

Data analysis: Statistical principals and computational methods

Introduction

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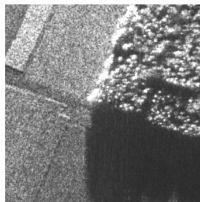


1. Statistics (Ingo Röder)
2. Machine Learning (Lars Kaderali)
3. Structural models (Dmitrij Schlesinger, Carsten Rother)
 - 04.06: Markov chains – the model, Dynamic Programming
 - 18.06: Energy Minimization – search techniques
 - 25.06: Energy Minimization – LP-relaxation
 - 02.07: Statistical inference for MRF-s, sampling techniques
 - 09.07: Statistical Learning – Maximum Likelihood for MRF-s
 - 16.07: Structural SVM

Structural Models:

Data that consists of several parts, and not only the parts themselves contain information, but also the way in which the parts belong together.

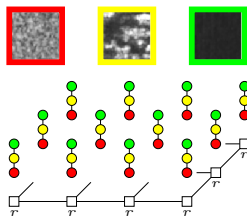
Example – Segmentation



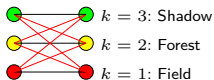
Original



A possible segmentation

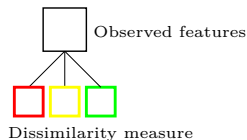


Compactness terms

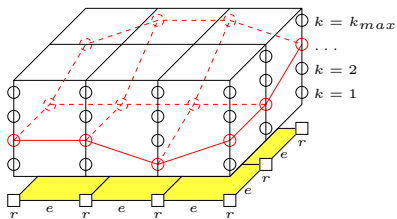
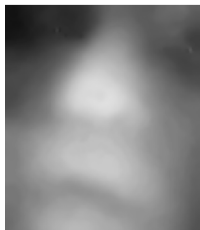
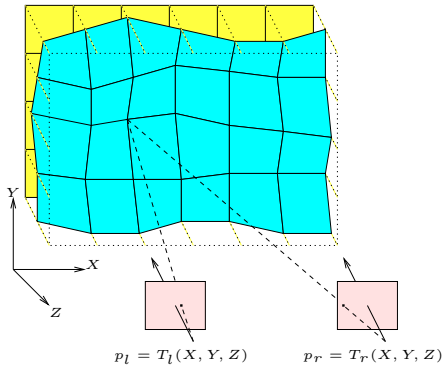


— Penalty
— Zero

Data terms

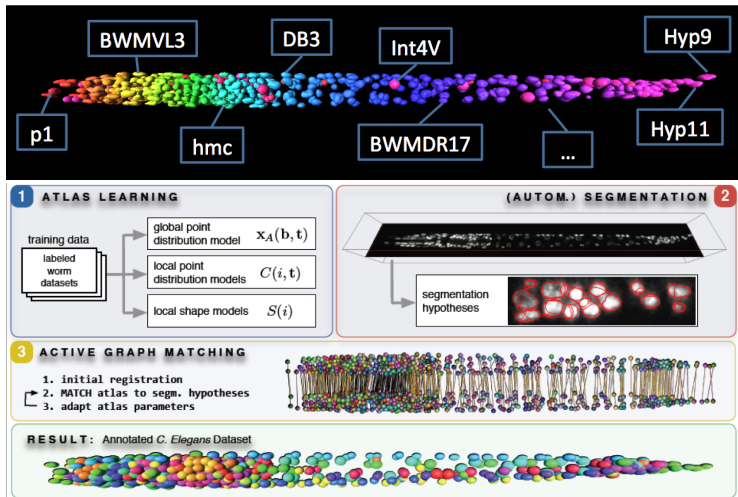


Example – Stereo



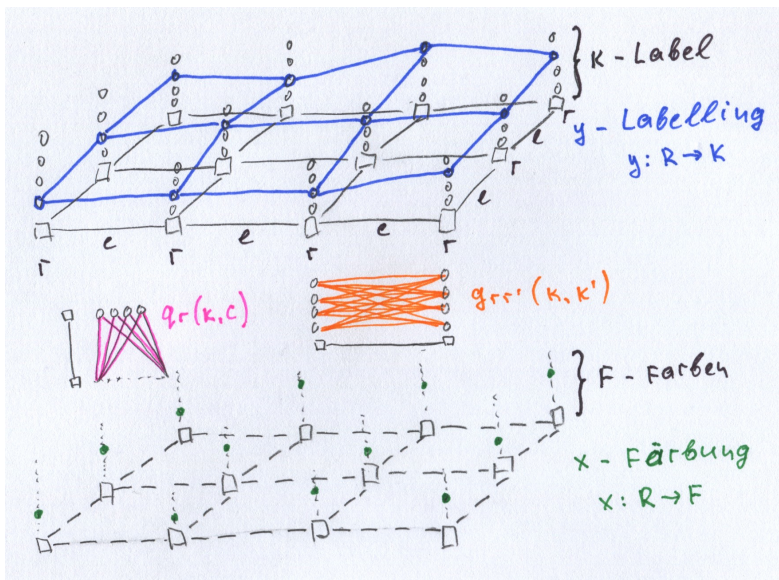
Example – Active Graph Matching

Automatic Joint Segmentation and Annotation of *C. Elegans*



Input 3D volume Matching

Markov Random Fields (simplified)



Markov Random Fields (simplified)

Graph $G = (V, \mathcal{E})$, K – label set, F – “observations” set,
 $y \in \mathcal{Y} : V \rightarrow K$ – labeling, $x \in \mathcal{X} : V \rightarrow F$ – observation

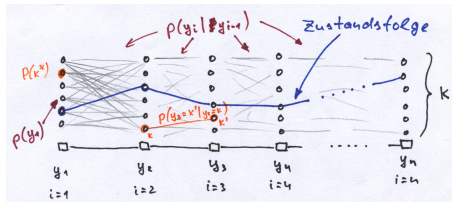
An elementary event is a pair (x, y) , the (negative) energy:

$$E(x, y) = \sum_{ij \in \mathcal{E}} \psi_{ij}(y_i, y_j) + \sum_{i \in V} \psi_i(x_i, y_i)$$

The joint probability:

$$p(x, y) = \frac{1}{Z} \exp[-E(x, y)]$$

Special case – Markov Chains:



Some popular MRF-s

... of second order over the pixel grid, 4-neighborhood (because simple) – segmentation, denoising, deconvolution, stereo, motion fields etc.

... with **continuous** label spaces – denoising, stereo

... with **dense** neighborhood structure – shape modeling (e.g. curvature), segmentation

... of **higher order** – all the stuff above

Conditional Random Fields (CRF) – MRF-s that model posterior distributions of labellings instead of the joint ones

Seminars: assignments on the board,
own solutions (ideas, propositions etc.) are expected !!!

Literature:

- Christopher M. Bishop
Pattern Recognition and Machine Learning
<http://research.microsoft.com/en-us/um/people/cmbishop/prml/>
- Sebastian Nowozin and Christoph H. Lampert
Structured Prediction and Learning in Computer Vision
<http://www.nowozin.net/sebastian/cvpr2011tutorial/>

Scripts:

http:

[//wwwpub.zih.tu-dresden.de/~ds24/lehre/spcm_ss_2014/spcm_ss_2014.html](http://wwwpub.zih.tu-dresden.de/~ds24/lehre/spcm_ss_2014/spcm_ss_2014.html)