

# **Probabilistic shape modelling**

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#### About me



Lecturer (75%)

- Programming
- Software Engineering
- Algorithms and Datastructures
- Probabilistic shape modelling
- Machine intelligence



Researcher (whenever there is time)

- PhD and PostDoc at Graphics and Vision research group (GraVis)
- Research interests
  - Image analysis
  - Statistical (shape) modelling
- Member of GraVis-group



Co-founder & board member Shapemeans GmbH

#### **Graphics and Vision Research Group**



#### Statistical model of a face



## Analysis of an image using the model



## Agenda for today

Probabilistic shape modelling

- The course in a nutshell
- Connections to other courses / topics

Course organization

- Online course?
- How do I get the credit points?
- Exercises

Goal: You can make an informed decision whether this course is interesting for you.

#### Statistical shape models

Statistical Shape model: A probability distribution of shapes, learned from example data.



#### **Statistical shape models**

Statistical Shape model: A probability distribution of shapes, learned from example data.



#### **Statistical shape model**











#### **Observing Data**



### **Probability after observing data**



## **Probability after observing data**



### **Probability after observing data**



#### Model-based data analysis – a Bayesian approach



#### Model-based data analysis – a Bayesian approach



• Bayesian inference gives mathematically sound way of updating our knowledge.

#### Model-based data analysis – a Bayesian approach







#### Challenges

- How do we model shape variations?
- How do we update probabilities?
- How do we make this applicable and useful in practice?

#### Computational problem:

$$P(\alpha | \text{Data}) = \frac{P(\text{Data} | \alpha) P(\alpha)}{\int \dots \int P(\text{Data} | \alpha_1, \dots, \alpha_n) P(\alpha_1, \dots, \alpha_n) d\alpha_1, \dots, d\alpha_n}$$

#### Software

Medical image analysis is not only a mathematical, but also an engineering challenge

Scalismo (https://www.scalismo.org)

Open source software for model-based image analysis

- Strong emphasis on visualization
- Written in Scala
- Developed and maintained by Graphics and Vision Research Group

Design goals:

- Easy and efficient to experiment
- Able to scale to professional applications



## **Relationship to other courses / subjects**

**Mathematics** 

- Gaussian processes
- Markov Chains

Data analysis

- Bayesian modelling
- Bayesian inference / model fitting
- Markov Chain Monte Carlo



Programming

- Implementing systems for image analysis
- New language: Scala

#### Course organization

- Basics of shape modelling
- Basics of Gaussian processes
- The scalismo framework

- Model-based image analysis
- Markov Chain Monte Carlo
- Face image analysis

## Online course (MOOC): Shape Modelling

Classroom lectures: Model fitting



## **Massive Open Online Course (MOOC)**

#### Massive:

No limitation on the number of participants

#### **Open:**

Everybody can access free of charge No formal enrollment procedure

#### **Online**:

Offered via the internet

#### Course:

Offered during a fixed period Mentoring/assistance provided



Illustration Till Hafenbrak

#### **Your MOOC**



#### **Studying with international peers**



#### How does FutureLearn work?



#### https://www.futurelearn.com/about/how-it-works

#### How to register on FutureLearn?



You need to provide

- First name / Last name
- Email address
- Password

Do not use your university password!

You need to agree to the

- Terms and conditions
- Privacy policy
- Code of Conduct

## Your identity on FutureLearn

FutureLearn asks you to

- create only one account
- use your real name

You must not

- share the account with anybody else
- falsely state, impersonate, misrepresent your identity

#### **Data protection**

Data protection policy: <a href="https://about.futurelearn.com/terms/data-protection-policy/">https://about.futurelearn.com/terms/data-protection-policy/</a>

The university of Basel:

- Will not and cannot access data of individual learners.
- does not check if you follow the course
- Does not exchange data between the study administration of the University of Basel and FutureLearn.

## It's free for you





- You don't need to buy the Statement of Participation
- You don't need to upgrade the course to access the material

#### **Exercises – Milestones - Credits**



• Exercises (in groups of 2) will be presented/discussed individually (mandatory)

Exercise sheet 2 Discussion

Projects count 25 % each to final grade

#### **Project 1: Shape reconstruction**

Challenge: Find best reconstruction for partial femur – Compete with researchers from all over the world



#### **Project 2: Segment an organ from a CT image**



Image source: http://www.sliver07.org/index.php

#### Next meeting

Tuesday, 25. February 14:15 – 16.00

- Introduction to the exercises and course project
- Using Scalismo from IntelliJ
- Basics of Scala

**Questions & Answer** 

Please bring your computer!

O ExampleA	no scala X S build sht X S Exercise0 scala X
- champier,	
29	// display it
30	<pre>val meshView = ul.show(mesh, "face")</pre>
31	// abango ita color
2	moshView color = Color BUNK
13	Meshview.color - color.rink
5	val binImage: ScalarImage[ 3D] = mesh operations toBinaryImage
6	val imageDomain = DiscreteImageDomain(mesh.boundingBox, size=IntVector(64, 64, 64))
37	val binDiscreteImage = binImage.sample[Short](imageDomain, outsideValue = 0)
38	······································
39	<pre>val vtkImage = ImageConversion.imageToVtkStructuredPoints(binDiscreteImage)</pre>
10	
10	<pre>val largestComponent = new vtk.vtkImageThreshold()</pre>
10 11 12	<pre>val largestComponent = new vtk.vtkImageThreshold() largestComponent.SetInputData(vtkImage)</pre>
10 11 12 13	<pre>val largestComponent = new vtk.vtkImageThreshold() largestComponent.SetInputData(vtkImage) largestComponent.Update()</pre>
0 1 2 3 4	<pre>val largestComponent = new vtk.vtkImageThreshold() largestComponent.SetInputData(vtkImage) largestComponent.Update() ImageConversion.vtkStructuredPointsToScalarImage(largestComponent.GetOutput())</pre>
10 11 12 13 14	<pre>val largestComponent = new vtk.vtkImageThreshold() largestComponent.SetInputData(vtkImage) largestComponent.Update() ImageConversion.vtkStructuredPointsToScalarImage(largestComponent.GetOutput()) }</pre>

#### Homework

Work through first week of the online course.

ONLINE COURSE

#### Statistical Shape Modelling: Computing the Human Anatomy

Learn the technology of modelling, as used in computational face recognition or in surgeries, with this free online course.



Join course



https://www.futurelearn.com/courses/statistical-shape-modelling