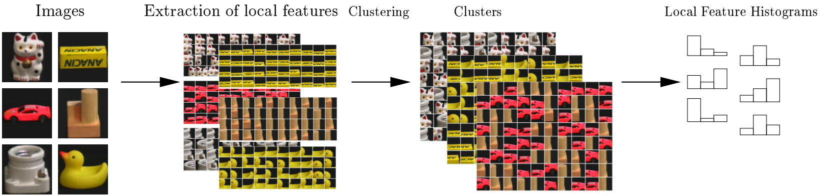
Extraction of image patches





Further Processing of Patches

Image Patch Histograms



- extract local features from all images in the database
- cluster these local features to a reasonable number of clusters (e.g. 512)
- save for each image how many features are in which cluster

Classification using image patches

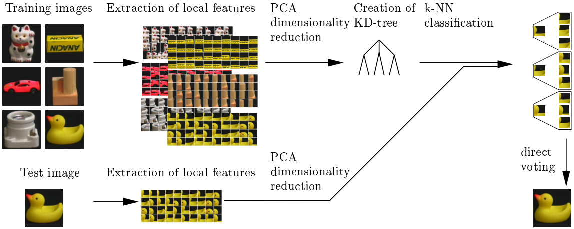
using patches directly

- global patch search and direct voting

using image patch histograms

- nearest neighbor
- naive Bayes
- statistical models

Global Patch Search



training:

- extract local features from all training images
- build KD-Tree of this large set of local features

testing:

- extract local features from the test image
- query the KD-Tree about these local features
- use a direct voting scheme for classification

idea:

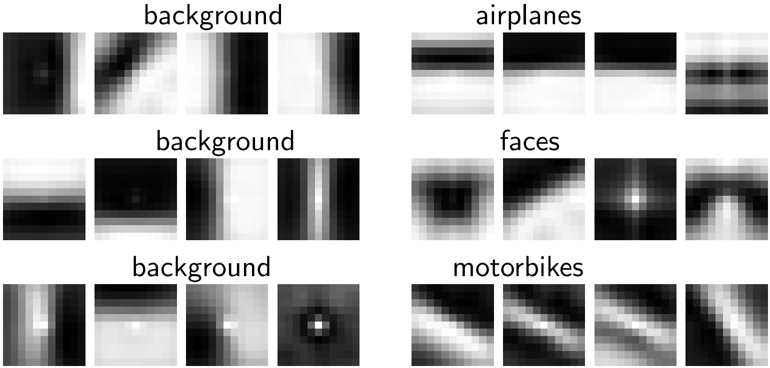
- compact representation: histograms
- learn which objects consist of what object parts. e.g. what is typical for faces?
- different learning techniques possible

parameters:

- position of the image patches
- size of the image patches
- number of clusters for the histograms

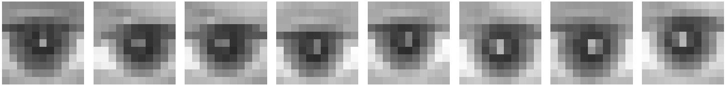
Statistical Models

example images: discriminative parts



Statistical Models

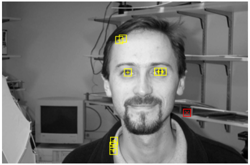
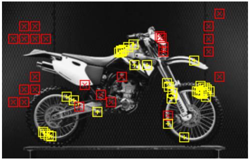
example images: examples for most discriminative parts



Statistical Models

example images: images classified correctly/incorrectly

correctly classified:

incorrectly classified:

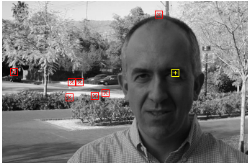
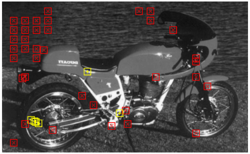




Image Retrieval Demo

How is this done?

Features

important aspects within content-based image retrieval:

- how are the images represented
  ⇒ features
- how are the image representations compared
  ⇒ comparison measures
- how do we retrieve similar images from a database
  ⇒ retrieval method

properties of images

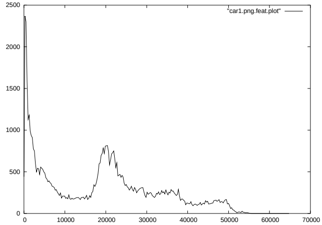
- features describing color
- features describing texture
- images as features
- features describing shapes
- objects contained in images

Color Histograms
feature describing color

idea:

- Partition feature space $\mathcal{S}$ into M regions: $\mathcal{S}^m \subset \mathcal{S}$ with
$$\bigcup_{m=0}^{M-1} \mathcal{S}^m = \mathcal{S}$$
- $P(x \in \mathcal{S}^m) = \frac{K^m}{N}$
- usually regularly spaced grid

example



Tamura Texture Features

feature describing texture proposed by Tamura et al. 1978:

- how do algorithmic features correspond to human perception?
- examined 6 different features, three correspond strongly to human perception
  - coarseness – coarse vs. fine
  - contrast – high vs. low
  - directionality – directional vs. non-directional
  - line-likeness – line-like vs. blob-like
  - regularity – regular vs. irregular
  - roughness – rough vs. smooth
- calculate the first three features pixel wise
- create a 3D histogram of these features

Image Features
images as features

idea:

- use images directly
- different methods to compare images

comparison methods:

- Euclidean distance
- tangent distance
- image distortion model

Comparing Images
Euclidean Distance

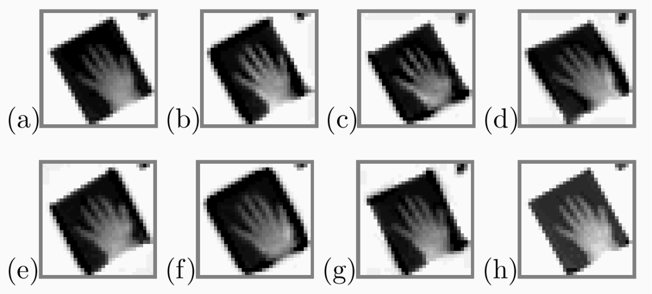
- scale images to common size
- calculate distance

$$D(A,B) = \sum_{x=1}^{X} \sum_{y=1}^{Y} (A(x,y) - B(x,y))^2$$

- advantages:
  - easy to calculate
  - fast
- drawbacks
  - no invariance against any transformation
  - sensitive to lighting changes

introduced by Simard et al.

captures transformations in linear subspace



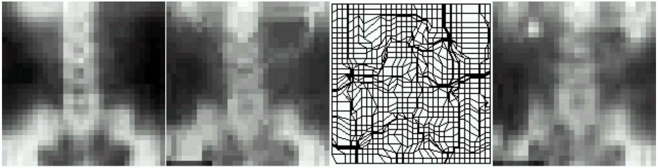
examples: linear approximations of affine transforms and image brightness

(a) original image, (b) left shift, (c) down shift (d) hyperbolic diagonal, (e) hyperbolic axis, (f) scaling, (g) rotation, (h) increased brightness

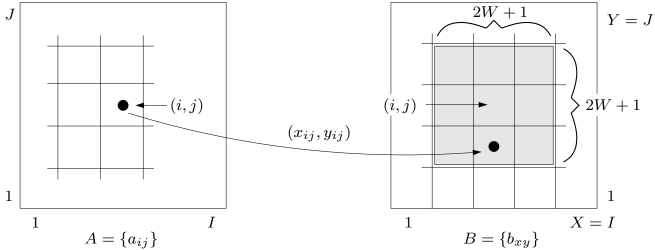
- advantages:
  - fast
  - can account for some transformations
  - can account for lighting changes
- drawbacks
  - only global transformations considered

idea:

- account for small local transformations
- important: take local context into account

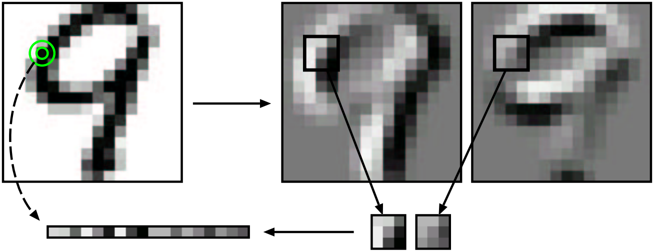


- no dependencies between mappings



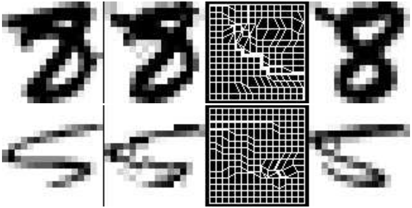
Comparing Images

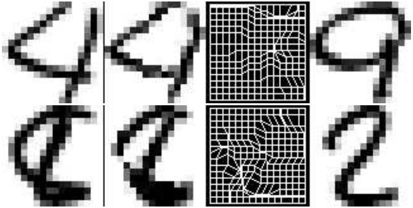
Image Distortion Model (cont.) / Local Context



Comparing Images

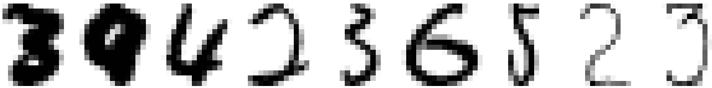
Image Distortion Model (cont.) / Examples



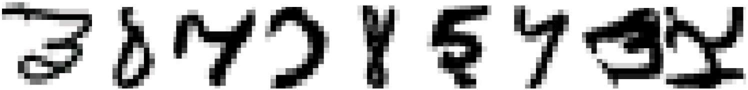


Comparing Image Comparison Measures

correct with tangent distance



correct with image patches



Feature-based Retrieval Method

Combining Features

- database B
- image X represented by a set of features: $X := \{X_1, \ldots, X_m, \ldots, X_M\}$
- query image $Q := \{Q_1, \ldots, Q_m, \ldots, Q_M\}$
- query is processed by calculating distance:

$$D(Q, X) := \sum_{m=1}^{M} w_m \cdot d_m(Q_m, X_m)$$

- d_m distance function, w_m weight
- for each d_m, $\sum_{X \in B} d_m(Q_m, X_m) = 1$ by re-normalization
- the K images with smallest distances are returned
- simple extension to support relevance feedback

Evaluation of CBIR

Problems:

- which images are relevant
- what does the user want
- how to measure performance

Performance measures:

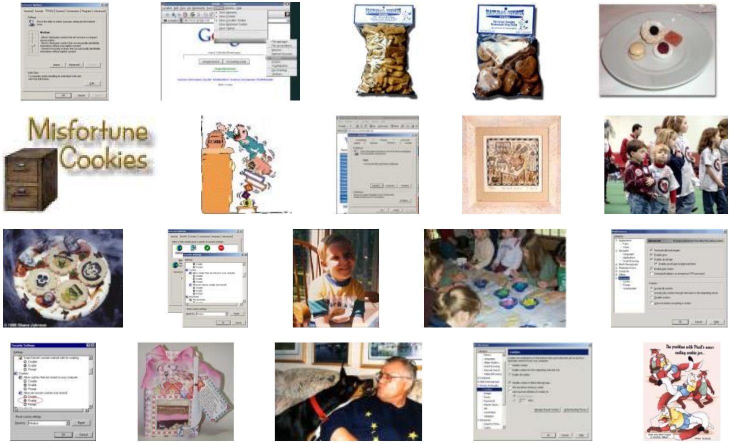
- precision $P = \frac{\#(\text{relevant retrieved})}{\#(\text{retrieved})}$
- recall $R = \frac{\#(\text{relevant retrieved})}{\#(\text{relevant})}$
- other measures based on these (strongly correlated)

Competitions / Evaluations:

- systematic comparison of different systems on the same task

Browsing an image database

results from Google image search ('cookie')
(order: as from Google in March 2003)



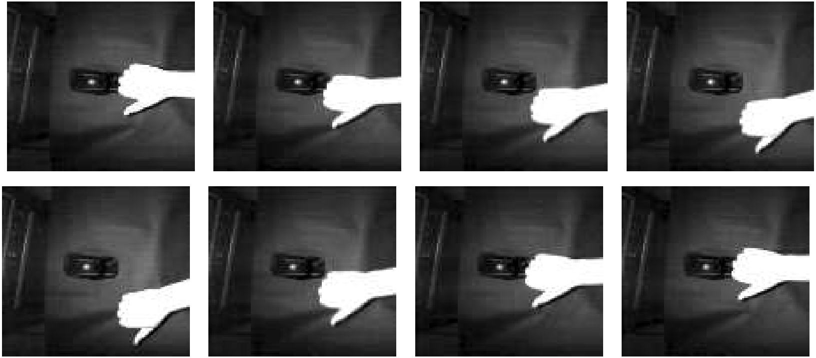
Results
for Clustering Google Images ('cookie')

Cluster 1					
Cluster 2					
Cluster 3					
Cluster 4					

Results
for Clustering Google Images ('aircraft')

cluster 1					
cluster 2					
cluster 3					
cluster 4					
cluster 5					

Videos / image sequences



Data Mining Cup 2004

task:

- classify customer data of mail-order company
- classes: returning much, returning little, unspecified
- $\sim$ 20 000 training examples
- $\sim$ 20 000 examples to be classified

methods

- data transformations
- logistic regression
- naive bayes classification

results

- places 1,3,5 of 97 student submissions

Studienarbeiten:

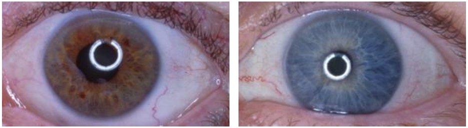
- Im Rahmen des IRMA Projektes
- IRMA= Image Retrieval in Medical Applications

Mögliche Themen:

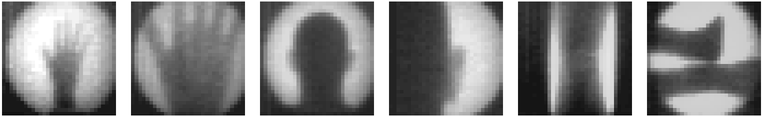
- Bilderkennung
- Bildverarbeitung
- Bildsuche

Bisherige Studienarbeiten am i6

- Automatische Iris-Detektion und Merkmalsextraktion in digitalen Farbbildern des menschlichen Auges



- Parameterbestimmung für die Dosisregelung von Durchleuchtungssystemen



- Merkmale zur statistischen Objekterkennung
- Kombination von Text- und Image Retrieval

Mögliche Studienarbeiten

Image Retrieval / Bildsuche