



# Master in Computer Vision *Barcelona*

Module: Optimization methods in CV  
Inference algorithms: Guided problems  
Lecturer: O. Ramos Terrades

# Goals & Tools of this Lecture

## Goal

- ▶ Model a simple examples
- ▶ build PGMs using public libraries
- ▶ applied available inference algorithms

## Tools

- ▶ UGM: Undirected Graphical Models
- ▶ Matlab and Python

# Outline

Low level segmentation

## Low level segmentation



Original Image



Segmented image by color

### Definition

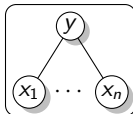
- ▶  $x_p$  RGB vector at pixel  $p$
- ▶ Assign to  $p$  the most *similar* color

### Question

How to define each group of colors?

## Definition of Unary potentials: Gaussian mixture model

$$\{x_p\} \in V$$



### Main idea:

- ▶ Define  $y \in \{1, \dots, K\}$  Hidden (not observed) variable.
- ▶  $x_p = (x_1, \dots, x_n)$  random vector of observed variables
- ▶ Get  $k$

$$\hat{k}_p = \operatorname{argmax}_{k \in \{1, \dots, K\}} P(k|x_p)$$

%Preparing data for GMM fitting  
%

```
im=double(im);  
x=reshape(im,[size(im,1)*size(im,2)  
size(im,3)]);  
gmm_color = gmdistribution.fit(x,K);  
mu_color=gmm_color.mu;
```

Join pdf

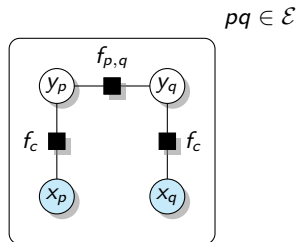
$$P(y, x) = \sum_{k=1}^K \frac{1}{(2\pi)^{n/2} |\Sigma_k|} \exp\{(x - \mu_k)^t \Sigma_k^{-1} (x - \mu_k)\} P(k) \mathbb{1}_k(y)$$

# Definition of CRF

## Main idea:

- Unary potential: GMM
- Pair-wise potential: Potts model

$$f_{p,q}(k, k') = \theta_{p,q} \mathbb{1}_{\{y_p \neq y_q\}}(k, k')$$



## CRF

$$P(y|x) = \prod_p P(y_p|x_p) \prod_{p,q} P(y_p, y_q)$$

% Estimate Unary potentials

```
data_term=gmm_color.posterior(x);
```

```
[~,c] = max(data_term,[],2);
```

$$f_c(y_p = k, x_p) = (x_p - \mu_k)^t \Sigma_k^{-1} (x_p - \mu_k)$$

# Implementation of CRF

## With UGM:

- ▶ Fix a number of color clusters,  $K$ , and estimate a *gmm* as Unary factors
- ▶ Fix parameter for a Potts model.
- ▶ Implement function CreateGridUGMMModel.m
  - ▶ Define Grid
  - ▶ Define *Edge* structure
- ▶ Call inference algorithms
- ▶ **optional 1:** add an extra inference algorithm
- ▶ **optional 2:** change the pairwise potential