Organization and Introduction

Michael Moeller

Visual
Scene
Analysis

Organizational Things

What will we do?

Chapter 0
Organization and Introduction

Numerical Methods for Visual Computing
WS 17/18

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Organizational Stuff

Numercial methods for Visual Computing?

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What will we do?

Numerical Methods

- Many problems are too large or too complicated to be solved with pen and paper or do not have a closed form solution
- Goal of this lecture: Study different basic types of problems and learn about ways to solve them with a computer
- Understand why such methods work
- Learn how to implement them in Matlab

Visual Computing

- Synthesizing, reconstructing or analyzing image and video data
- Key technology in many areas
- I'll try to tailor the examples to visual computing

Formalities

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What will we do?

Exercises

- Exercise sheets covering the content of the lecture will be passed out every Tuesday
- Exercises contain theoretical as well as programming problems
- You have one week for the exercise sheets and will turn in your solutions on Tuesday
- You may work on the exercises in groups of two
- The solutions will be discussed in the exercises on Friday
- **Reaching at least** 50% **of the total exercise points is required for being admitted to the final exam**
- If solutions have obviously been copied, both groups will get 0 points

Formalities

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What will we do?

Questions within the lecture

The more we discuss in the lecture, the more interesting the
course will be! Please don't be shy to say something!

Examination

- Depending on the number of attendees, the final exam will
 be either oral or written.
- This lecture is worth 5 credits.

Formalities

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Miscellaneous

- My office: H-A 7106
- Office hours: Please write an email.
- Lecture: Starts at quarter past. Short break in between.
- Course website: `http://www.vsa.informatik.uni-siegen.de/en/numerical-methods-1718`
- To access the course material: username: "student", password "100%brain"

Error analysis and the condition of a problem

Things that can go wrong,
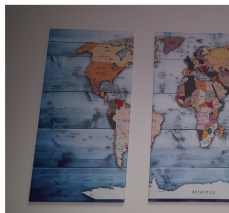
- Example 1: Does the distributive property hold?

$$(x - y)^2 = x^2 - xy - yx + y^2 \ ?$$

- Example 2: Image deblurring - does noise matter?
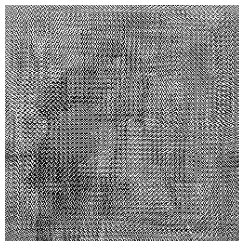
Linear regression

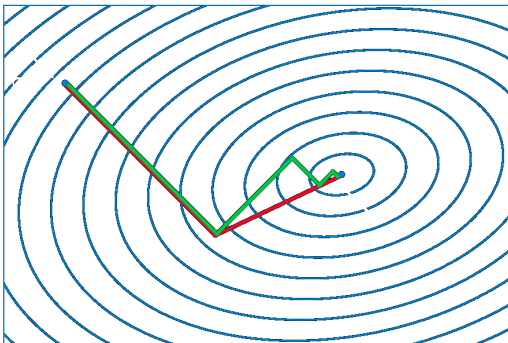How to fit a linear parametric model to some measured data?
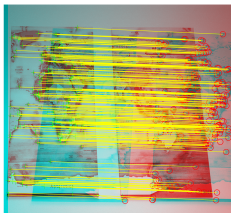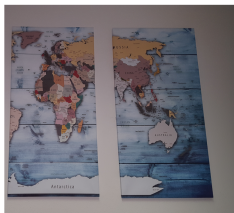
Solve $\min_{u} \|Au - f\|^2$ and variants thereof

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$$\begin{array}{l} \text{V}_{\text{isual}} \\ \text{S}_{\text{cene}} \\ \text{A}_{\text{nalysis}} \end{array}$$

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What will we do?

Linear equations

How to solve linear equations

- Exactly, e.g. using Gaussian elimination

$$\left[\begin{array}{ccc|c} a_{11} & a_{12} & a_{13} & b_1 \\ a_{21} & a_{22} & a_{23} & b_2 \\ a_{31} & a_{32} & a_{33} & b_3 \end{array} \right] \rightarrow \left[\begin{array}{ccc|c} \tilde{a}_{11} & \tilde{a}_{12} & \tilde{a}_{13} & \tilde{b}_1 \\ 0 & \tilde{a}_{22} & \tilde{a}_{23} & \tilde{b}_2 \\ 0 & 0 & \tilde{a}_{33} & \tilde{b}_3 \end{array} \right]$$

- Iteratively, e.g. using the conjugate gradient method

From Wikipedia: https://de.wikipedia.org/wiki/CG-Verfahren

Nonlinear optimization

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What will we do?

Assume you have a differentiable but slightly complicated function, e.g.

$$E(\theta) = \sum_{i=1}^{n}(1 - 2y_i)\log\left(\frac{1}{1 + \exp(-\langle\theta, x_i\rangle)}\right) + \frac{\lambda}{2}\|\theta\|^2$$

and you want to minimize it with respect to θ.

As we will see a necessary and sufficient condition is (in this case)

$$\nabla E(\theta) = 0$$

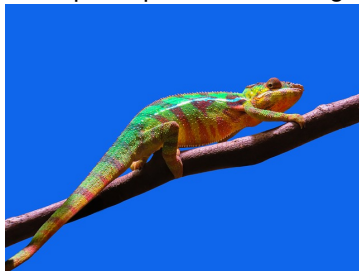But how can we solve this equation?

Solving nonlinear equations

Our answer here: Determine $\nabla E(u) = 0$ using Newton's method!

Our example: Learn a very simple color skin-detector!
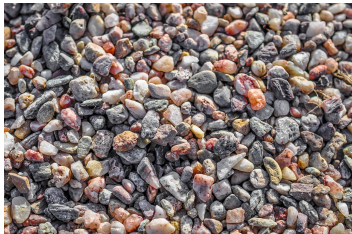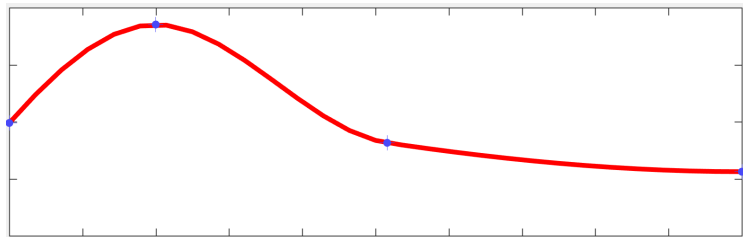
Computing eigenvalues and eigenvectors

Example: Spectral clustering

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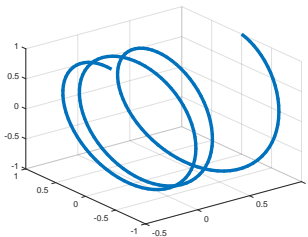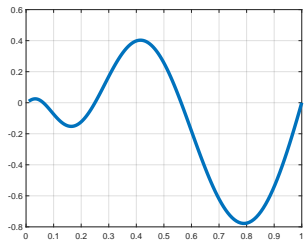
What will we do?
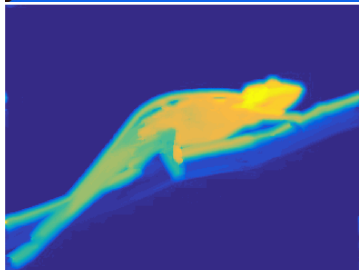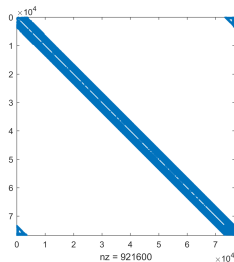
Interpolation

Example: Image filter gui with drag and drop points on a curve

Integration

How to compute the integral over a function numerically?
How to compute the line integral over a function?

In higher dimensions: What is the volume under a surface?

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