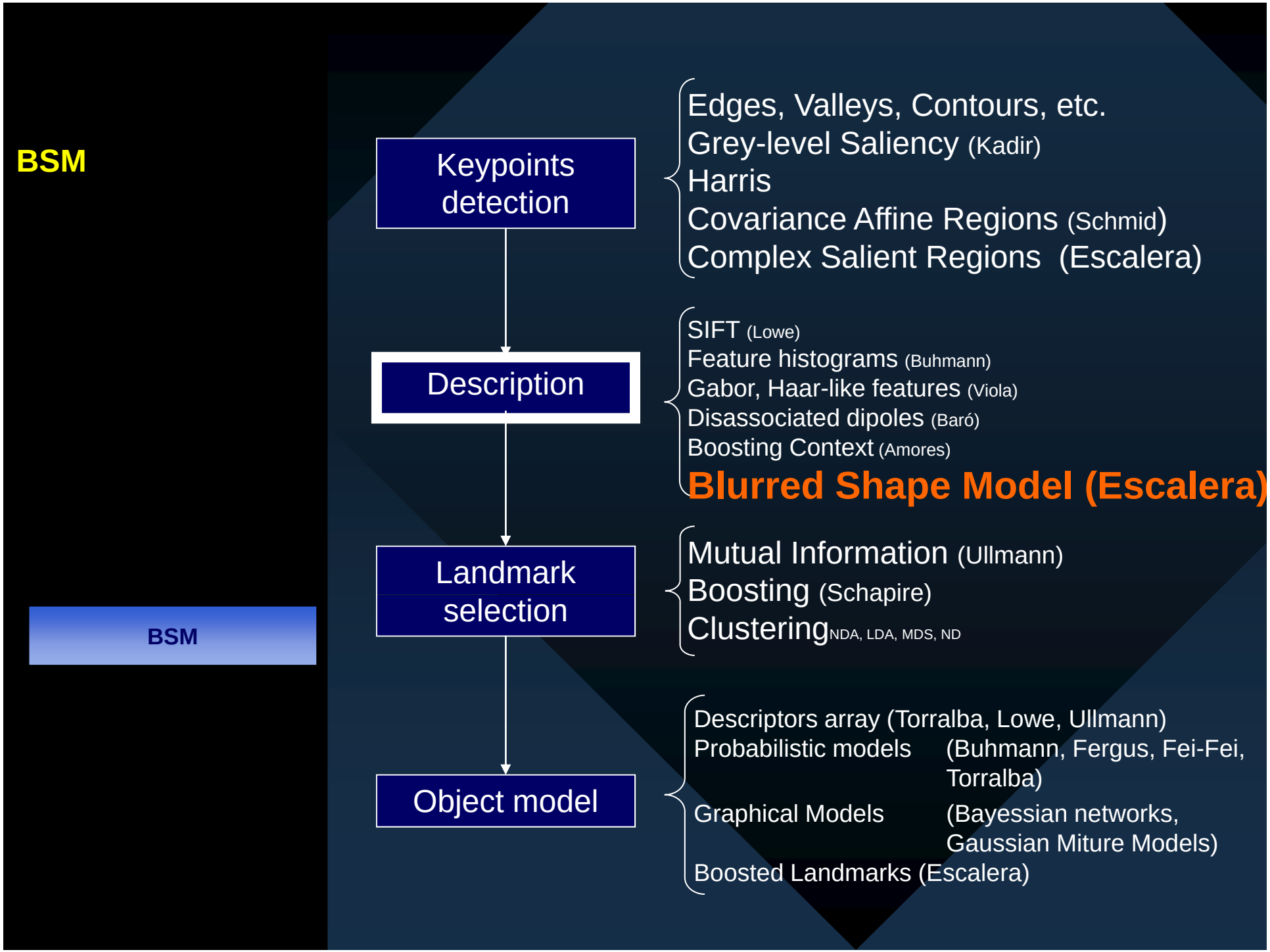
Blurred Shape Models


BSM
Keypoints detection
Edges, Valleys, Contours, etc.
Grey-level Saliency (Kadir)
Harris
Covariance Affine Regions (Schmid)
Complex Salient Regions (Escalera)
Description
SIFT (Lowe)
Feature histograms (Buhmann)
Gabor, Haar-like features (Viola)
Disassociated dipoles (Baró)
Boosting Context (Amores)
Blurred Shape Model (Escalera)
Landmark selection
Mutual Information (Ullmann)
Boosting (Schapire)
Clustering NDA, LDA, MDS, ND
Object model
Descriptors array (Torralba, Lowe, Ullmann)
Probabilistic models (Buhmann, Fergus, Fei-Fei, Torralba)
Graphical Models (Bayessian networks, Gaussian Miture Models)
Boosted Landmarks (Escalera)
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Multi-class binary object classification

- Rotation,
- Partial occlusions,
- Noise,
- Rigid and elastic deformations,
- Intra-class and inter-class variabilities,
- …

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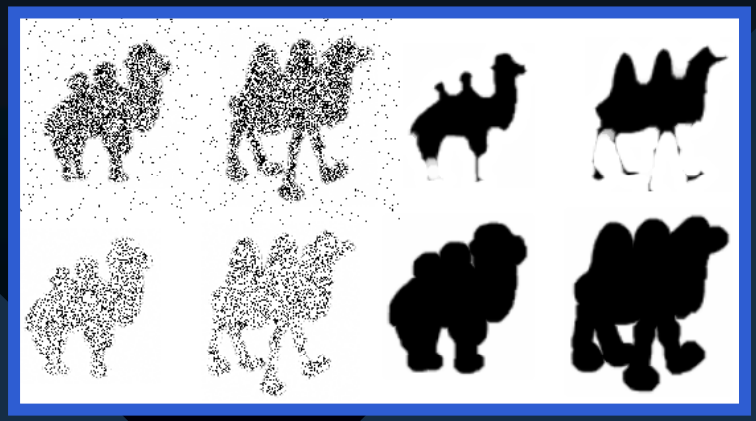

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Algorithm

Given a binary image I,
Obtain the *shape* S contained in I

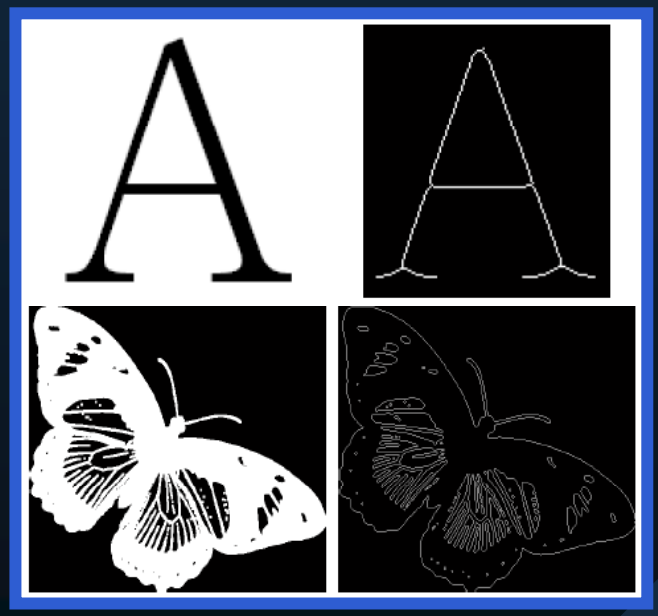
Object Shape

Grid

Points distances

Updating histogram

BSM PDF



- Determine shape:
- Contour map
- Skeleton
- …

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Algorithm

Object Shape

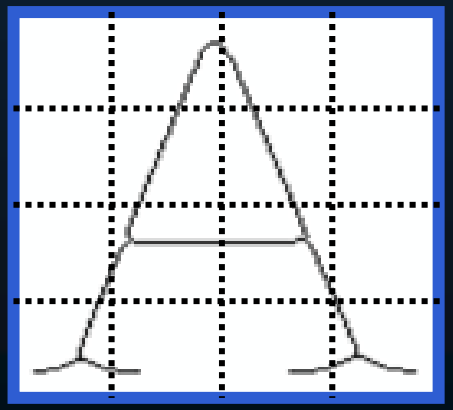
Grid

Points distances

Updating histogram

BSM PDF

Divide I in $n \times n$ equal size sub-regions $R = \{r_i, ..., r_{n \times n}\}$, with c_i the center of coordinates for each region r_i.
Let $N(r_i)$ be the neighbor regions of region r_i, defined as $N(r_i) = \{r_k | r \in R, ||c_k - c_i||^2 \leq 2 \times g^2\}$, where g is the cell size.



- *nxn* grid size

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Algorithm

Object Shape

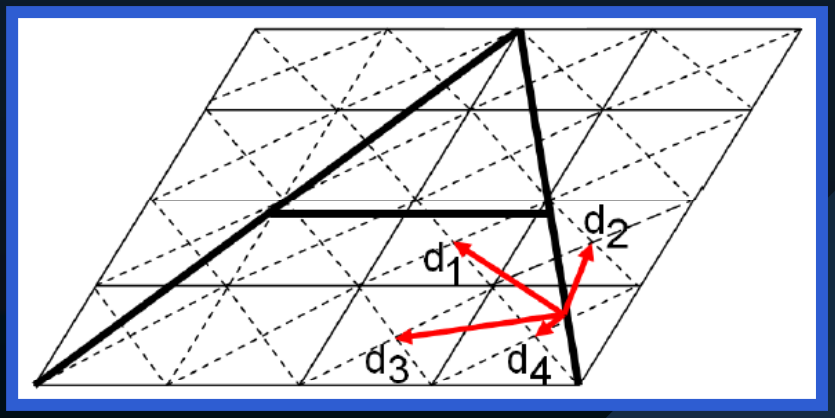
Grid

Points distances

Updating histogram

BSM PDF

For each point $\mathbf{x} \in S$,
  For each $r_i \in N(r_{\mathbf{x}})$,
    $d_i = d(\mathbf{x}, r_i) = ||\mathbf{x} - c_i||^2$
  End_For



- Distances to the nearest centroids

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Algorithm

Object Shape

Grid

Points distances

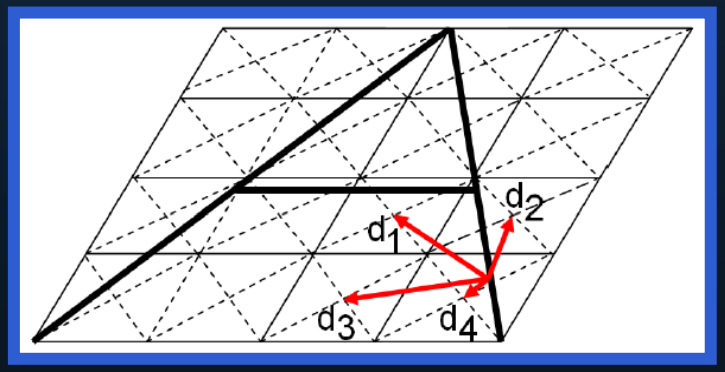
Updating histogram

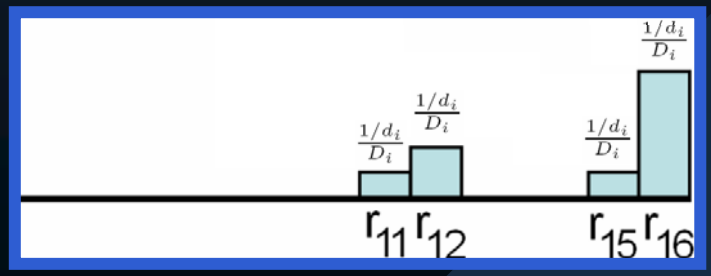
BSM PDF

Update the probabilities vector v positions as:

$v(r_i) = v(r_i) + \frac{1/d_i}{D_i}, \quad D_i = \sum_{c_k \in N(r_i)} \frac{1}{||\mathbf{x} - c_k||^2}$

End_For





- Spatial distribution of points

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Algorithm

Object Shape

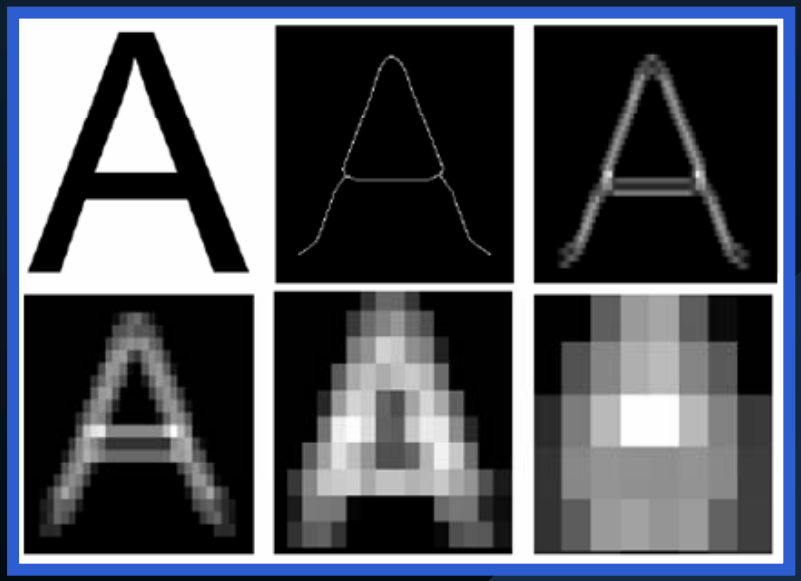
Grid

Points distances

Updating histogram

BSM PDF

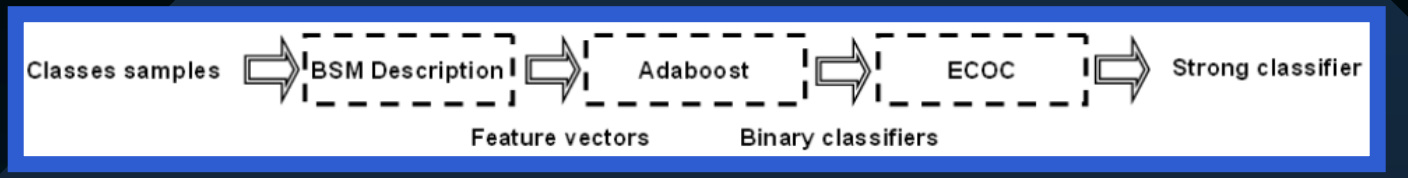
Normalize the vector v as: $v = \frac{v(i)}{\sum_{j=1}^{n^2} v(j)} \forall i \in [1, ..., n^2]$



•BSM for different grid sizes

BSM

BSM



•The method is scaling and stretching invariant.

•The BSM descriptor is robust against rigid and elastic deformations.

→ Cross-validation → optimum grid size

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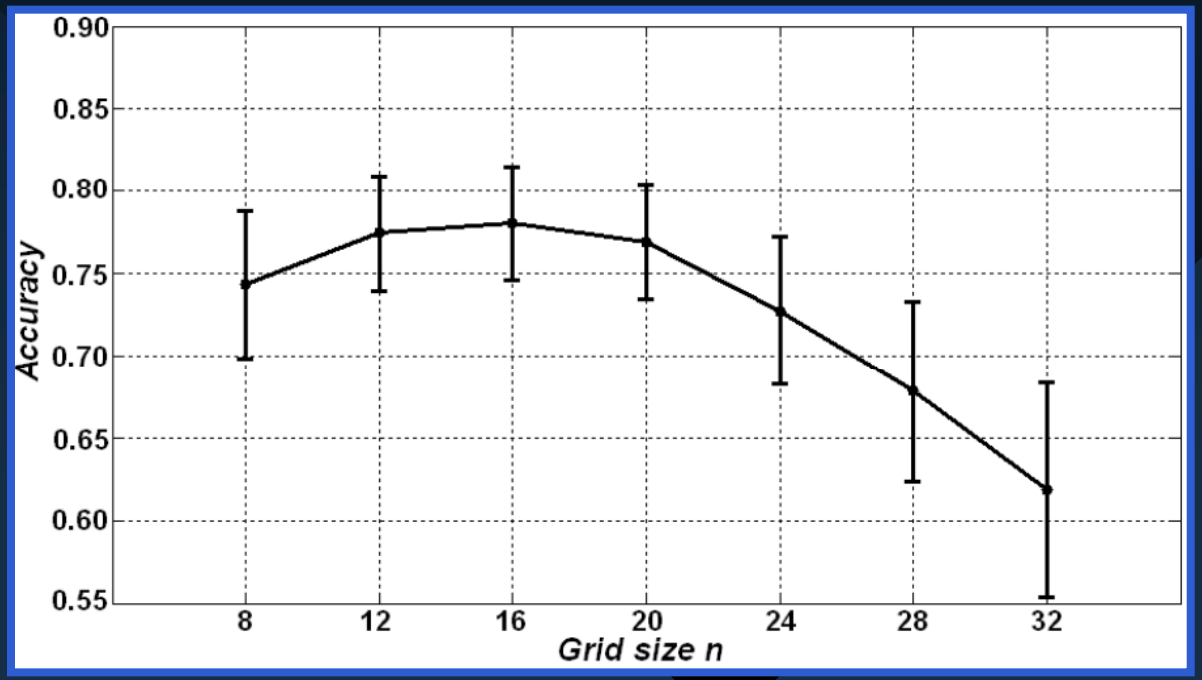
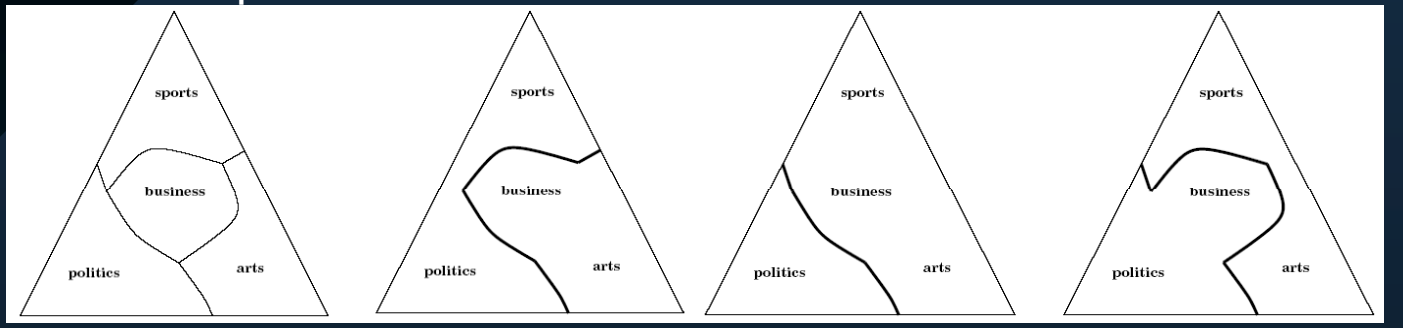


ECOC CODING

BSM

Example	Classifier 1	Classifier 2	Classifier 3



C1= sports	1	1	1
C2=business	-1	1	-1
C3=politics	1	-1	-1
C4=arts	-1	1	1

BSM

C1= sports
C2=business
C3=politics
C4=arts

coding matrix

1	1	1
-1	1	-1
1	-1	-1
-1	1	1

Coding

One-vs-one

One-vs-all

Dense Random

Sparse Random

Decoding: Given a test sample, we obtain a code according to the output of each classifier and find the “closest” code.

-1 1 1

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ECOC DECODING

Decoding

Hamming decoding

Euclidean decoding

Loss-based decoding

1 versus All

Code length: Nc

1	-1	-1
-1	1	-1
-1	-1	1

Three symbol codes

1 versus 1: “All pairs”

Code length: Nc (Nc-1)/2

1	1	0
-1	0	1
0	-1	-1

Random Dense ECOC

Code length: 10 log Nc

1	-1	1
-1	1	-1
1	-1	-1

Random Sparse ECOC

Code length: 15 log Nc

1	0	-1
-1	1	0
0	-1	1

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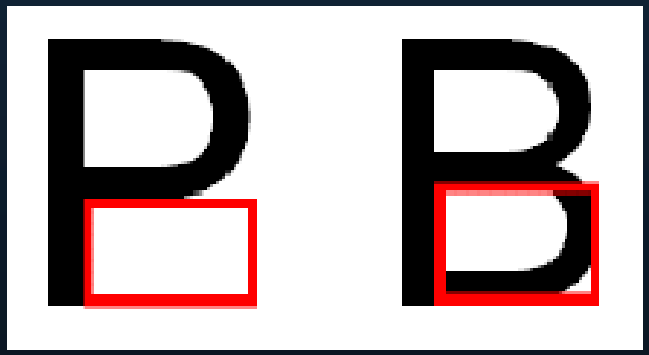
•Adaboost learns difficult classes which may share features.



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•The multi-class ECOC framework can correct possible classification errors produced by the binary classifiers.

•When the classifiers are trained only few features are selected

→ Fast and suitable for real-time categorization problems.

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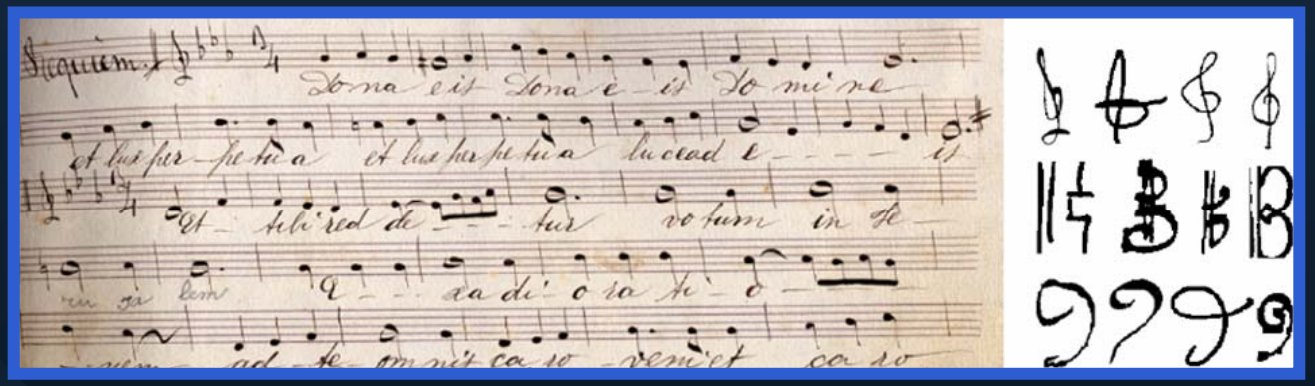
Evaluation data



•Clefs database: collection of modern and old musical scores (19th century) of the Archive of the Seminar of Barcelona. The database contains a total of 2128 samples between the three different types of clefs from 24 different authors.

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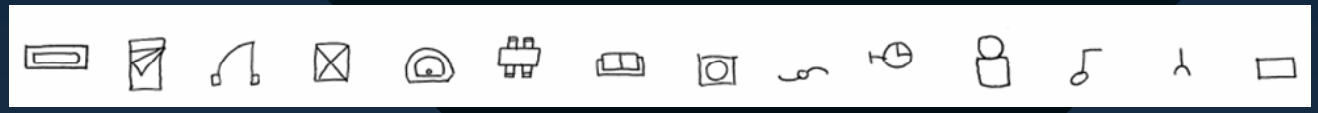

•Architectural hand-drawn symbols database: 2762 total samples organized in 14 classes. Each class consists of an average of 200 samples drawn by 13 different authors.

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Comparatives

DESCRIPTORS

Zoning	16x16 grid size
BSM	16x16 grid size
ART	Radial order with value 2 and angular order 10 with value 11
Zernique	7 moments

Measurements

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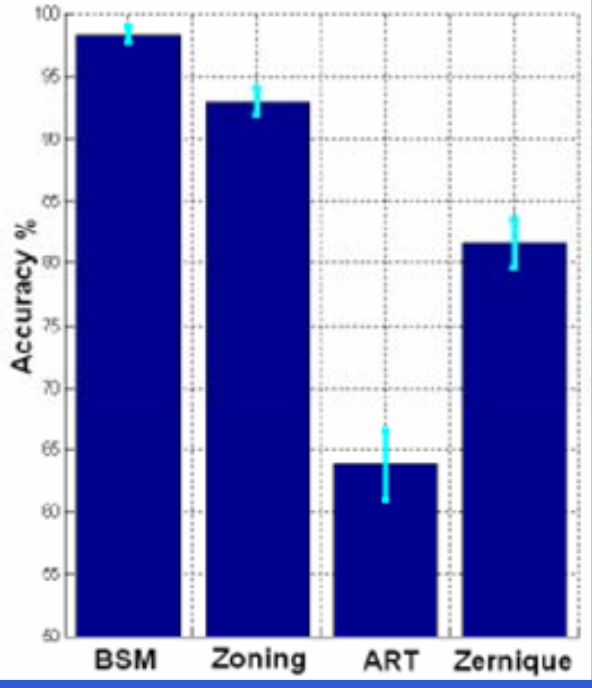
50 runs Discrete Adaboost with Decission Stumps
Two optimal trees of Forest-ECOC with Beta-Density Decoding.
Classification score: stratified ten-fold cross-validation
With two-tailed t-test at 95% of the confidence interval

Evaluation

Method	Accuracy
BSM	98.11 ± 0.59
Zoning	92.45 ± 1.06
ART	63.75 ± 2.76
Zernike	81.50 ± 1.97

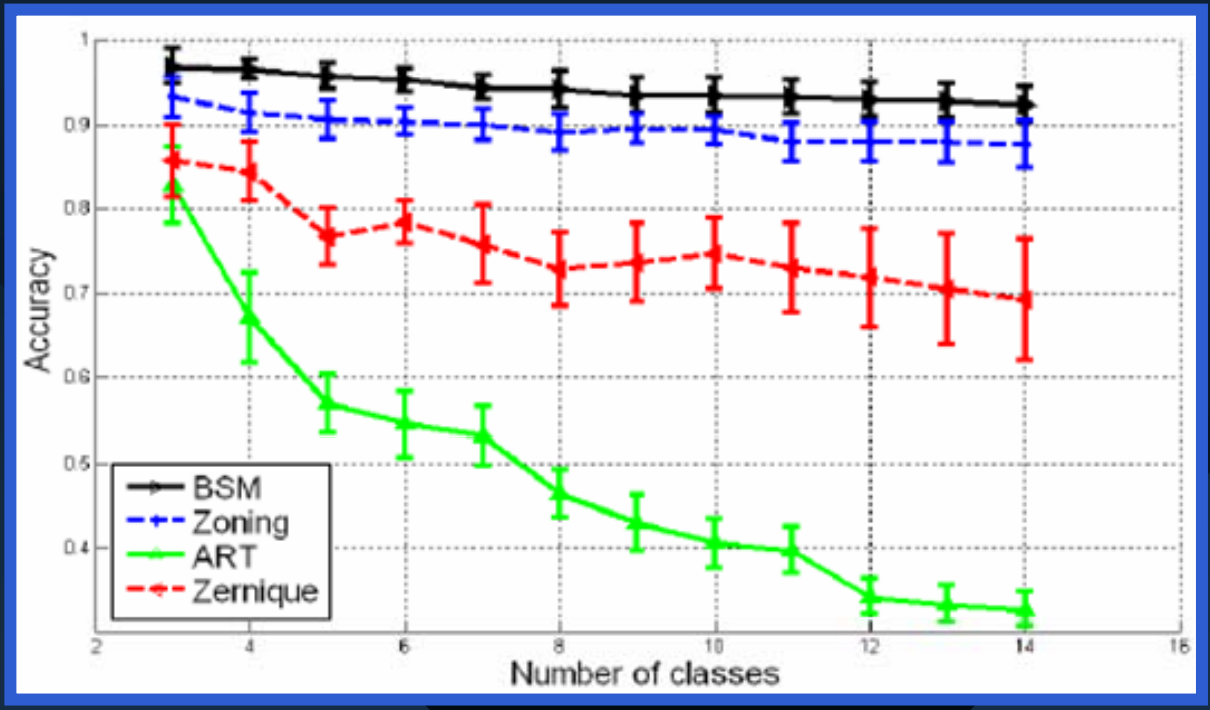


Clefs database

BSM

BSM

Evaluation



Architectural hand-drawn symbols database

BSM

Conclusions

→Robust to noise, occlusions, rigid and elastic deformations and inter-class and intra-class variabilities.