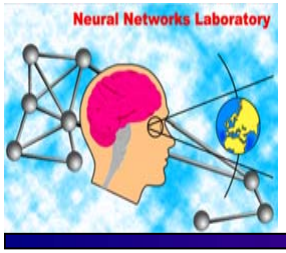

Technological Educational Institute Of Crete

Department Of Applied Informatics and Multimedia

Intelligent Systems Laboratory

Unsupervised Texture Segmentation Via Adaptive Gabor Filters

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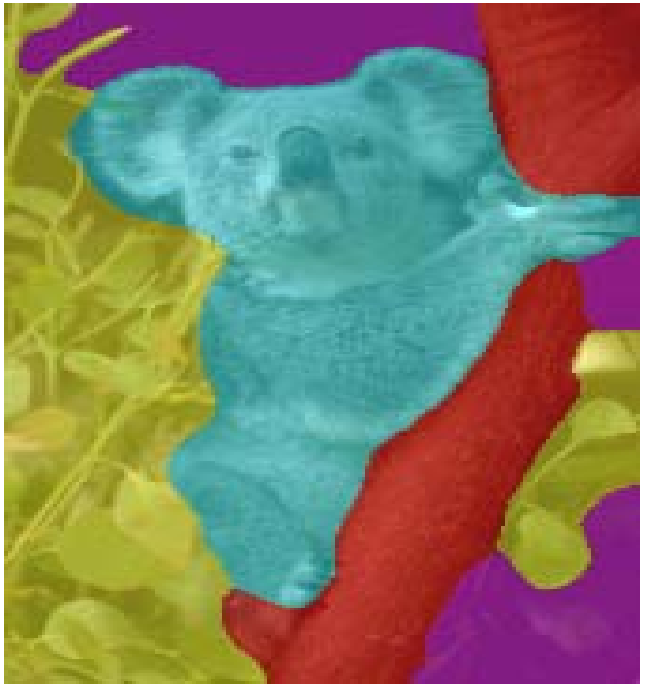
Image Segmentation

- Partitioning an image into meaningful regions
- Necessary to reduce the amount of information
- Compact representation

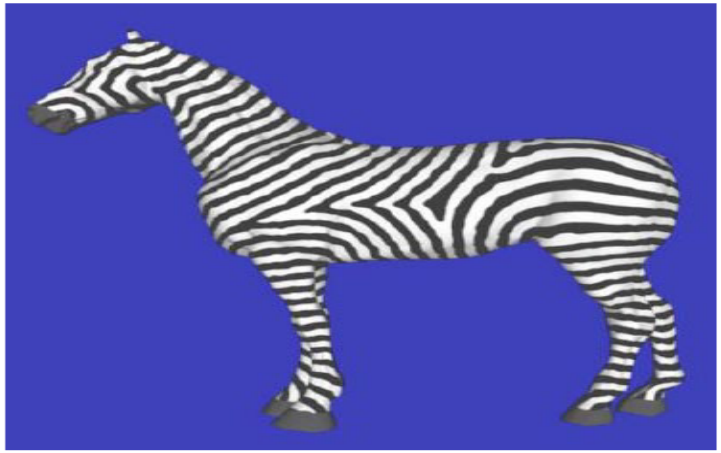
But, what is a meaningful region?

Good representation means:
The content of regions should be as similar as possible
content of different regions should be as dissimilar as possible



What is texture ?

- No accurate definition.
- Often used to represent the "flavor" or "nuance" of the image.
- In our case: pixel arrangements with some kind of "structure".

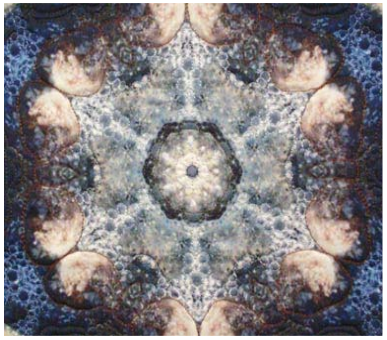


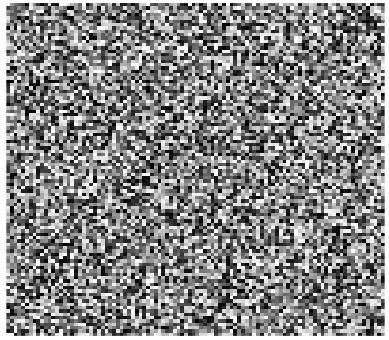
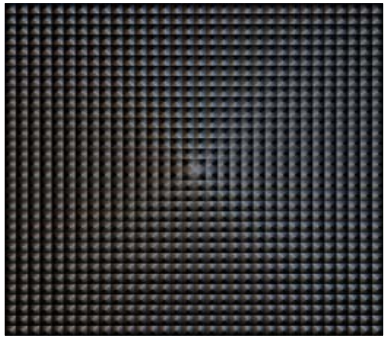
Shapes are textured regions ?

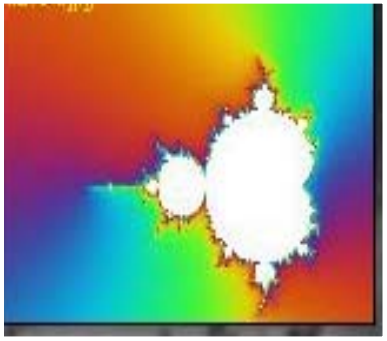
The Problem: Texture Similarity

S( , ) = ?

What structure?






Fractal?

Both

Random

Repetition

Texture Similarity based on Response Statistics

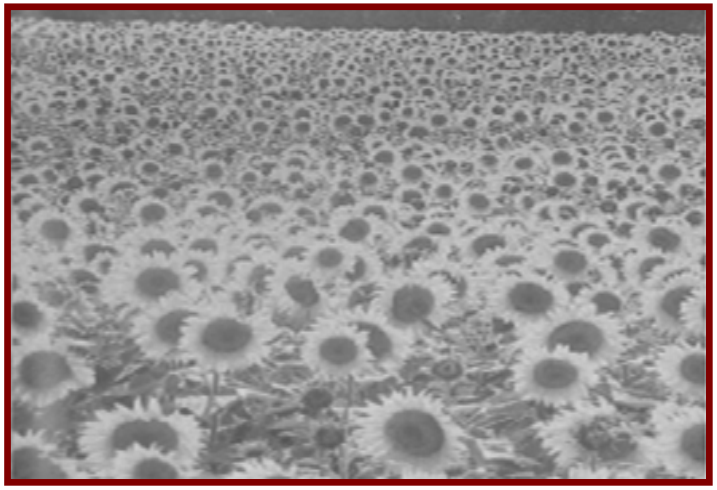
- Collect statistics of responses over a small subimage
- Calculate distance metrics between vectors of response statistics

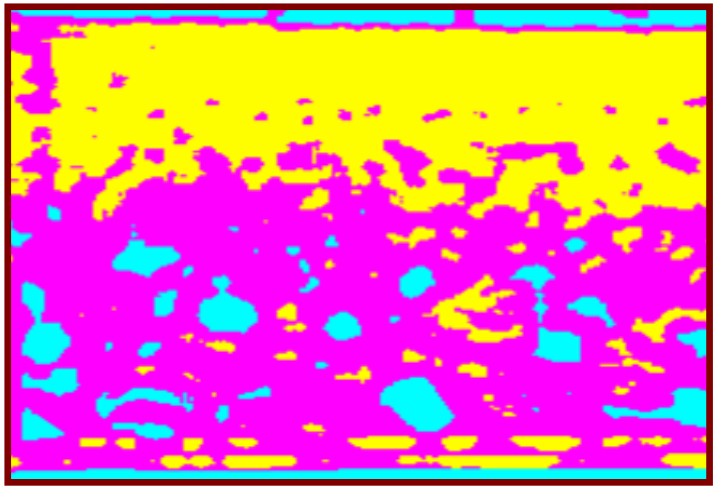
241	29	241	231	29
145	29	29	27	28
23	241	24	96	27
24	33	27	56	159
174	29	106	27	116

Mean: 21.4

What is the optimal window size?

- A critical question with **all** the statistical texture methods.
- we don't know yet!





Statistics of responces

Average Intensity $$m = \sum_{i=1}^{L-1} z_i p(z_i)$$

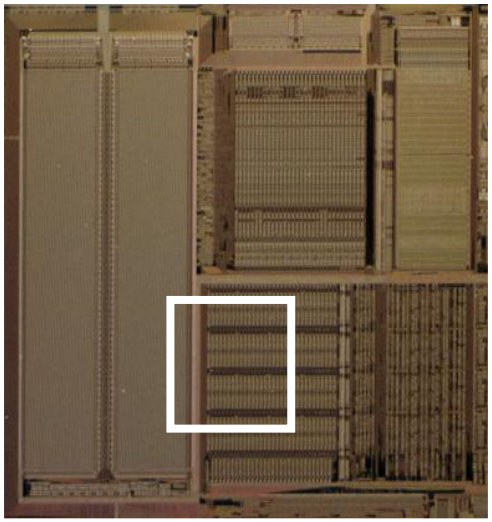
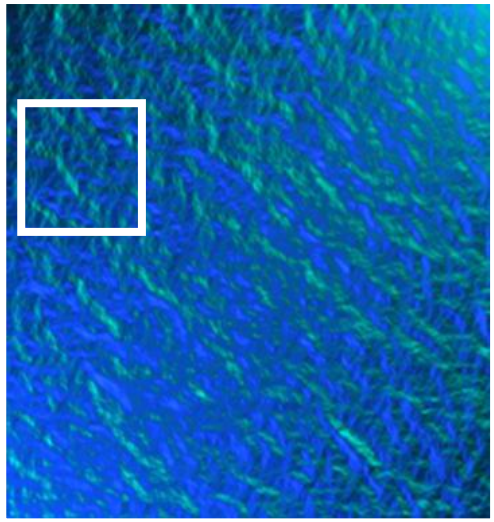
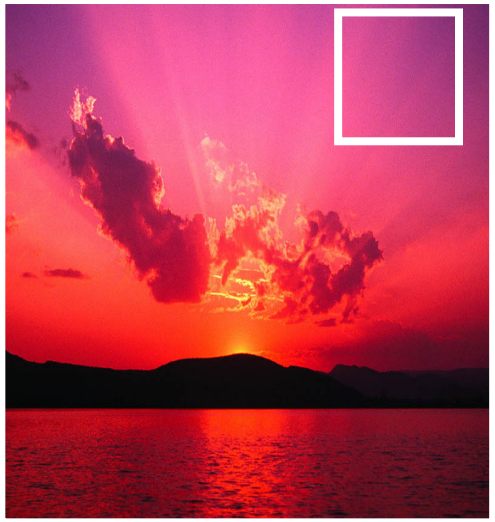
Average Contrast $$\sigma = \sqrt{\mu_2(z)}$$

Smoothness $$R = 1 - 1/(1+\sigma^2)$$

Uniformity $$U = \sum_{i=0}^{L-1} p^2(z_i)$$

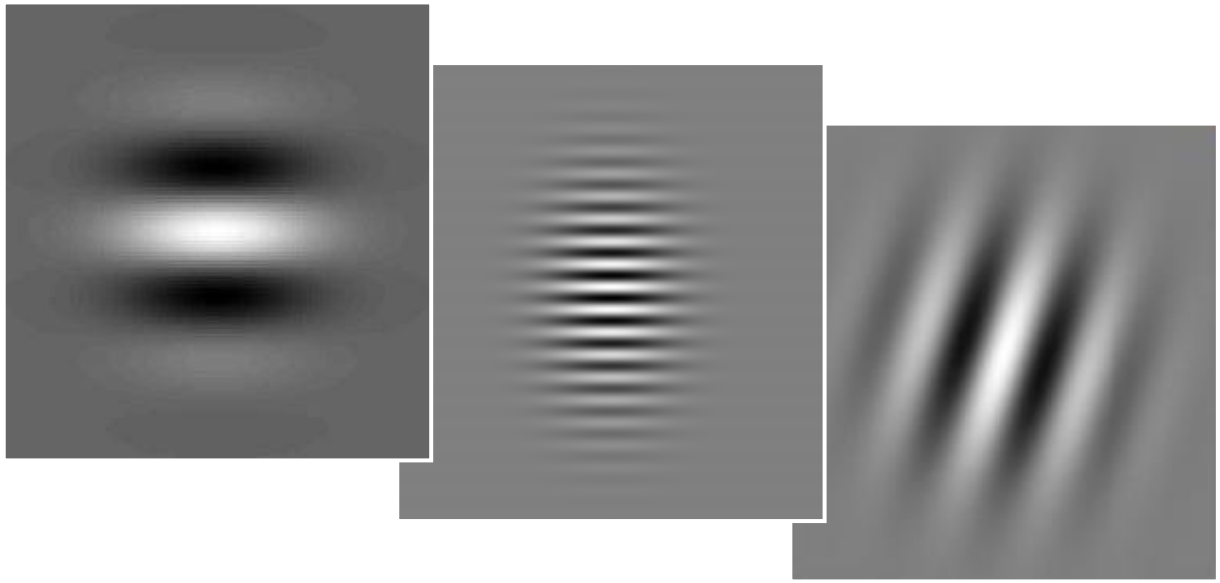
Entropy $$e = -\sum_{i=0}^{L-1} p(z_i) \log_2 p(z_i)$$

Texture Signatures

Texture	Average Intensity	Average Contrast	Smoothness	Uniformity	Entropy
Smooth	67.34	14.21	0.006	0.032	5,89
Coarse	127.04	84.18	0.055	0.007	8.64
Periodic	104.31	48.79	0.021	0.019	6.35

Texture Representation: Filter Responses

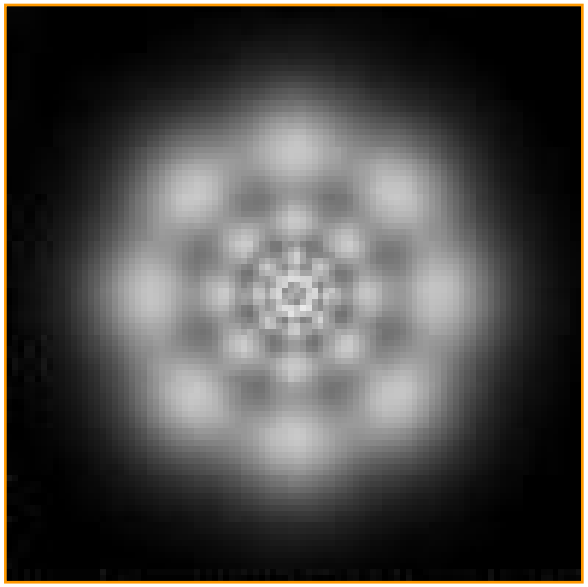


- Choose a group of Band-pass Gabor filters at different orientations, scales
- Run filters over image to get a set of *response images*

Each contains specific texture information

predefined tessellation of the frequency plane, consisting of overlapping filters whose centre frequencies lie on concentric circles, logarithmically spaced, centred at the origin.

This approach can lead to disadvantages since a large number of filtered images are involved and a large dimensional feature space needs to be processed



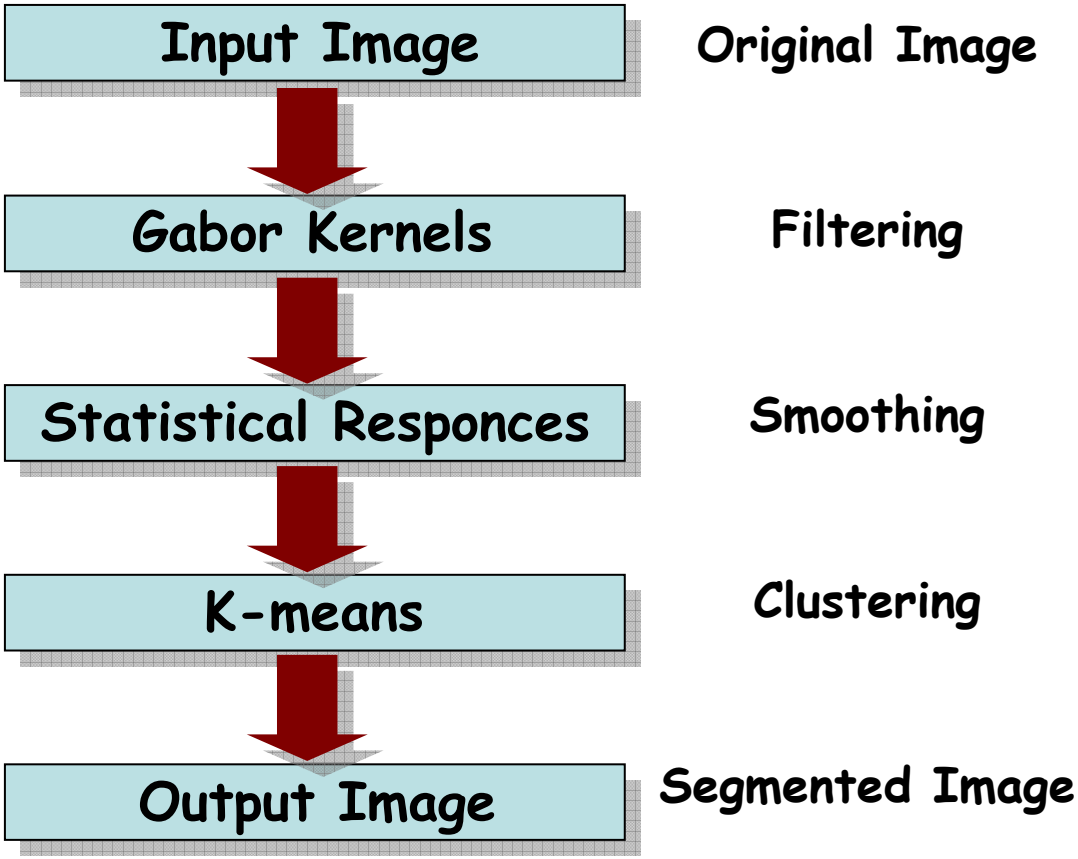
Daisy shaped filter kernels (frequency domain)

Biological Motivation

- Later studies on human vision shows that the retina and brain have receptive fields (filters) sensitive to different spatial frequencies, at a variety of scales and translations within a region of the retina, known as the complex cells.

- Gabor analysis represents images in a way somewhat similar to complex cells

Pixel Based Texture Classification



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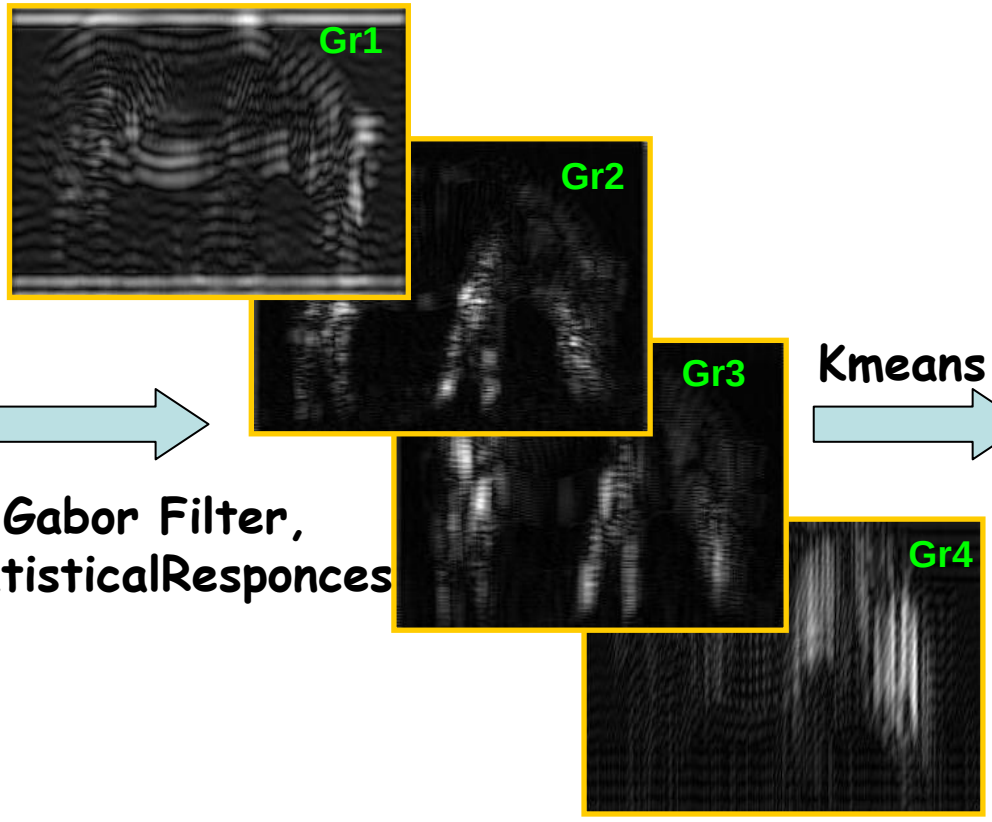
Pixel Classification

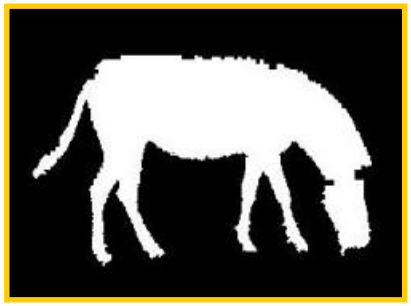
Source Image



Gabor Filter,
StatisticalResponces

Kmeans

Class Map



Pixel Signatures: $[Gr1_{ij}, GR2_{ij}, GR3_{ij}, GR4_{ij}]$

Optimization With GAs

Gabor Filter Kernel Equation

$$g(x,y)=\frac{1}{2\pi s_x s_y}\exp\left[-\frac{1}{2}\left\{\left(\frac{x}{s_x}\right)^2+\left(\frac{y}{s_y}\right)^2\right\}+2\pi j\,(Ux+Vy)\right]$$

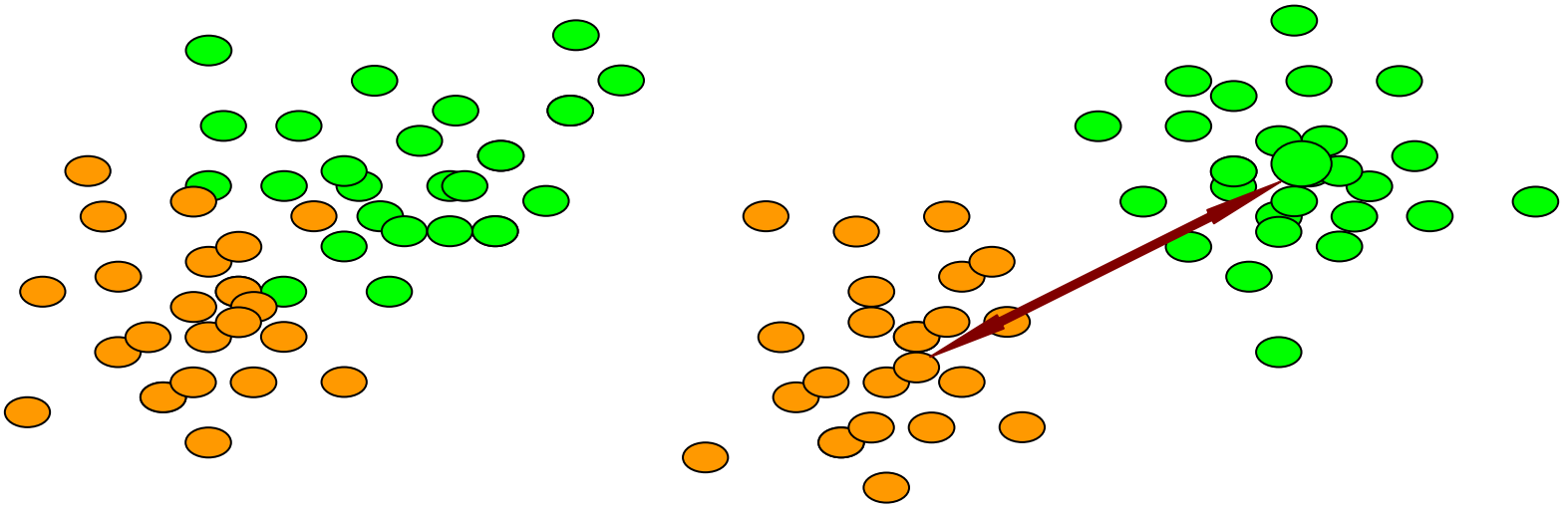
[Sx Sy Ux Vx]

[Sx1 Sy1 Ux1 Vy1; Sx2 Sy2 Ux2 Vy2; Sx3 Sy3 Ux3 Vy3]

Single Genome corresponding to three Gabor Kernels

Fitness Function

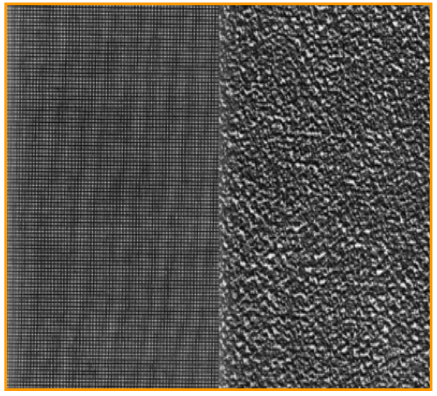
- Try to maximize the distance between clusters
  Dissimilar content between different regions
- Try to minimize distances between members of each cluster
  Similar content of the same region



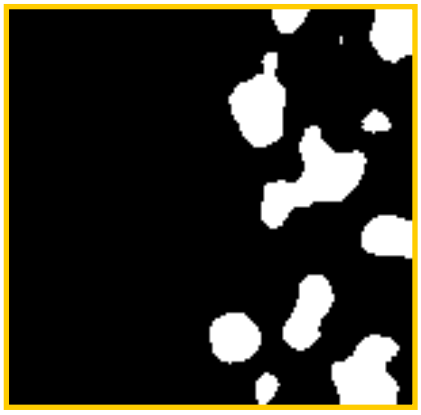
Overlapping Clusters

Non Overlapping Clusters

Evolution of filter Kernels



Input Image



a. Initial Random Genome

b. after 20 generations

c. after 100 generations

Conclusions

- Capturing behaviors of biological systems can lead to improved performance
- Evolutionary computation, offers solutions in difficult real world problems
- Conceptually simple procedure

Future Work

- Optimization of statistical responses window size
- Feature selection will also be investigated,
- Dimensionality reduction of the feature vectors
- Different clustering algorithms