

Lecture 1: Introduction

Statistical Image Analysis



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Practical information

Schedule:

Lectures: Mondays and Wednesdays (10-12)
Compute exercises: Mondays and Wednesdays (13-15)

The lectures will cover the theory, which you will use in practice in the computer exercise directly after each lecture.

Litterature:

- Lecture notes by Mats Rudemo.
- Handbook of Spatial Statistics by Gelfand et. al.
- Computer Age Statistical Inference by Efron and Hastie.

The books are available as eBooks, see homepage.

In the schedule, the relevant chapters are indicated for each lecture.

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Teachers:

David Bolin: Lecturer and examiner
Room: H3028
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Marco Longfils: Exercise supervisor and project assistance
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Homepage:

www.math.chalmers.se/Stat/Grundutb/CTH/tms016/1718/

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Examination

There will be two components in the examination:

- Written exam at the end of the course
- Project assignment.

these are weighted equally for the final grade.

Successful completion of the course will be rewarded by 7.5 hp.

The project:

- can be in groups of 1-3 students.
- will consist of three parts: two problems introduced in the computer exercises and one problem you can choose on your own (with approval from me).
- More information will be given after easter.

Practical

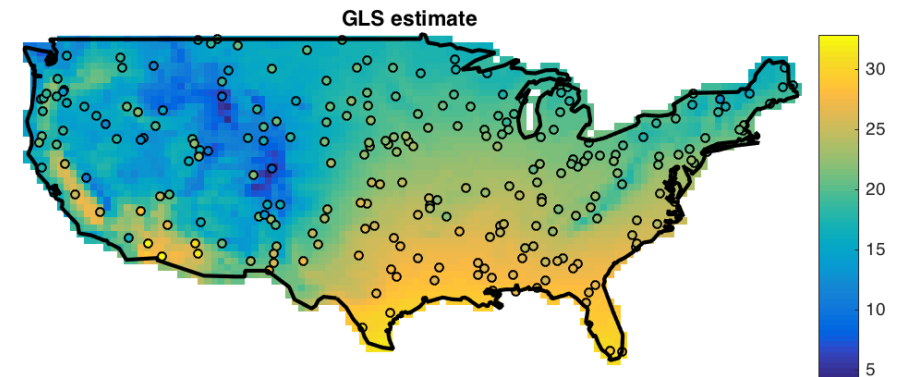
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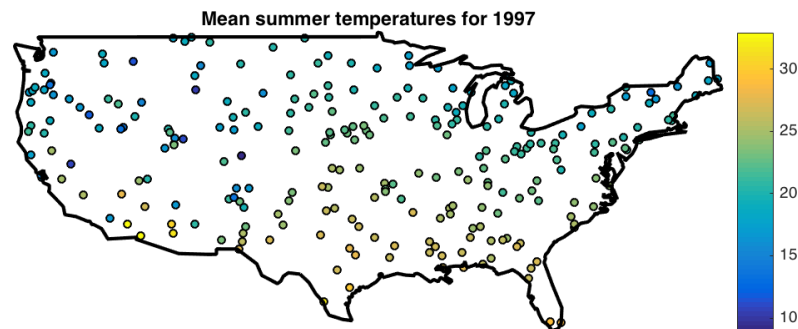
- Image analysis is a very active field of research.
- In statistical image analysis, we use statistical models and methods for applications in image analysis.
- The methods you will learn have applications also outside traditional image analysis:
 - climate science
 - environmental statistics
 - remote sensing
 - microscopy
 - medical imaging and fMRI
 - Disease mapping
 - +++

Kriging estimation

Using a statistical model, where we assume that there observations are noisy observations of the true temperatures, we obtain

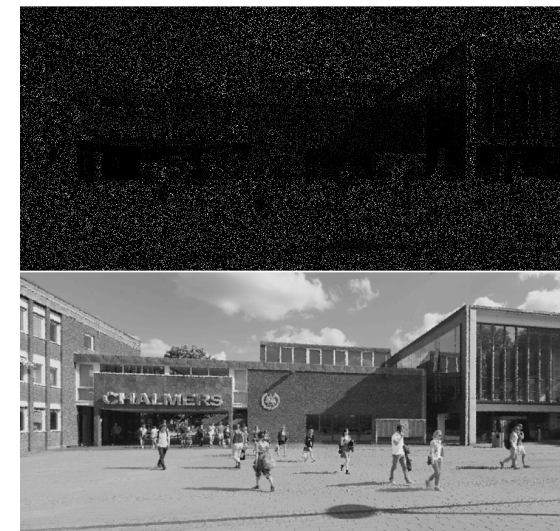


A common problem in geostatistics



- Mean summer temperatures (June-August) in the continental US 1997 recorded at 250 weather stations.
- We want to estimate all US temperatures based on the data.

Image reconstruction



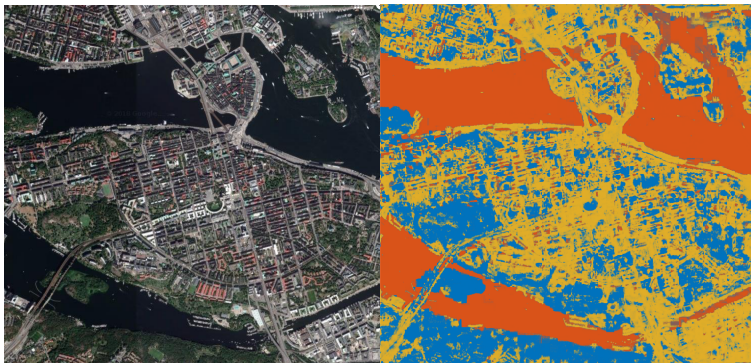
Noise reduction



Classification

5	0	4	1	9	2	1	3	1	4
3	5	3	6	1	7	2	8	6	9
4	0	9	1	1	2	4	3	2	7
3	8	6	9	0	5	6	0	7	6
1	8	7	9	3	9	8	5	9	3
3	0	7	4	9	8	0	9	4	1
4	4	6	0	4	5	6	1	0	0
1	7	1	6	3	0	2	1	1	7
9	0	2	6	7	8	3	9	0	4
6	7	4	6	8	0	7	8	3	1

Segmentation

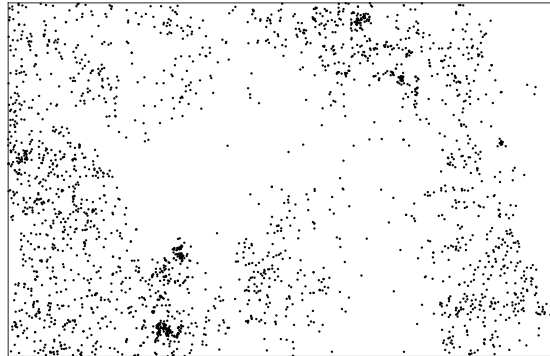


Puppy or bagel?



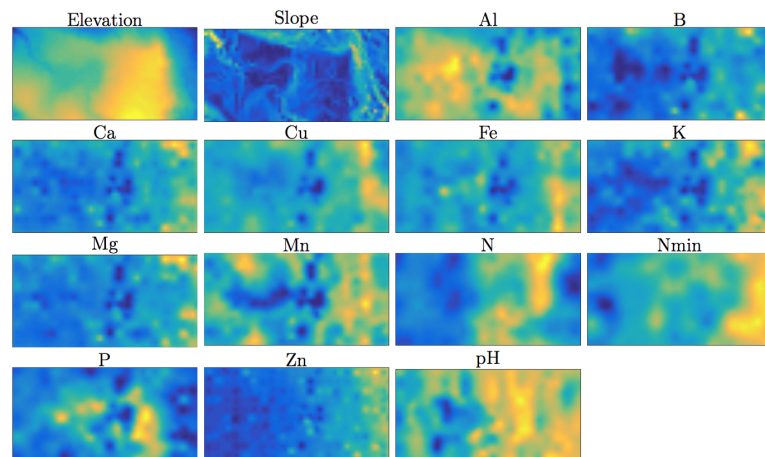
See twistedstifter.com/2016/03/puppy-or-bagel-meme-gallery/ for more important classification problems.

Point processes



The locations of the tree species *Beilschmiedia Pendula* in the tropical rainforest plot on Barro Colorado Island.

Point processes



Possible covariates that can be used for drawing conclusions on the association of habitat preferences.

Outline of course

Current plan for lectures:

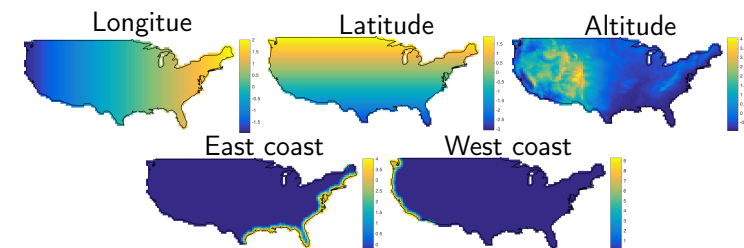
- 1 Introduction and background
- 2-3 Gaussian random fields
- 4-5 Markov random fields
- 6-7 Mixture models and image segmentation
- 8-10 Image classification and neural nets
- 11-12 Point processes
- 13 Recap and exam questions
- 14-15 Project seminars

Example: Interpolation of the temperature data

- A first idea is to use linear regression to interpolate the data:

$$Y(\mathbf{s}) = \sum_{i=1}^k \beta_i B_i(\mathbf{s}) + \varepsilon_{\mathbf{s}}, \quad \text{where } \varepsilon_{\mathbf{s}} \text{ are iid } N(0, \sigma^2)$$

- Possible covariates



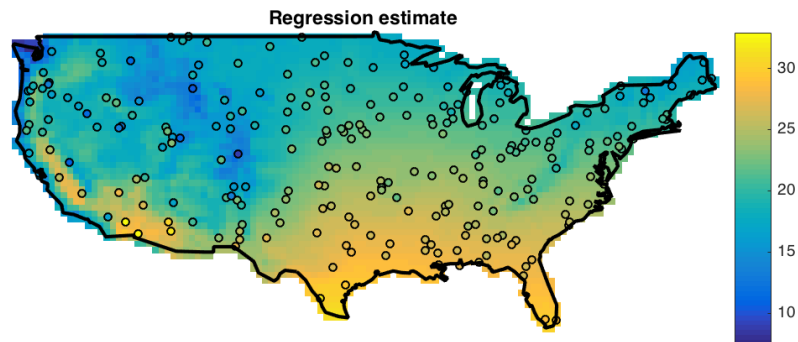
OLS estimate

- Estimate the parameters using ordinary least squares:

$$\hat{\beta} = \arg \min_{\beta} \|\mathbf{Y} - \mathbf{B}\beta\| \Rightarrow \hat{\beta} = (\mathbf{B}^T \mathbf{B})^{-1} \mathbf{B}^T \mathbf{Y},$$

where $\mathbf{B}_{ij} = B_i(\mathbf{s}_j)$ and $\mathbf{Y}_i = Y(\mathbf{s}_i)$.

- Calculate the prediction $\hat{X}(\mathbf{s}) = \sum_{i=1}^k \hat{\beta}_i B_i(\mathbf{s})$.

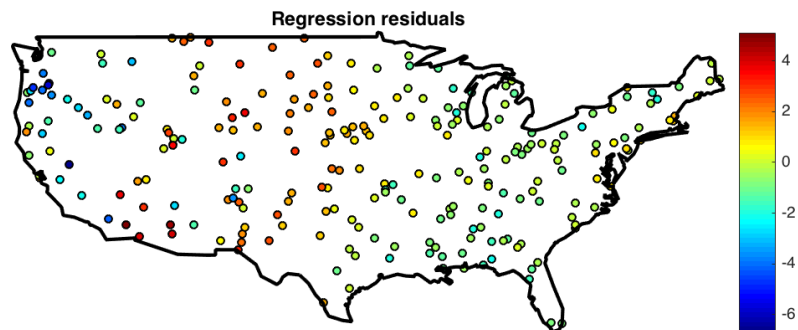


Example

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Residuals

- How do we test whether the prediction is reasonable?
- If the model assumptions hold, the residuals $Y(\mathbf{s}) - \hat{X}(\mathbf{s})$ should be independent identically distributed.



Example

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