A New Shape Descriptor Based on Tensor Scale

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Outline

- Introduction
- Tensor scale
  - Concepts
  - Algorithms
- Shape descriptor
  - Feature extraction function
  - Distance function
- Experiments
- Conclusions

Introduction

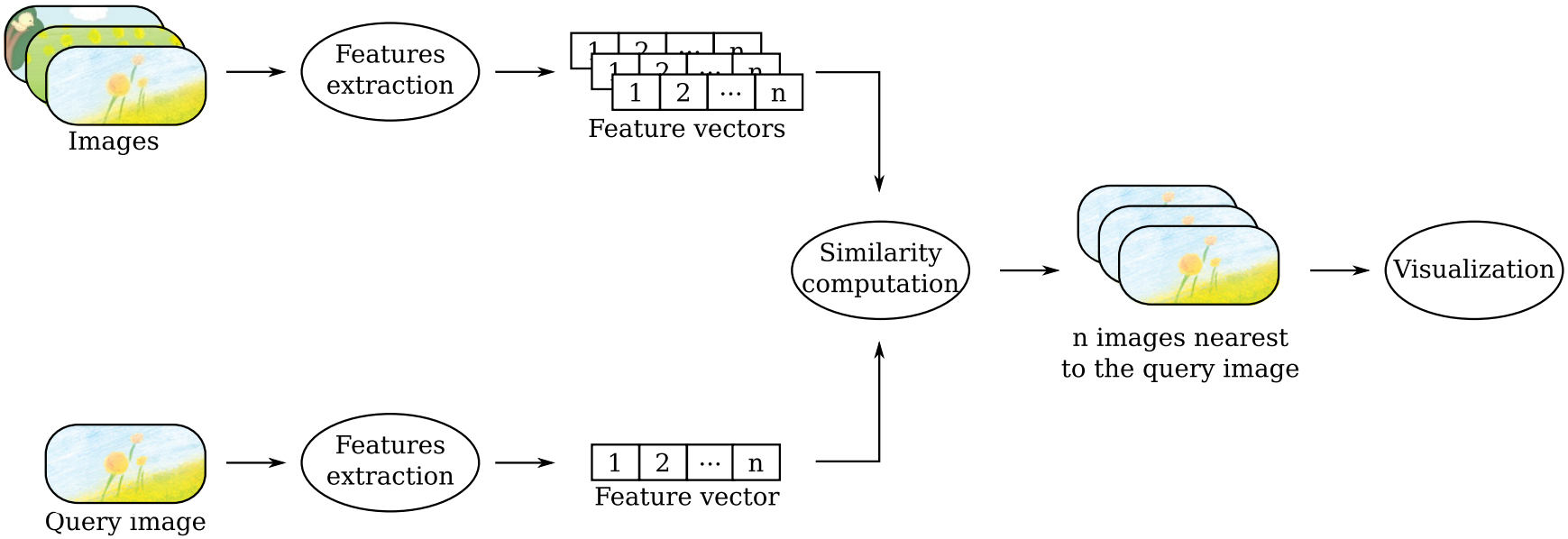
Problem

- Available images are increasing.
- Image annotation is expensive and subjective.

Solution

Content-based image retrieval systems (CBIR).

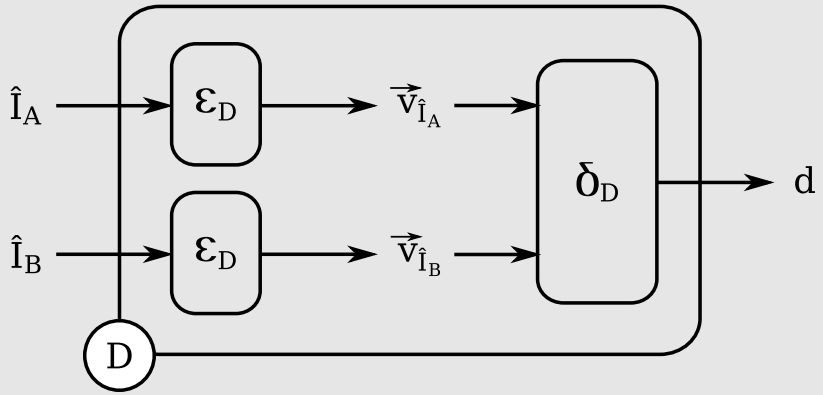
Introduction



Introduction

Image Descriptors

- Color
- Texture
- SHAPE



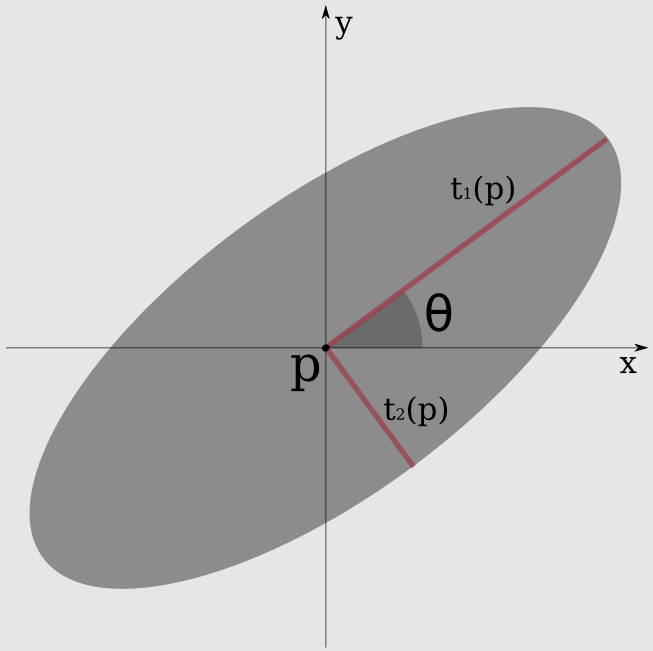
Objectives

- Propose a new shape descriptor based on TENSOR SCALE.
- Propose a faster algorithm to compute Tensor scale.

Tensor Scale

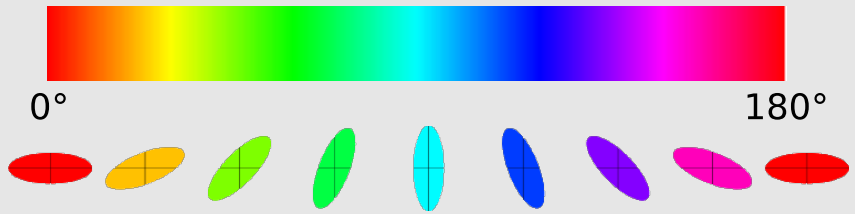
Factors

- Orientation(p) $= \theta$
- Anisotropy(p) $= \sqrt{1 - \frac{|t_2(p)|^2}{|t_1(p)|^2}}$
- Thickness(p) $= |t_2(p)|$

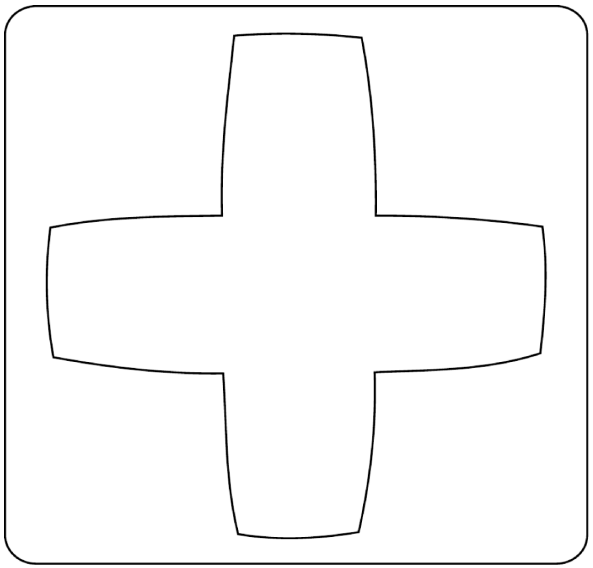


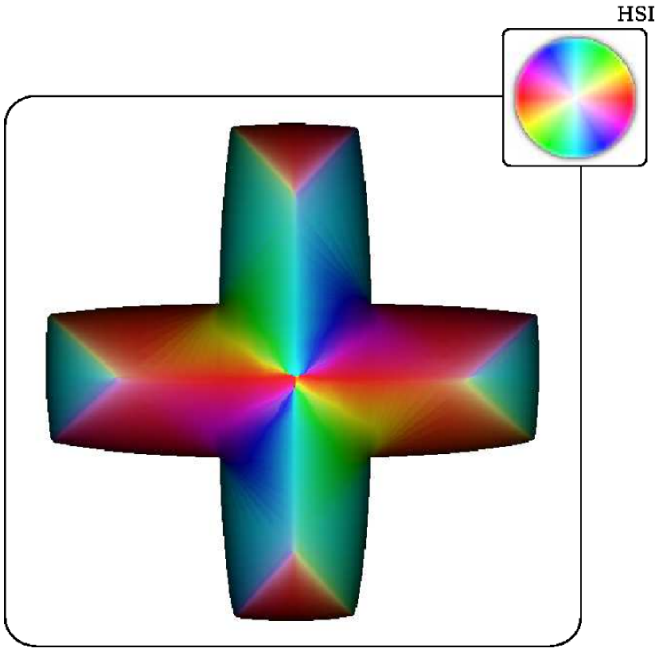
HSI space

- Orientation$\rightarrow$Hue
- Anisotropy $\rightarrow$Saturation
- Thickness$\rightarrow$Intensity



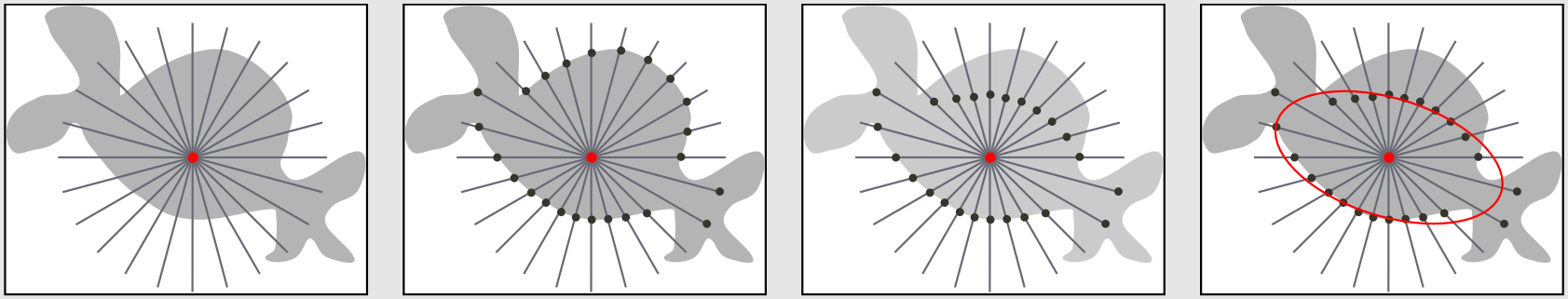
Tensor Scale





Tensor Scale

Punam Algorithm [Punam 2005]

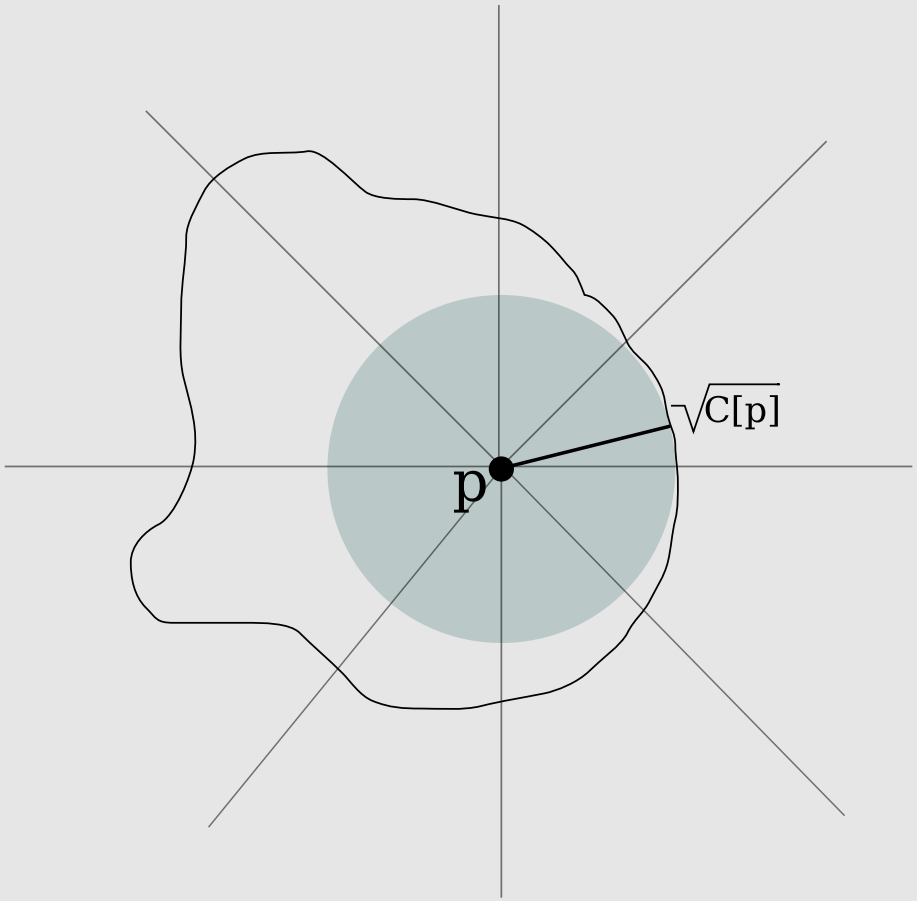


IFT-based Algorithm

- For binary images
- Contour pixels as seeds and the Euclidean distance as cost function.
- The IFT returns:
  - $Cost[p] \leftarrow$ Square of the Euclidean distance from pixel p to the nearest contour pixel.
  - $Label[p] \leftarrow$ The label of its influence zone.

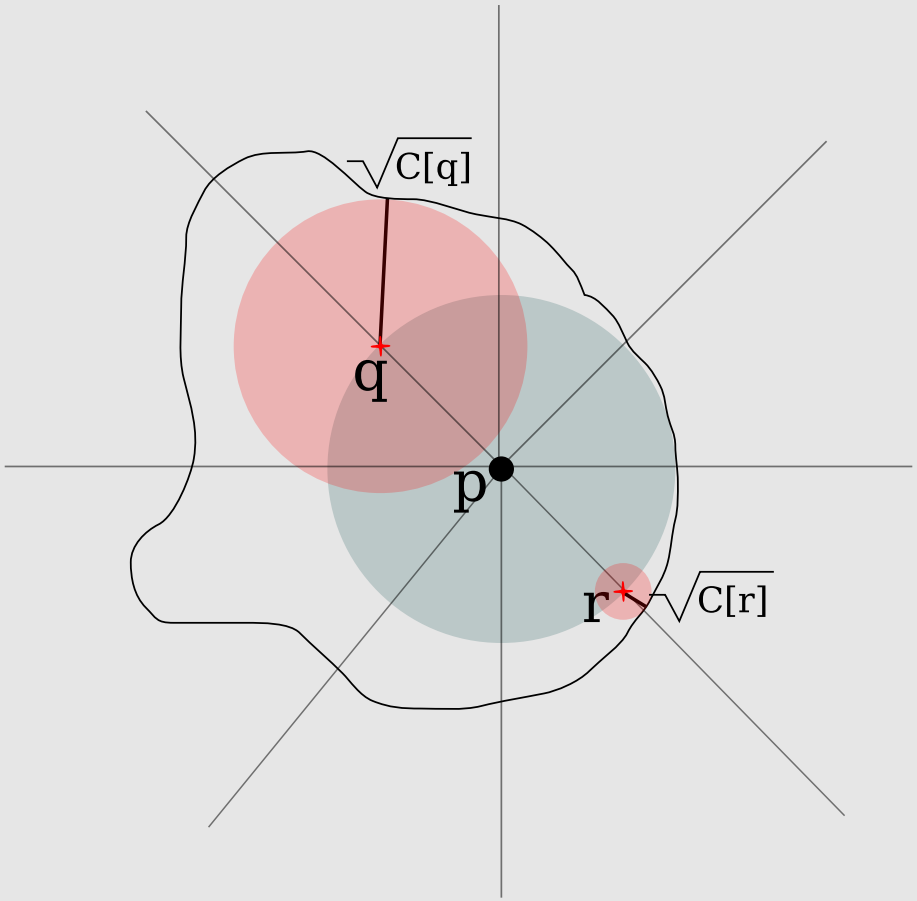
Tensor Scale Algorithm by IFT

First step



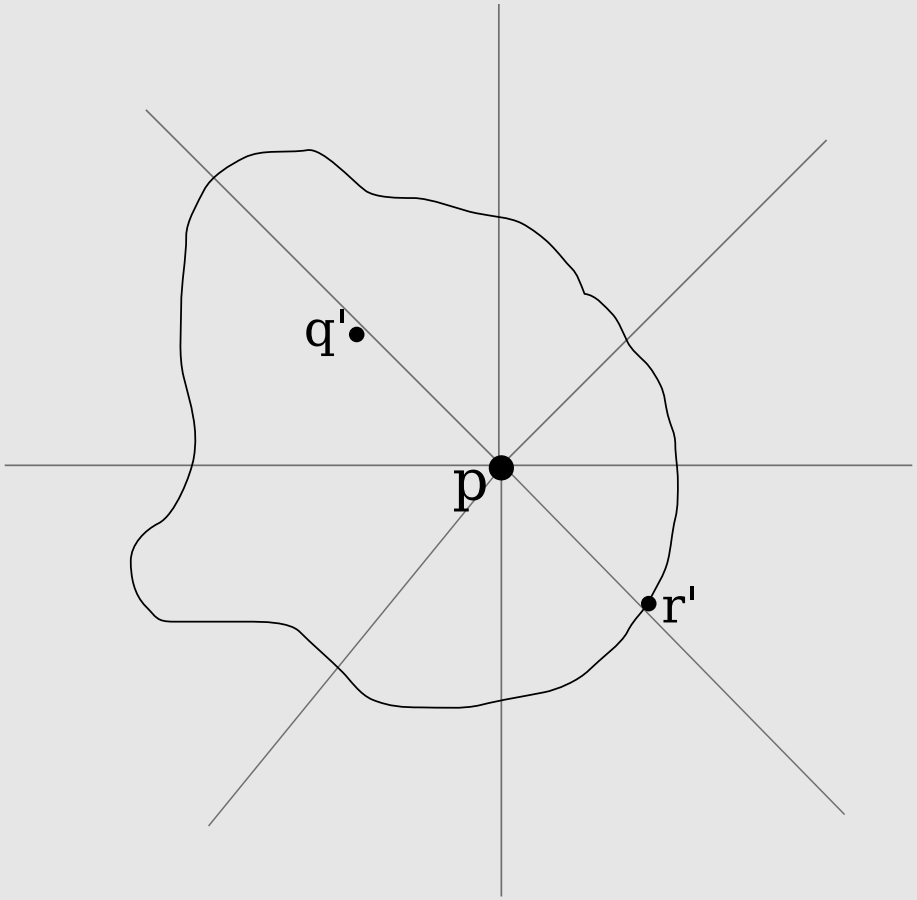
Tensor Scale Algorithm by IFT

Second step



Tensor Scale Algorithm by IFT

Third step



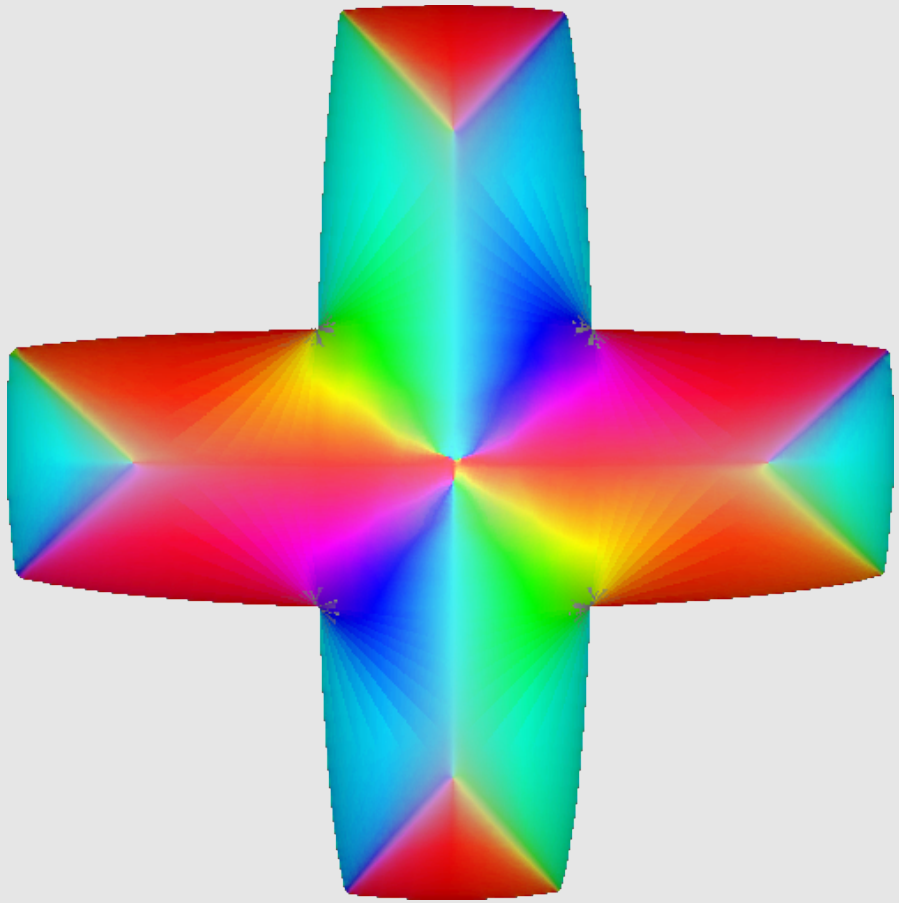
Shape Descriptor based on Tensor Scale

Feature extraction steps

- Tensor scale computation
- Contour division into segments and influence zones computation
- Orientation mapping

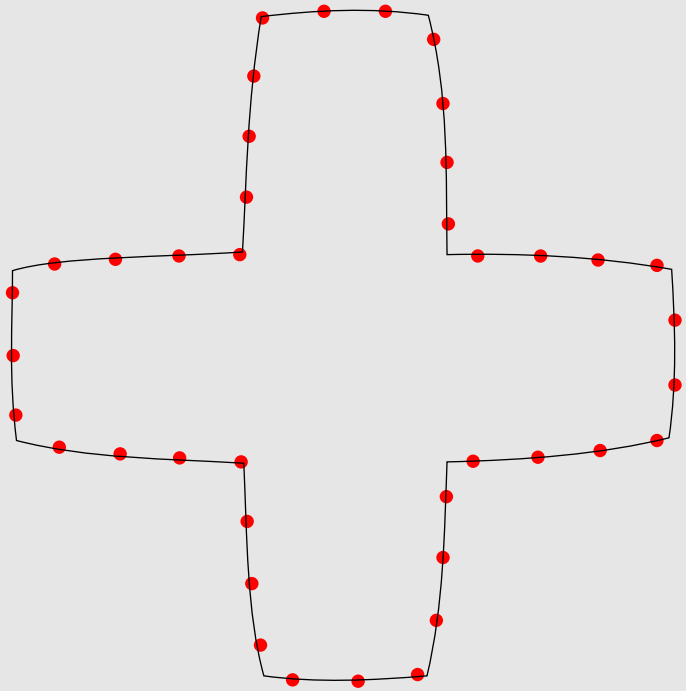
Shape Descriptor based on Tensor Scale

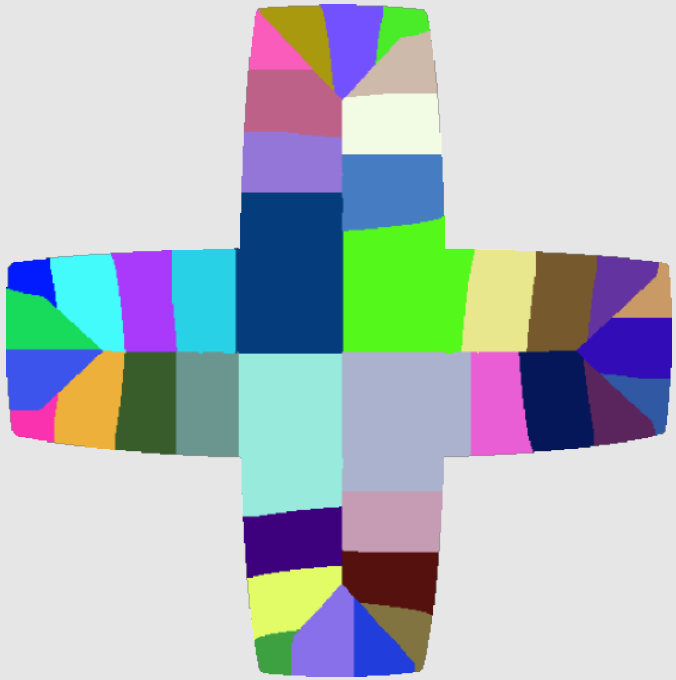
First step - Tensor Scale Computation by IFT



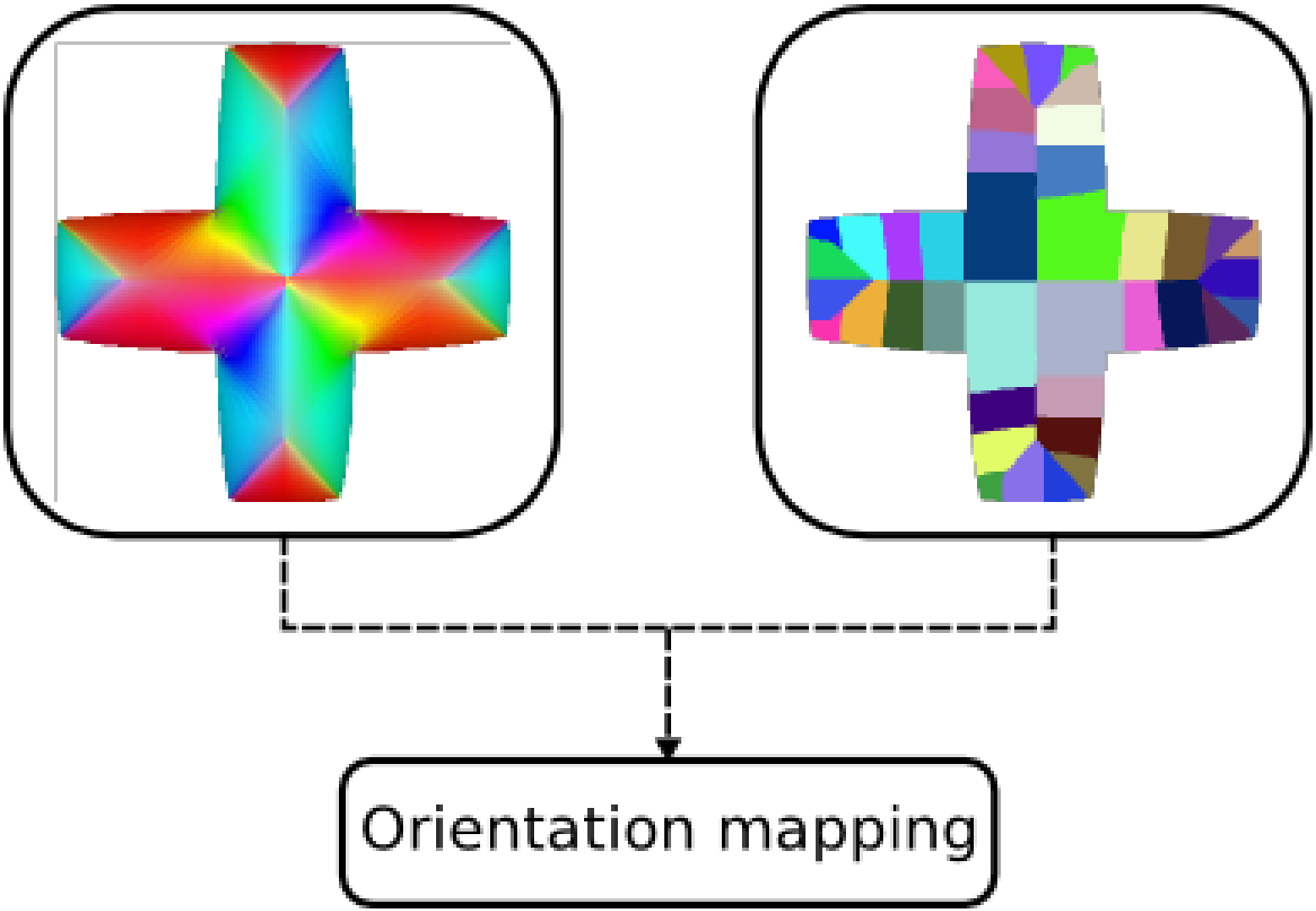
Shape Descriptor based on Tensor Scale

Second step - Contour division into segments and influence zones computation





Shape Descriptor based on Tensor Scale



Shape Descriptor based on Tensor Scale

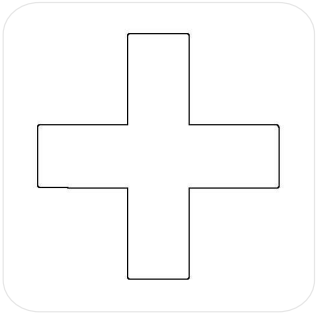
Third step - Orientation mapping

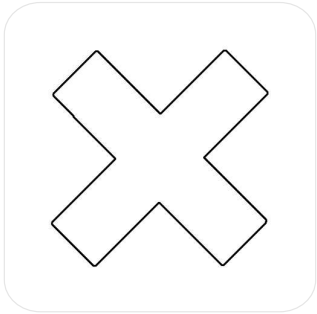
- In each influence zone, the descriptor computes the weighted angular mean of the orientations:

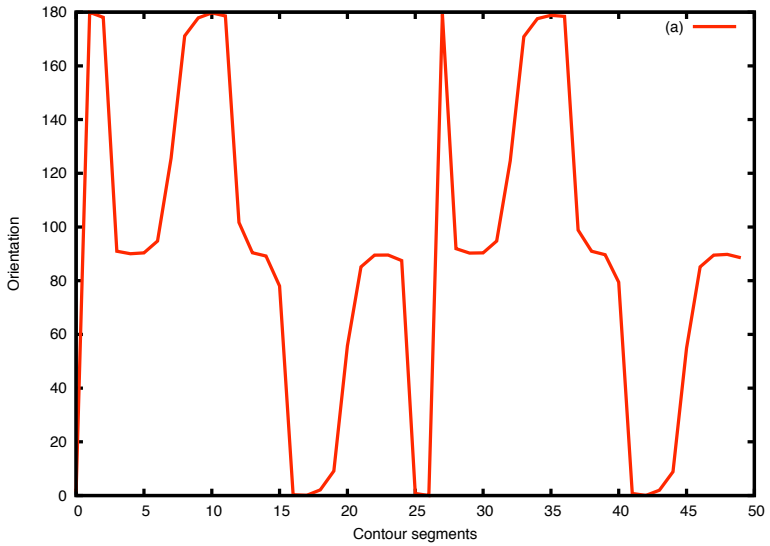
$$\bar{\theta} = arctan\left(\frac{\sum_{i=1}^{n} Anisotropy_i * sin(2\theta_i)}{\sum_{i=1}^{n} Anisotropy_i * cos(2\theta_i)}\right)$$

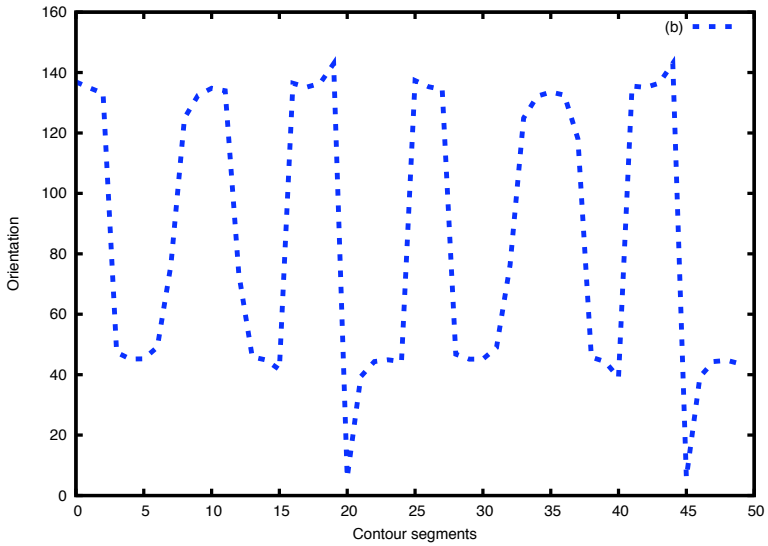
- The feature vector is formed by the mapped orientations.

Shape Descriptor based on Tensor Scale

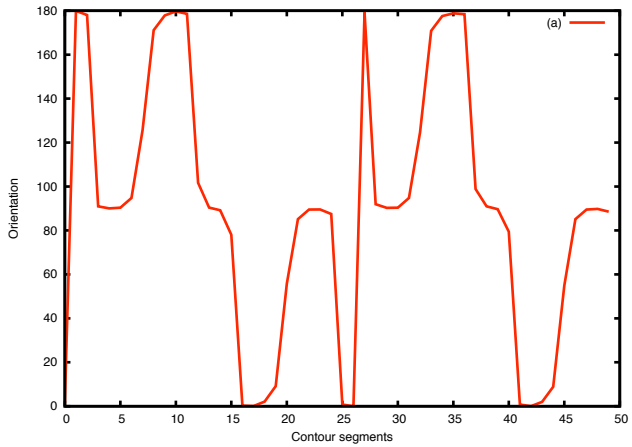


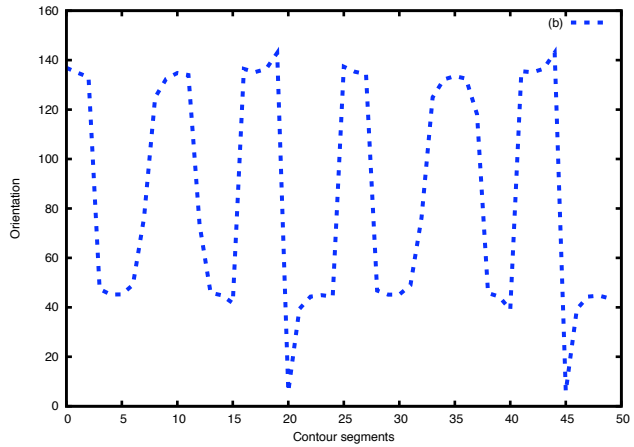


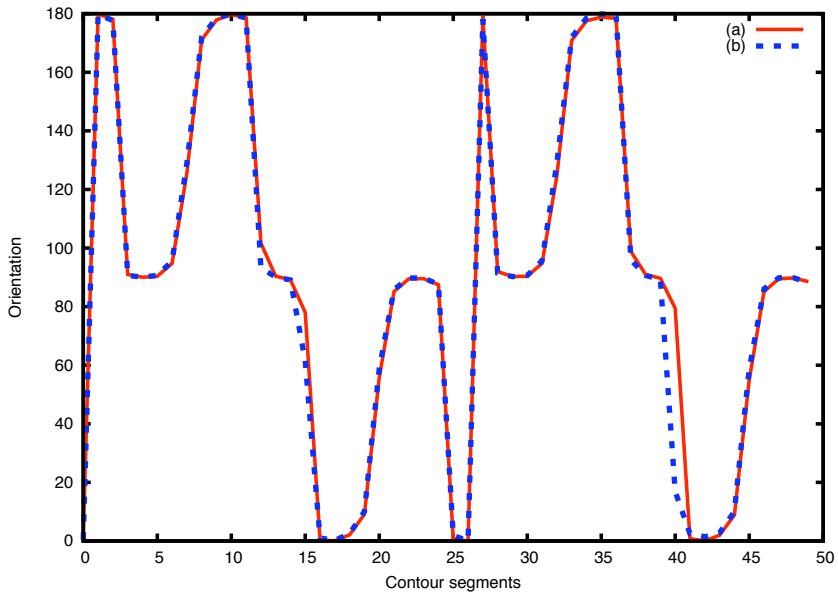




Shape Descriptor based on Tensor Scale







Experiments

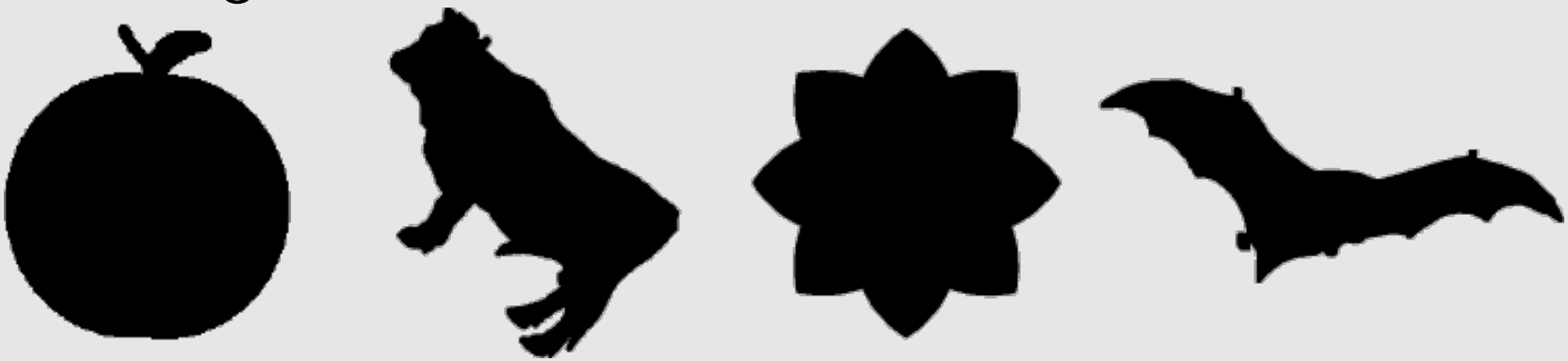
- Comparisons with relevant shape descriptors:
  - Beam Angle Statistics [Arica and Vural 2003]
  - Multiscale Fractal Dimension [Torres et al. 2004]
  - Moment Invariants [Hu 1962]
  - Fourier Descriptor [Gonzalez and Woods 2001]

- Experiments:
  - Visual CBIR examples
  - Efectiveness measures:
    - Precision $\times$ Recall
    - Multiscale separability

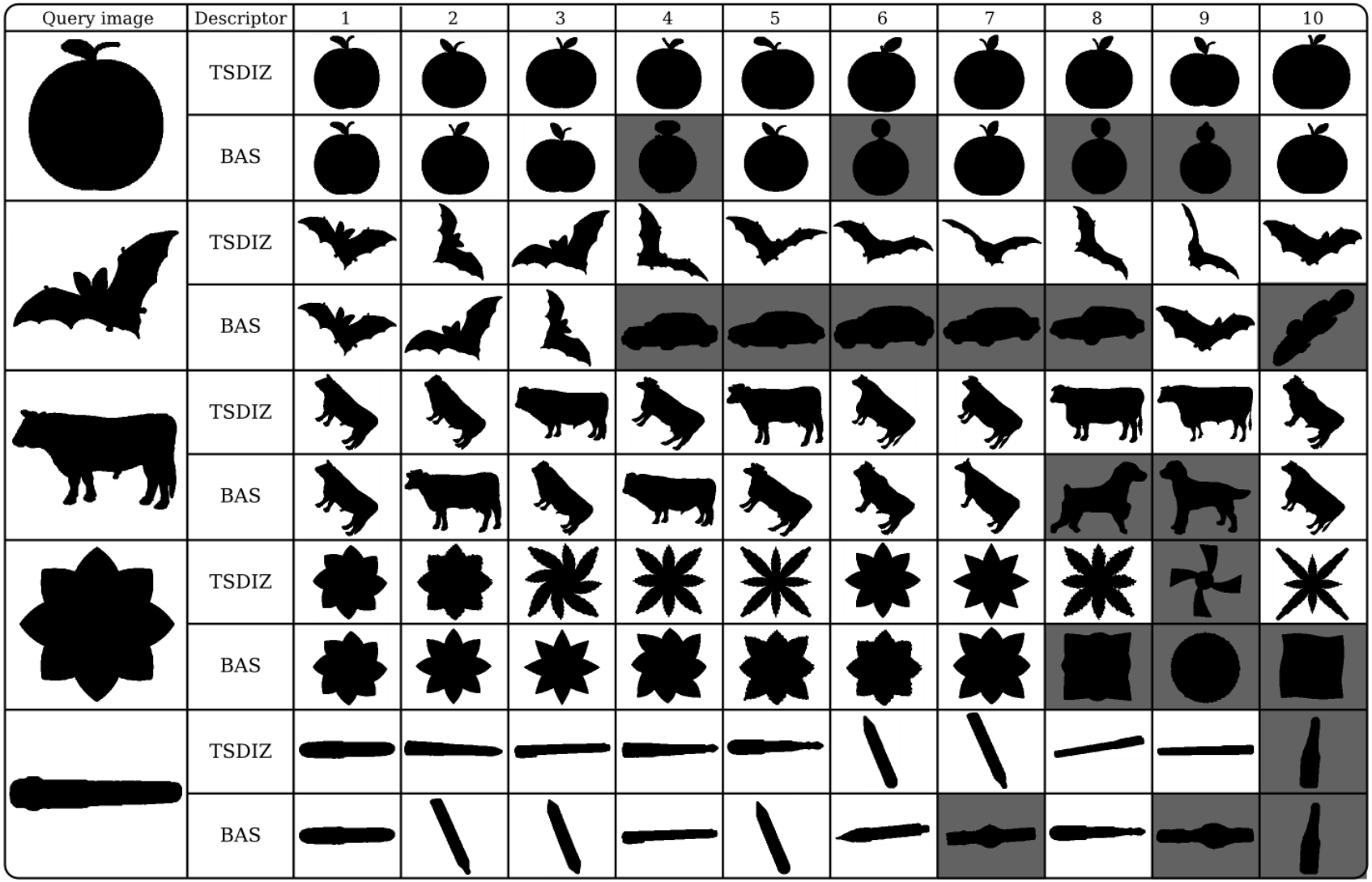
Experiments

MPEG-7 CE-shape-1 part B

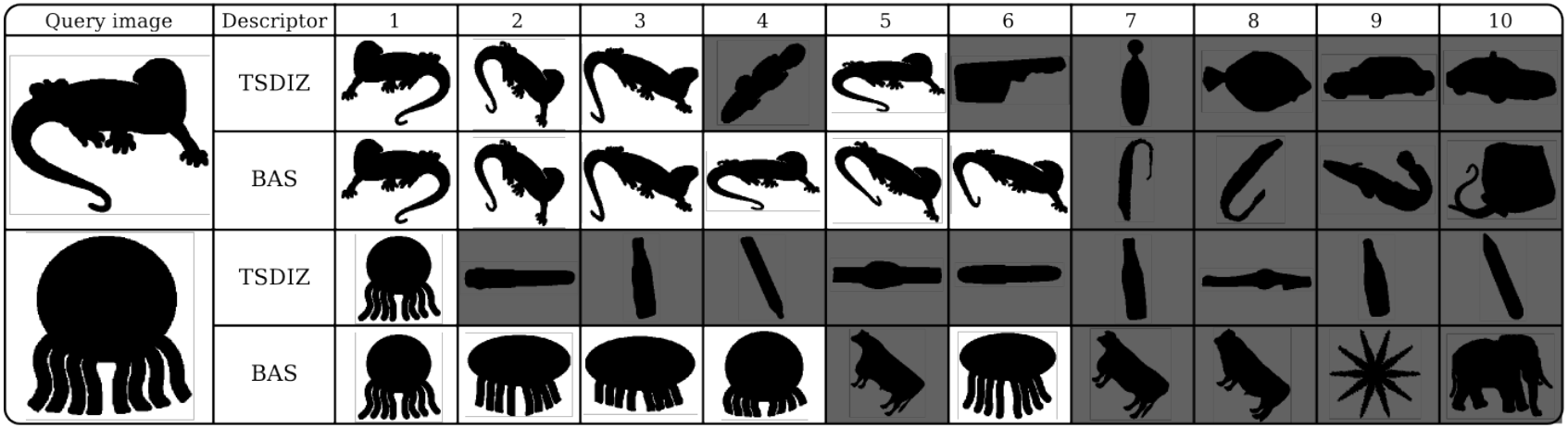
1400 images divided into 70 classes



Experiments

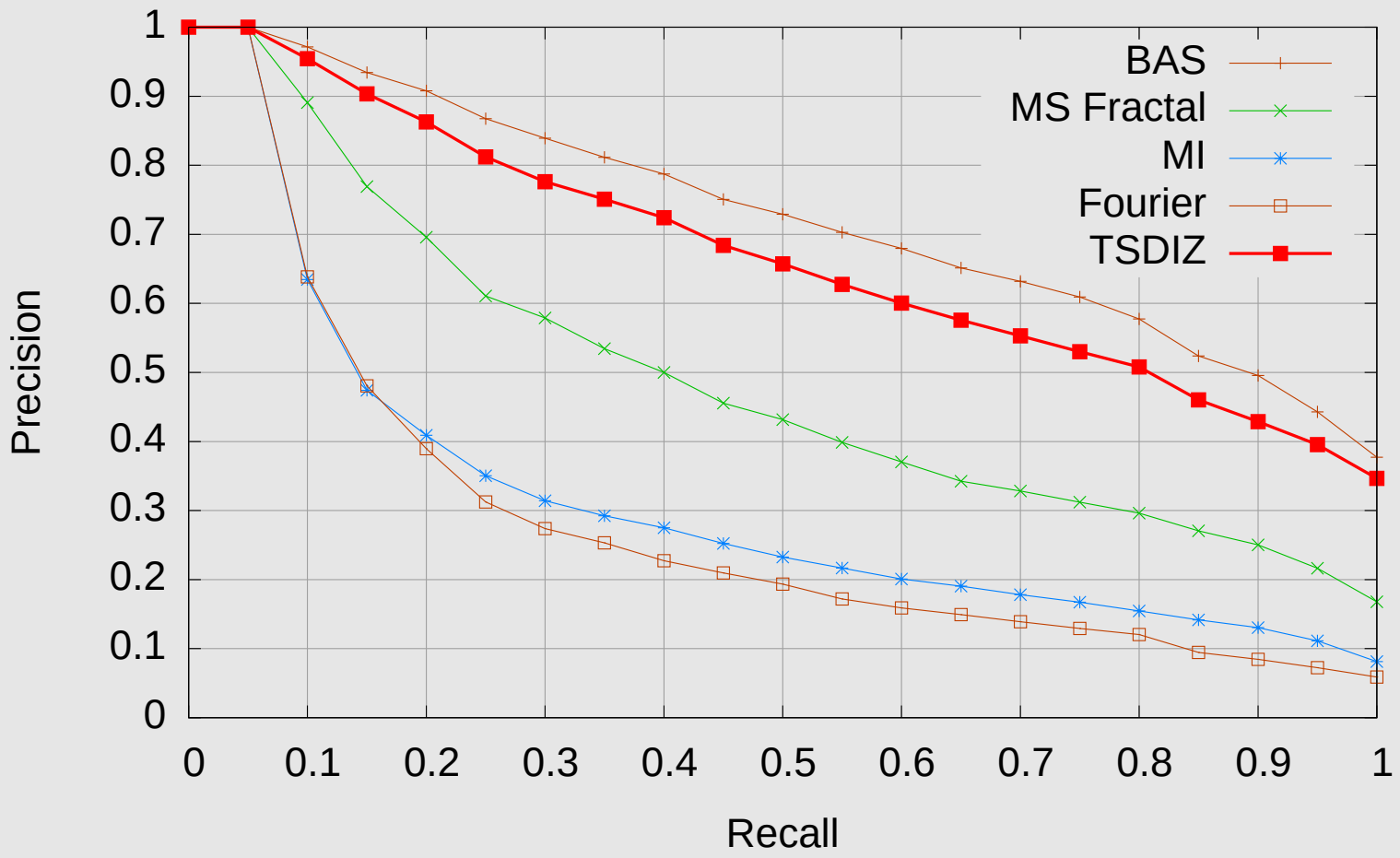


Experiments



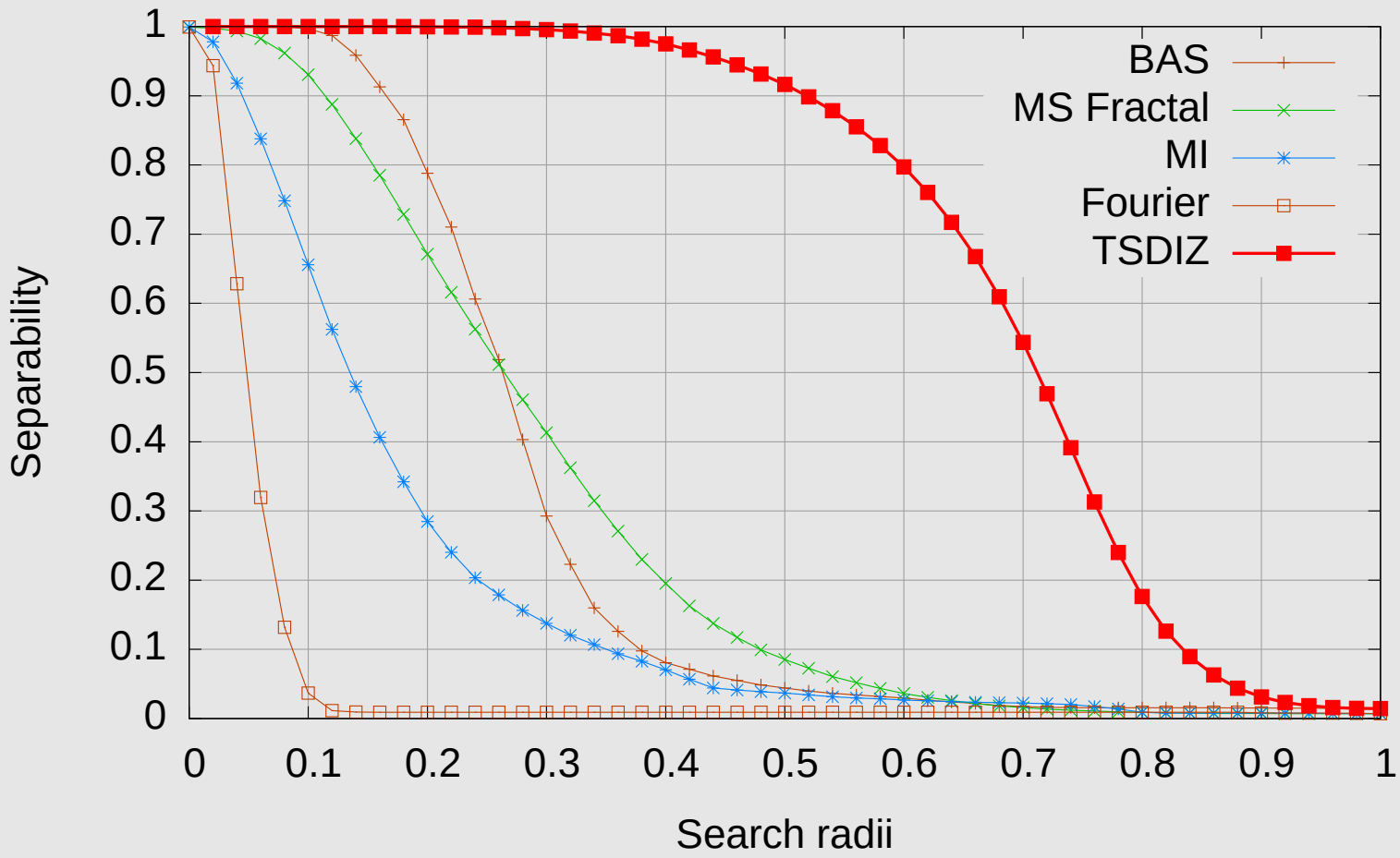
Experiments

Precision × Recall curve



Experiments

Multiscale separability curve



Conclusions

- This work introduces a new shape descriptor based on Tensor scale.
- It also proposes a faster algorithm for tensor scale computation using the IFT.
- Our descriptor has better PR curve than all relevant shape descriptors (except BAS) and the best separability curve among them.