Symbol Recognition by Multi-class Blurred Shape Models

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BSM

Motivation

- Binary Shape recognition
- Symbol recognition
- Problems:
  - Rotation, Partial occlusions, Noise, Rigid and elastic deformations

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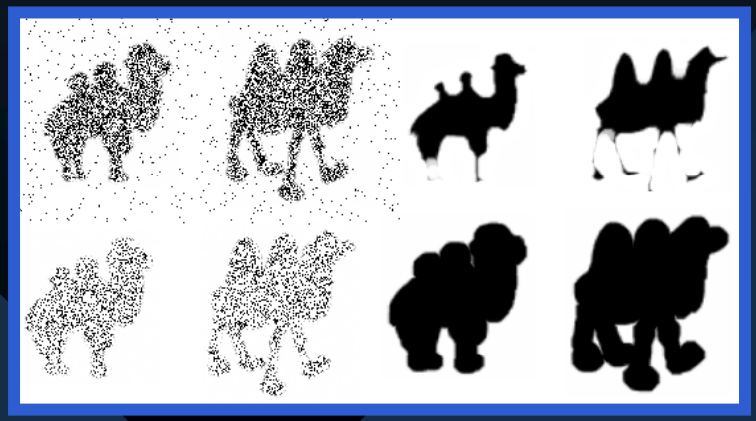

Blurred Shape Model - Algorithm

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

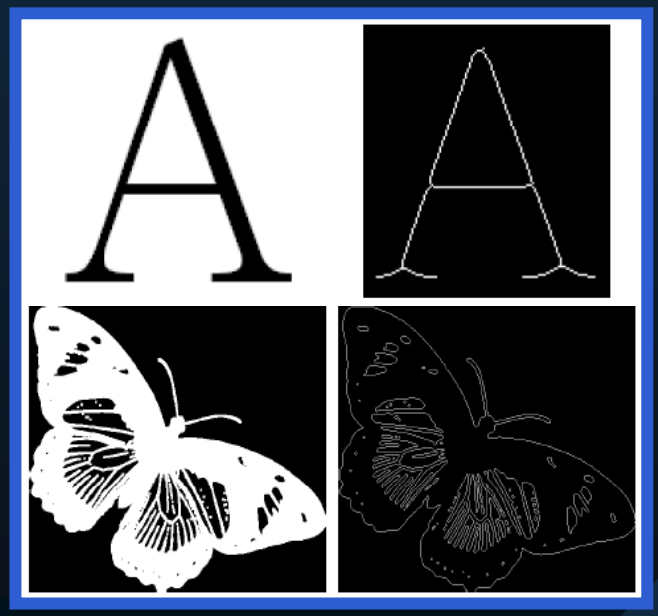
Object Shape

Grid

Points distances

Updating histogram

BSM PDF



•Determine shape:

- •Contour map
- •Skeleton

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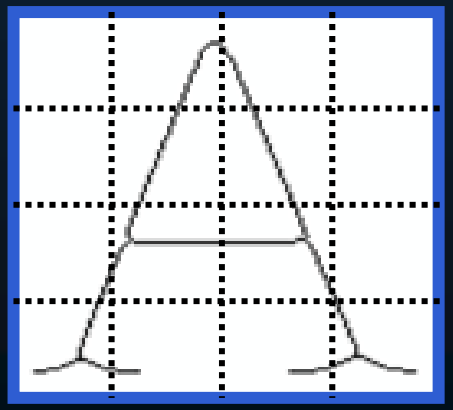
Divide I in $n \times n$ equal size sub-regions $R = \{r_i, ..., r_{n \times n}\}$, with c_i the center of coordinates for each region r_i.
Let $N(r_i)$ be the neighbor regions of region r_i, defined as $N(r_i) = \{r_k | r \in R, ||c_k - c_i||^2 \leq 2 \times g^2\}$, where g is the cell size.



- *nxn* grid size

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Algorithm

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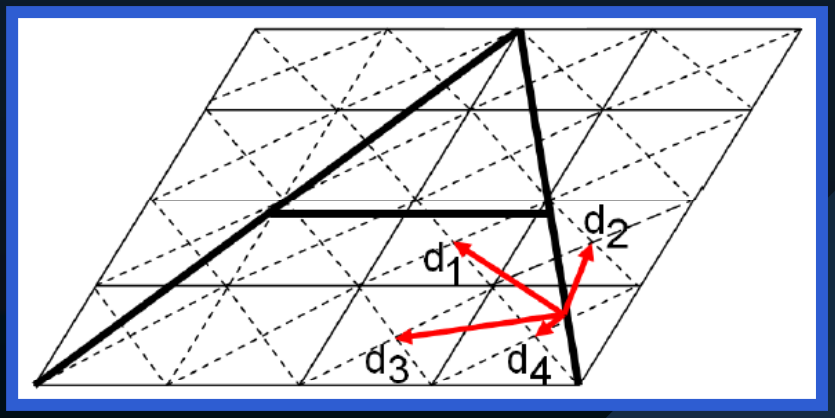
For each point $\mathbf{x} \in S$,
  For each $r_i \in N(r_{\mathbf{x}})$,
    $d_i = d(\mathbf{x}, r_i) = ||\mathbf{x} - c_i||^2$
  End_For



- Distances to the nearest centroids

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Algorithm

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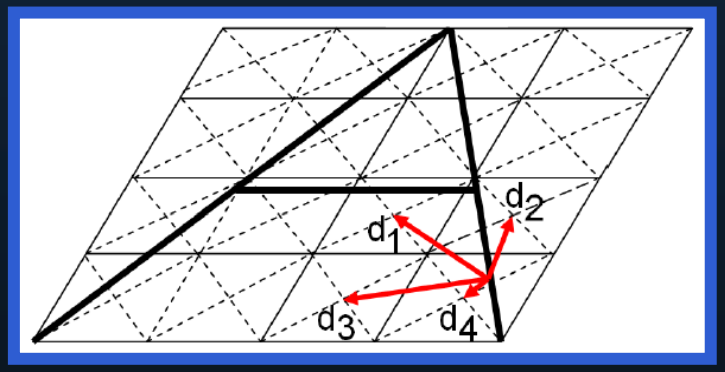
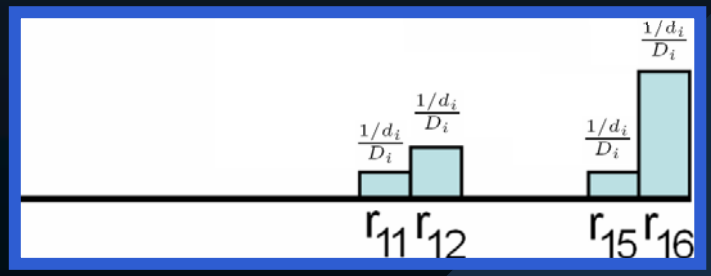
Update the probabilities vector v positions as:

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

End_For





- Spatial distribution of points

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Algorithm

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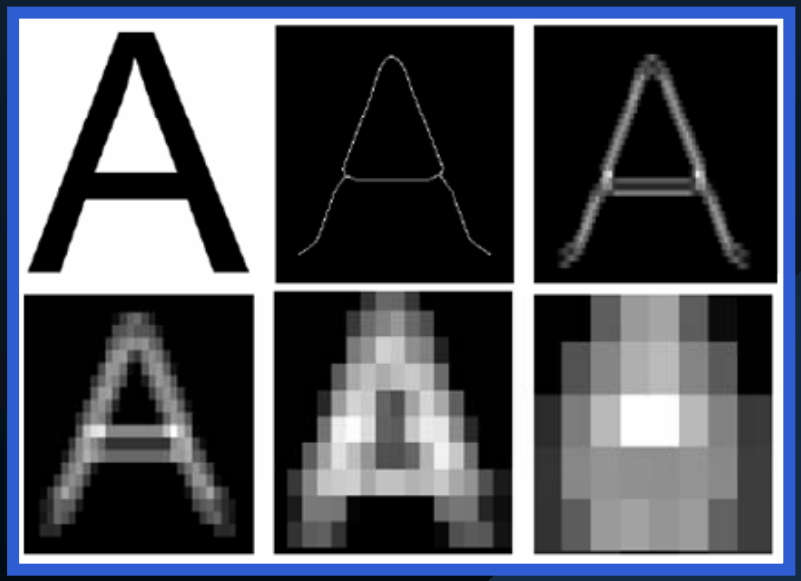
Normalize the vector v as: $v = \frac{v(i)}{\sum_{j=1}^{n^2} v(j)} \forall i \in [1, ..., n^2]$



•BSM for different grid sizes

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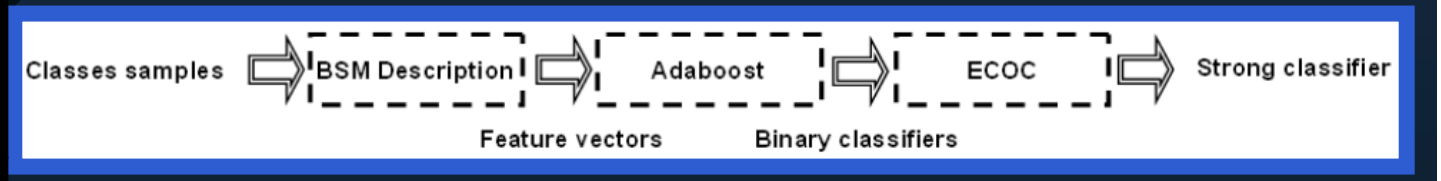
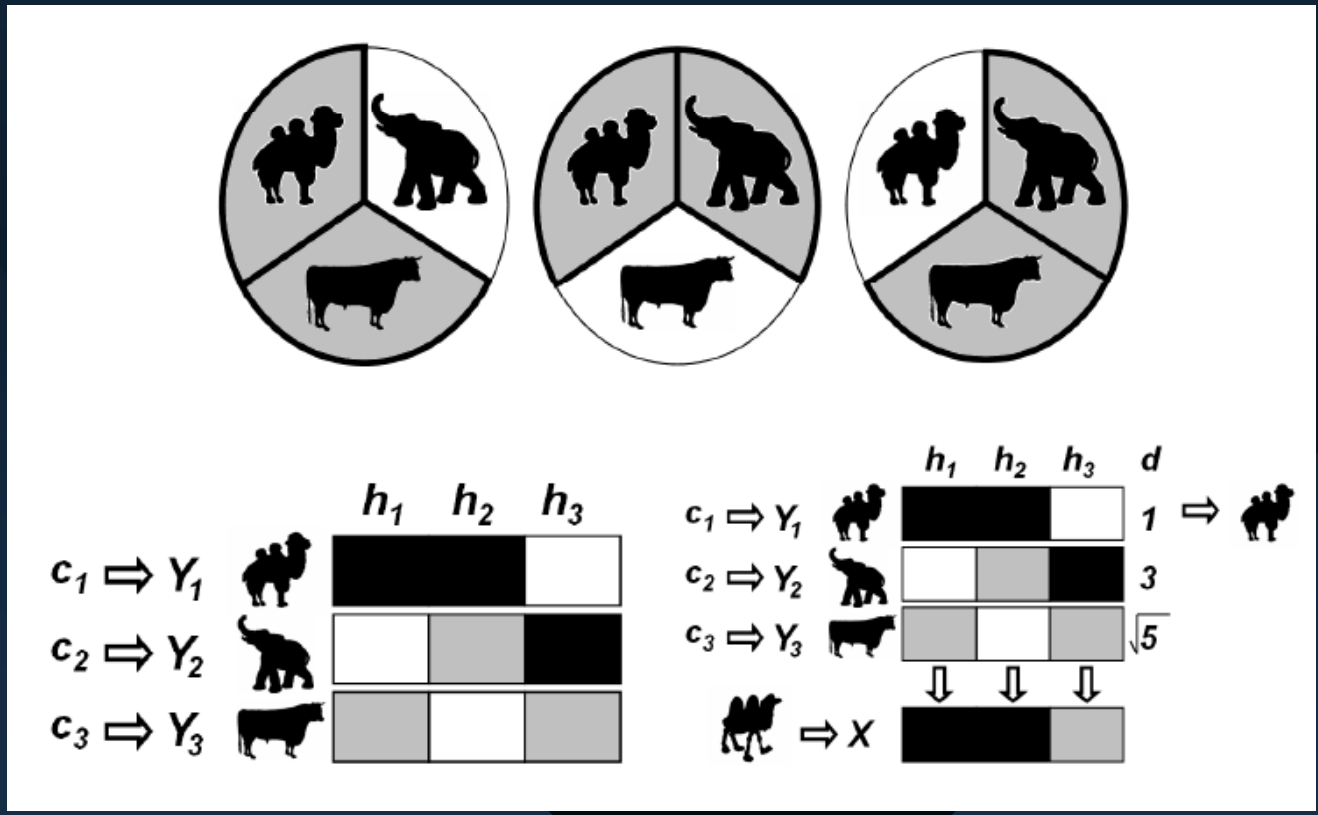
Classification



- Adaboost
  - Adaboost learns difficult classes which may share features.

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

ECOC



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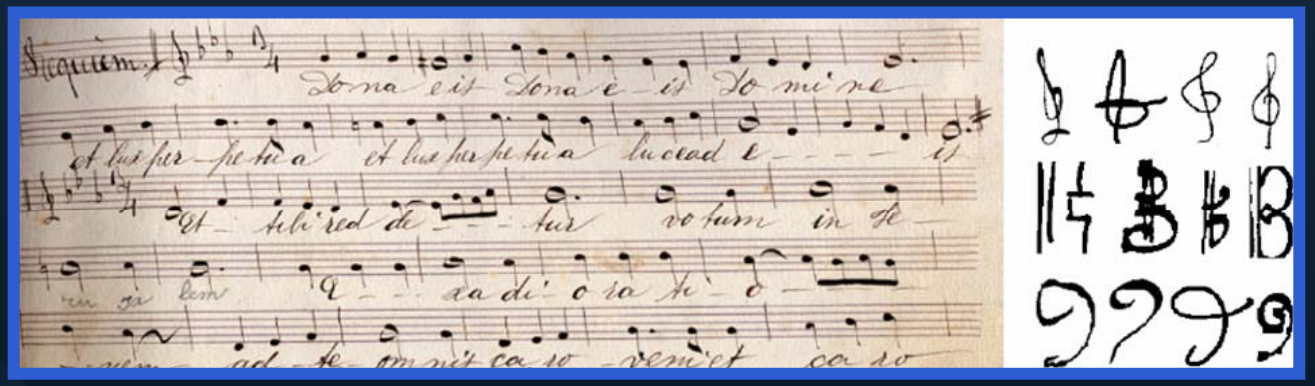
Evaluation data



•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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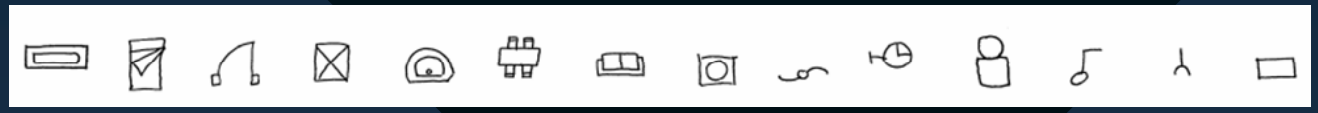

•Architectural hand-drawn symbols database: 2762 total samples organized in 14 classes. Each class consists of an average of 200 samples drawn by 13 different authors.

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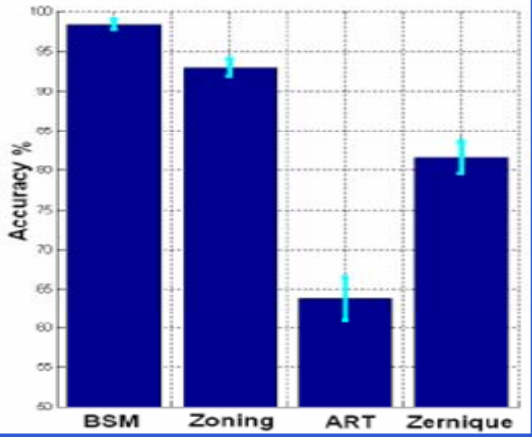
50 runs Discrete Adaboost with Decission Stumps
Two optimal trees of Forest-ECOC with Beta-Density Decoding.
Classification score: stratified ten-fold cross-validation
With two-tailed t-test at 95% of the confidence interval

Evaluation

Clefs database

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



Architectural hand-drawn symbols database