From Healthcare Imaging to Shape Interpretation

Jacek Kustra
Philips Research
9 July 2015

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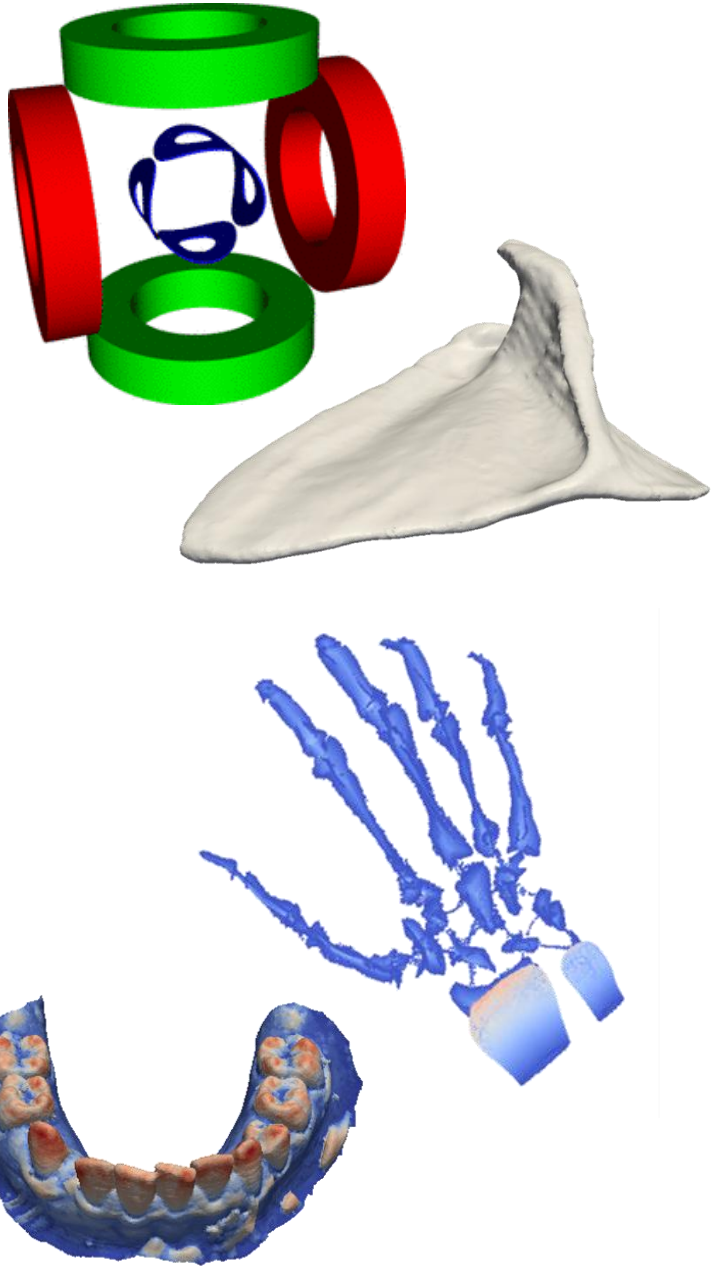

Contents

About Philips

About Myself

Imaging techniques

- Novel Imaging Modalities Magnetic Particle Imaging
- New Challenges in fast 3D imaging
- Algorithm Development for Real Time Performance

Shape analysis

- Introduction to medial surfaces
- Medial axis extraction
- Medial point cloud regularization
- Manifold extraction / reconstruction

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1. Facts and figures

A born innovator



Philips' founding fathers: Frederik, Gerard and Anton Philips

Founded in 1891, in Eindhoven, The Netherlands, to manufacture incandescent lamps and other electrical products.

For more than 120 years, we have been improving people's lives with a steady flow of ground-breaking innovations.

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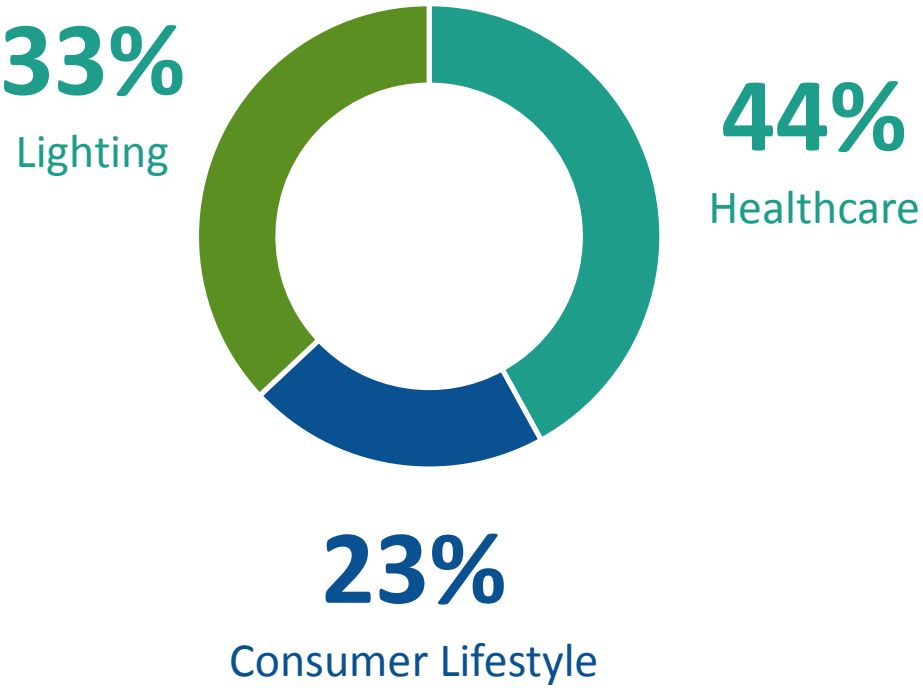
Royal Philips



Est. **1891**

Headquarters in
Amsterdam, Netherlands

105,000+

Employees worldwide
in 100+ countries

€ 21.4 billion

Sales in 2014
Portfolio ~70% B2B

$10.3 billion

Brand value in 2014

* Based on sales last 12 months December 2014
Note - Prior-period financials have been restated for the treatment of the combined businesses of Automotive and Lumileds as discontinued operations.

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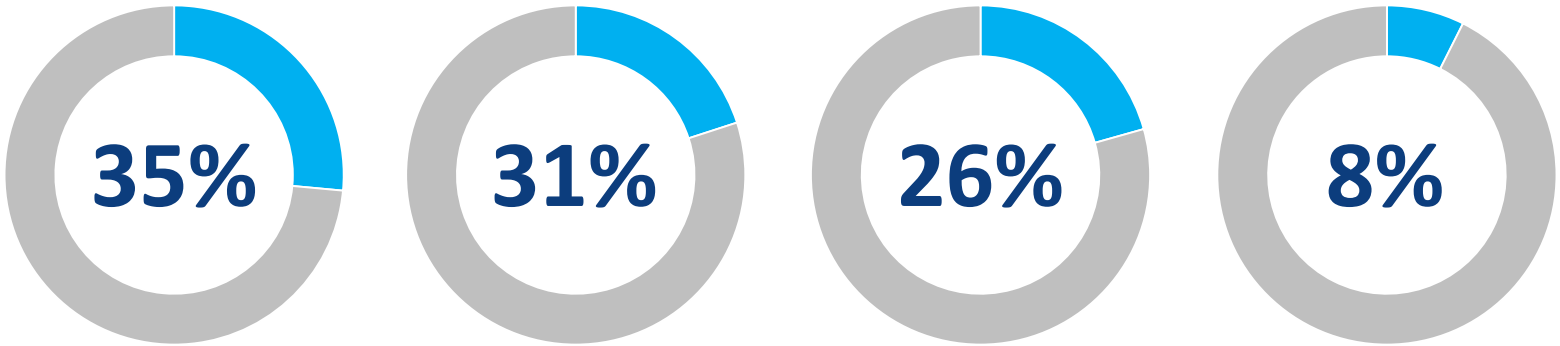
Presence in more than +100 countries

Philips' revenue across geographies



[1] Based on sales last 12 months December 2014

[2] Growth geographies and Other geographies excluding USA, Canada, Western Europe, Australia, New Zealand, South Korea, Japan and Israel

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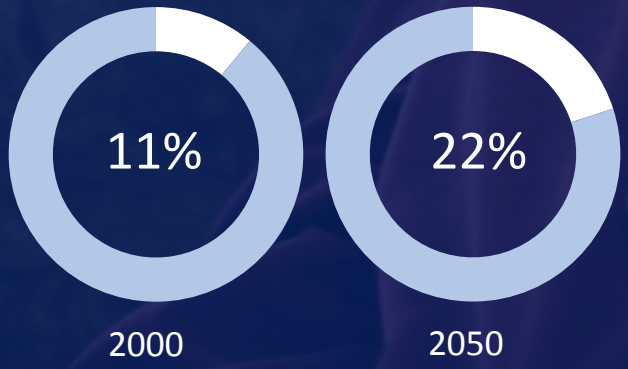
2. Responding to global challenges

With our understanding of many of the longer-term challenges our world faces, we see major opportunities to apply our innovative competencies and create value for our stakeholders.

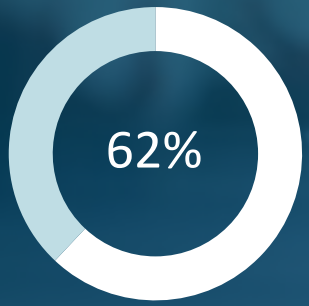
We see a growing need for healthcare

The world's population aged 60 and older



We see increased focus on personal well-being

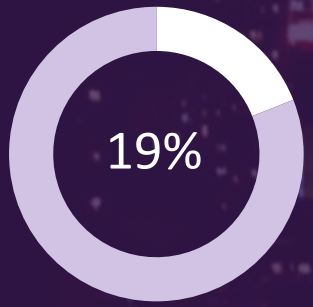
Well-being of people around the world



Only 62% of people around the globe rate their current state of health and well-being as “good” or “very good”

We see rising demand for energy-efficient solutions

The world’s electricity consumption



Lighting

Average saving we can make by switching to energy efficient LED lighting

40%

We strive to make the world healthier and more sustainable through innovation

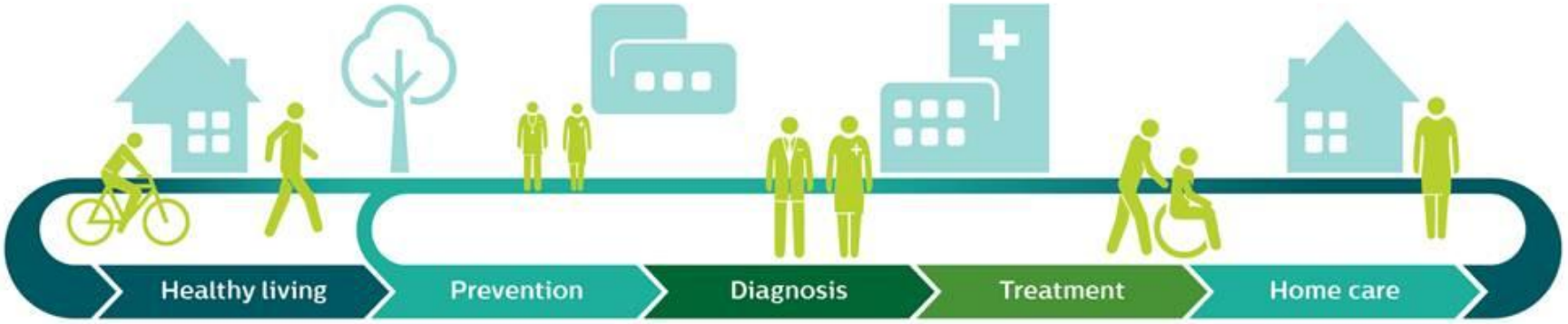
We're aiming to improve the lives of

three billion people

a year by 2025

Making a difference in HealthTech

Our unique approach to the health continuum



Healthy Living

We support people to live a healthy life based on personal hygiene and wellness and nutrition in a healthy home environment.

Prevention

We provide digital solutions to measure, monitor, and motivate people to manage their own health.

Diagnosis

We drive definitive diagnosis, ensuring the right diagnosis is delivered the first time.

Treatment

We create new clinical procedures for safer and more effective adaptive therapies.

Recovery

We support recovery through ubiquitous monitoring that improves health quality at a lower cost.

Home Care

We connect hospital to home to support transitions, independent living and aging in place.

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Building the leader in HealthTech

Healthy living	Prevention	Diagnosis	Treatment	Home care

Personal Care **11%**

Domestic appliances **16%**

Health & Wellness **7%**

Imaging Systems **23%**

Patient Care & Monitoring Solutions **21%**

Healthcare Informatics, Solutions & Services **4%**

Customer Services **18%**

Share of HealthTech sales[1]

[1] Sales last 12 months December 2014

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About me…

Creativity

Making a difference

Inspiration

Dreams

People

Innovation

Understanding

About me

Freelancing during University years from 1999…

EpilBi – Multimodal EEG-fMRI

Molecular Diagnostics

Distributed Health Network

Magnetic Particle Imaging

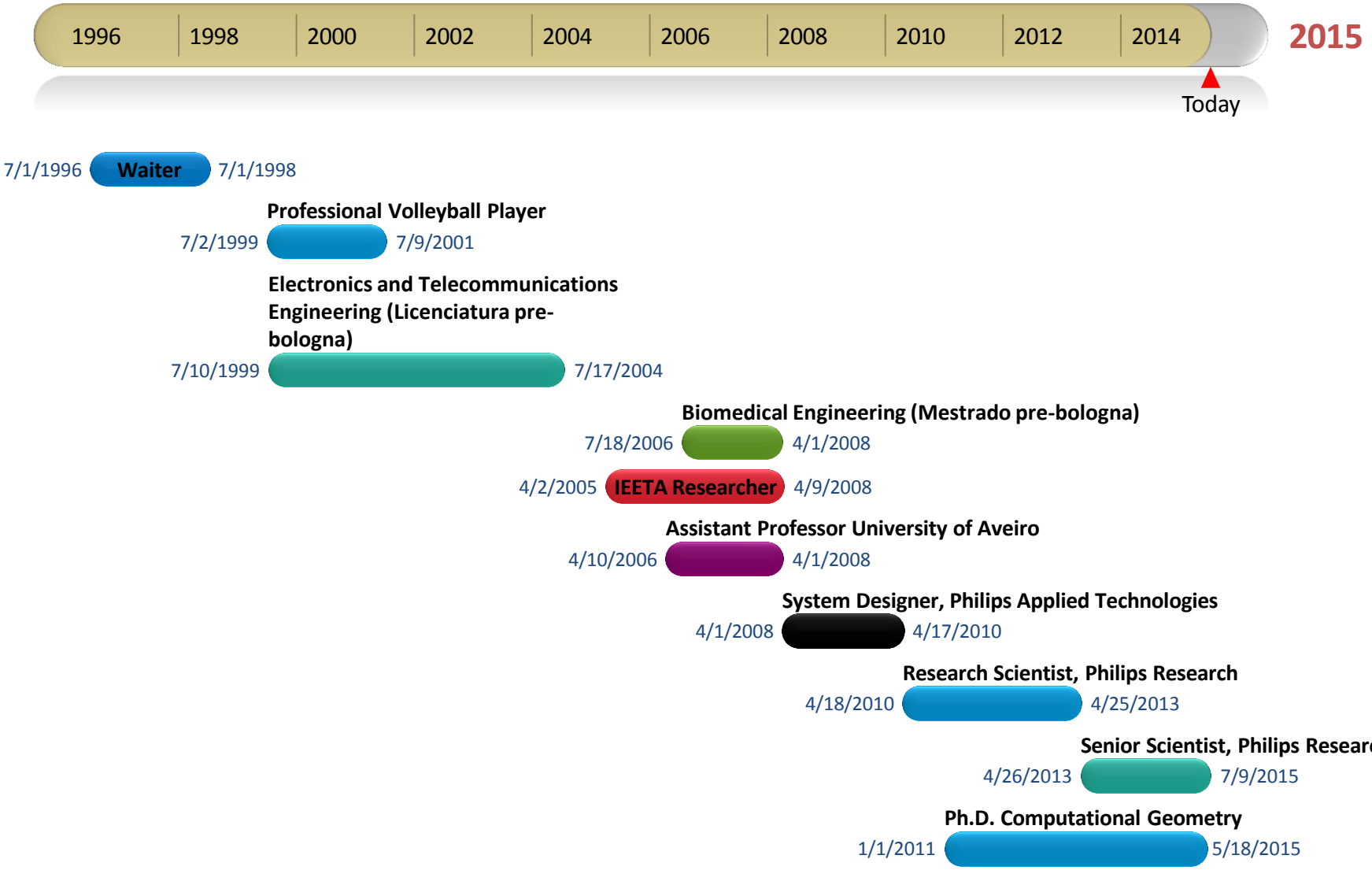
Segmentation and Alignment for Orthodontic Applications

Vessel tracking and segmentation

Manifold extraction from noisy point clouds

Point cloud surface skeleton reconstruction

Medial surface applications for shape segmentation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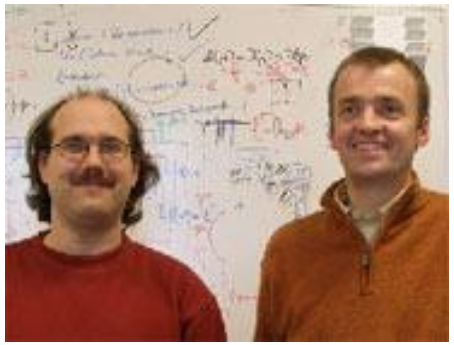
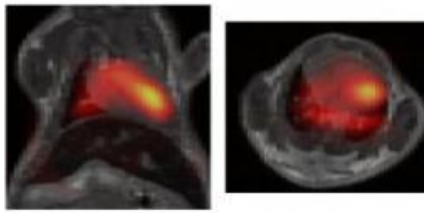
Professional Volleyball Player
7/2/1999
7/9/2001
Electronics and Telecommunications Engineering (Licenciatura pre-bologna)
7/10/1999
7/17/2004
Biomedical Engineering (Mestrado pre-bologna)
7/18/2006
4/1/2008
4/2/2005
IEETA Researcher
4/9/2008
Assistant Professor University of Aveiro
4/10/2006
4/1/2008
System Designer, Philips Applied Technologies
4/1/2008
4/17/2010
Research Scientist, Philips Research
4/18/2010
4/25/2013
Senior Scientist, Philips Research
4/26/2013
7/9/2015
Ph.D. Computational Geometry
1/1/2011
5/18/2015

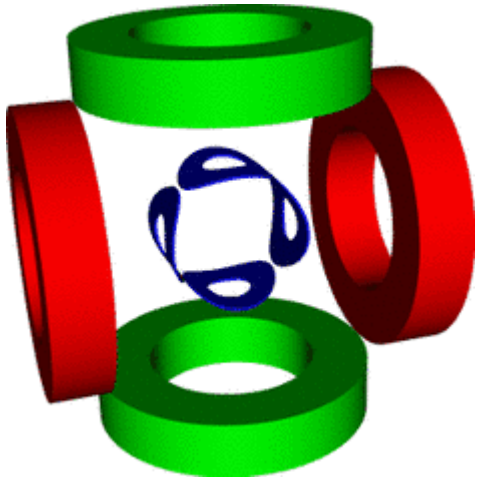
(Some) New Challenges in Medical Imaging

Magnetic Particle Imaging:

A new imaging modality







Michael Kuhn, Joern Borgert, Juergen Rahmer, Oliver Woywode, Ingo Schmale, Claas Bontus, Joachim Schmidt, DE) Thomas Reichel (Philips Technology GmbH, Hans Post, Thomas Reichel, Dirk Burdinski, Juergen Weizenecker, Bernard Gleich, Jurgen Kanzenbach, **Jacek Kustra**. *Magnetic Particle Imaging (MPI) - A New Imaging Modality,* In proceeding of BMT, 2009

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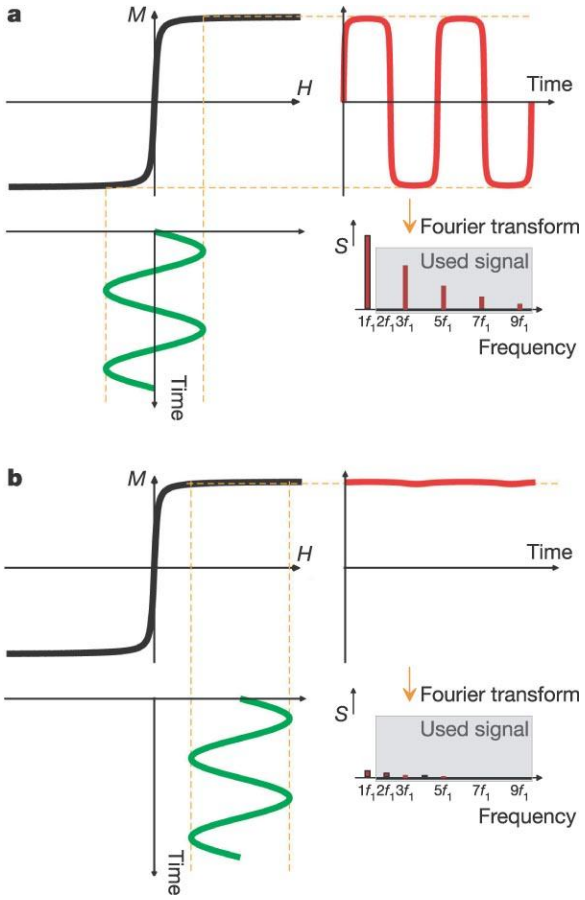
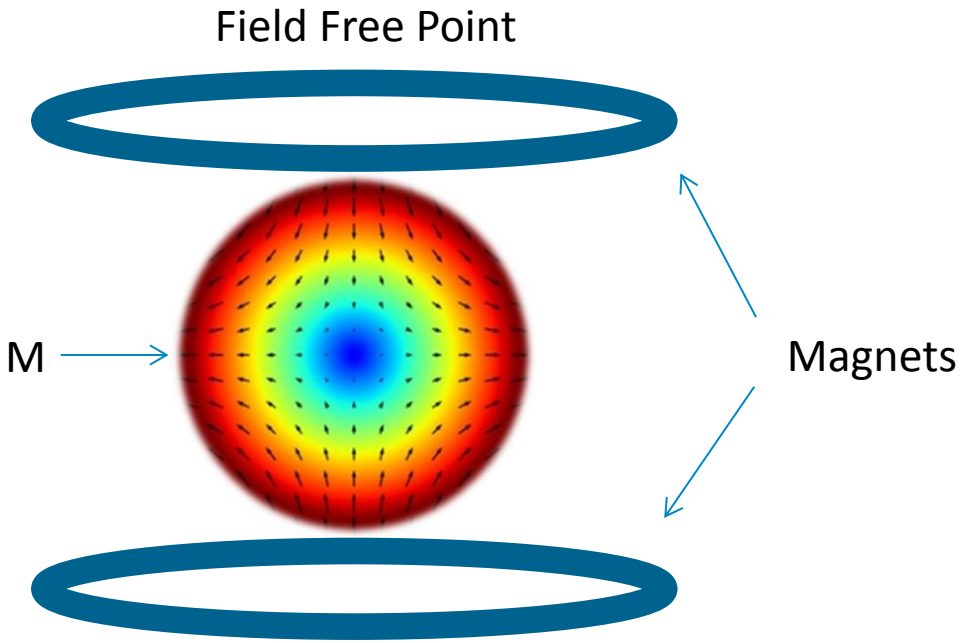
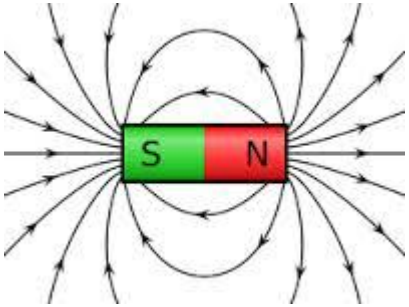
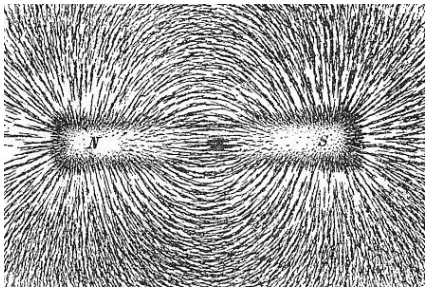
Magnetic Particle Imaging:

A new imaging modality









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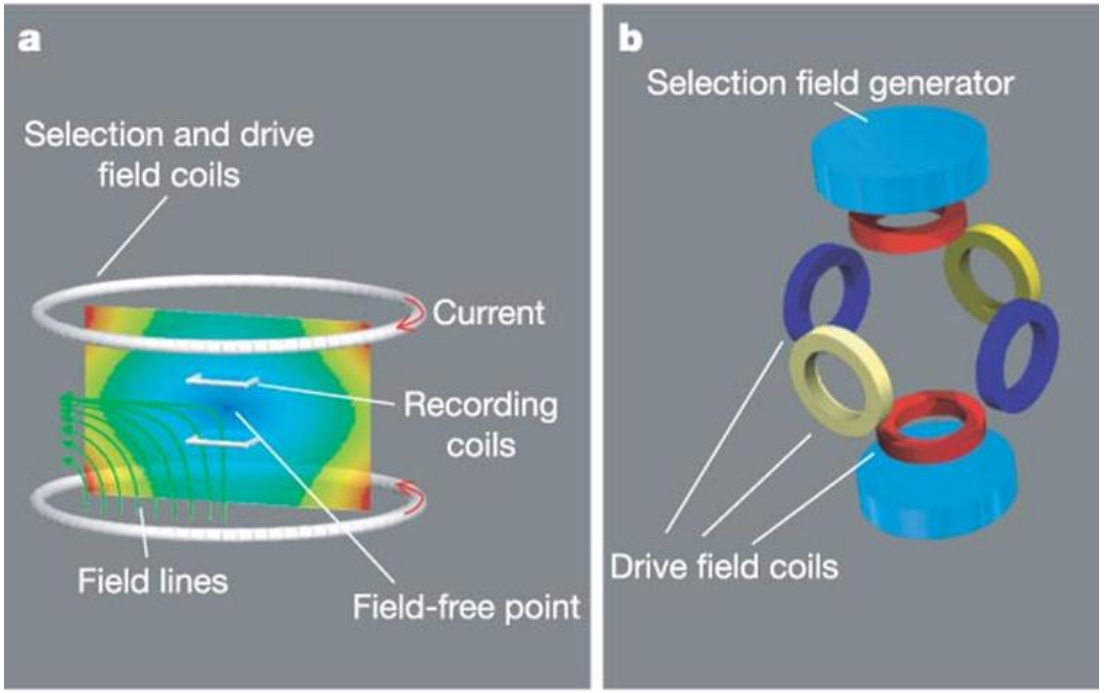
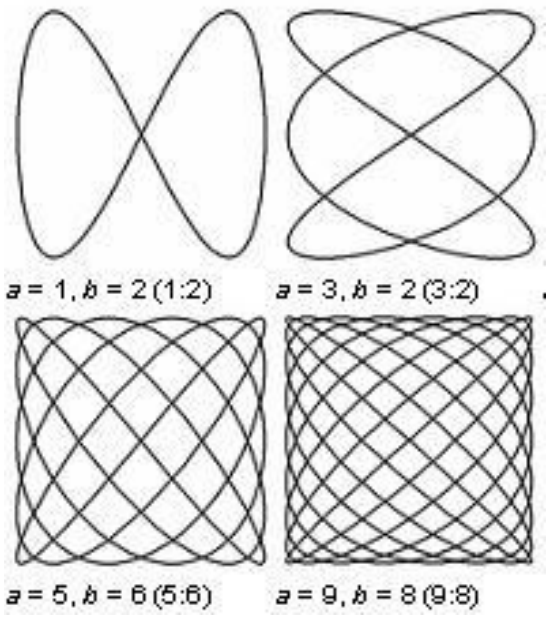
Magnetic Particle Imaging:

A new imaging modality





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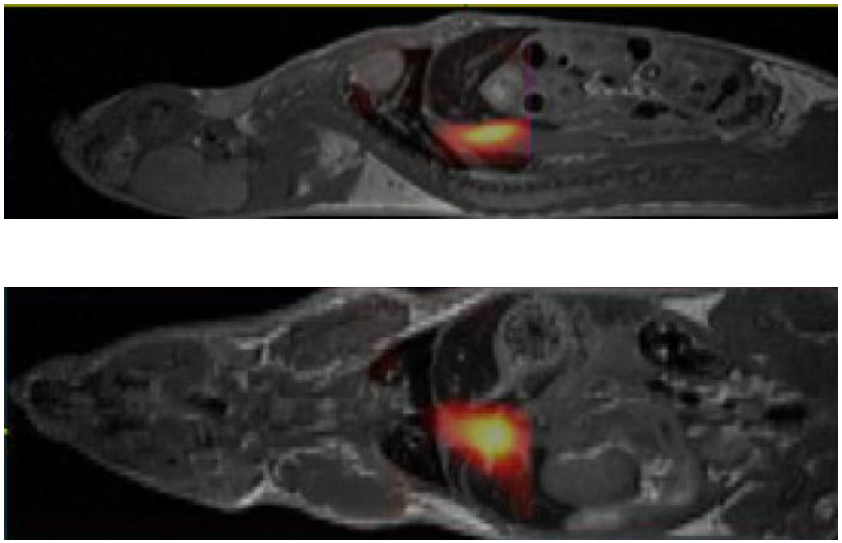
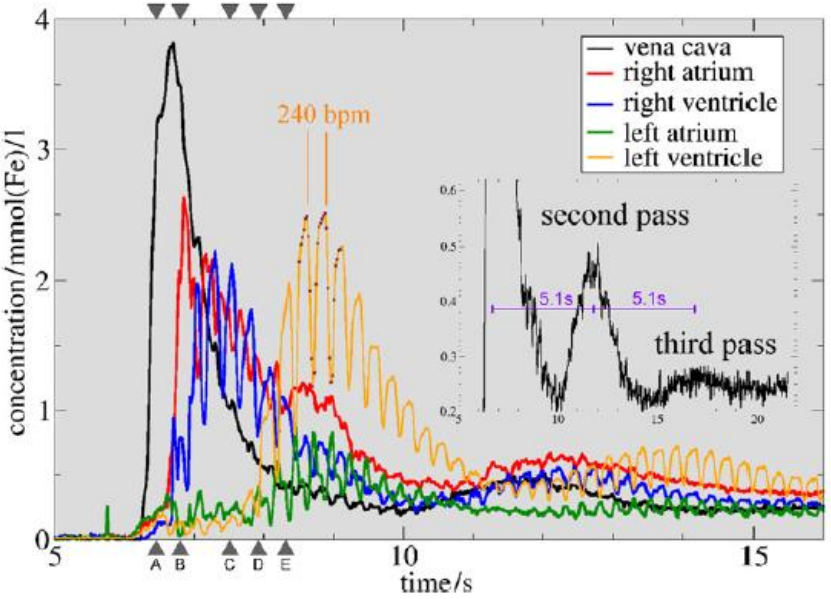
Magnetic Particle Imaging:

A new imaging modality





Images from: J. Weizeneker et. Al., *Three-dimensional real-time in vivo magnetic particle imaging, Physics in Medicine and Biology 2009*

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What challenges does a fast imaging modality bring?

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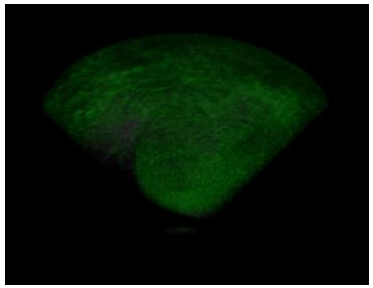
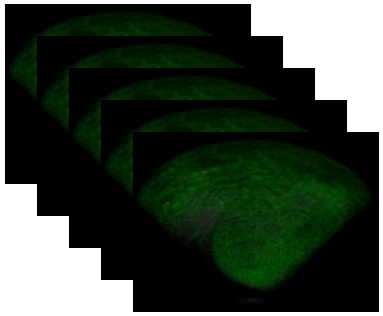
Ultrasound tracking

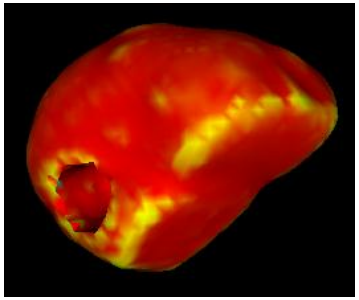
Challenges in fast imaging



Ultrasound 3D volume

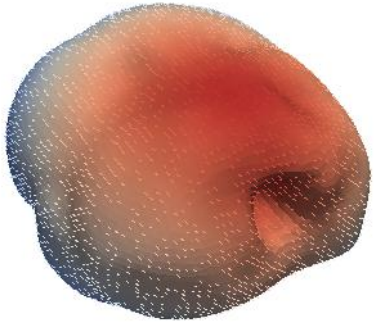


Sequence of Ultrasound Volumes



Surface Segmentation

Motion Estimation



Segmentation Tracking

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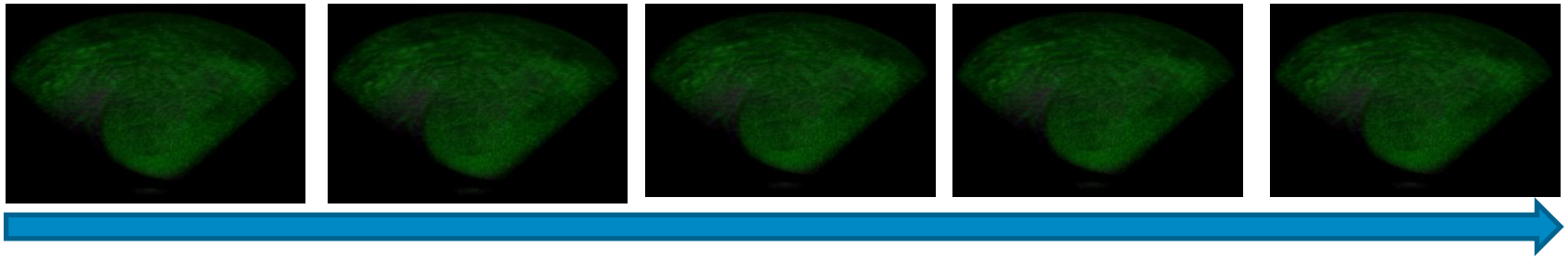
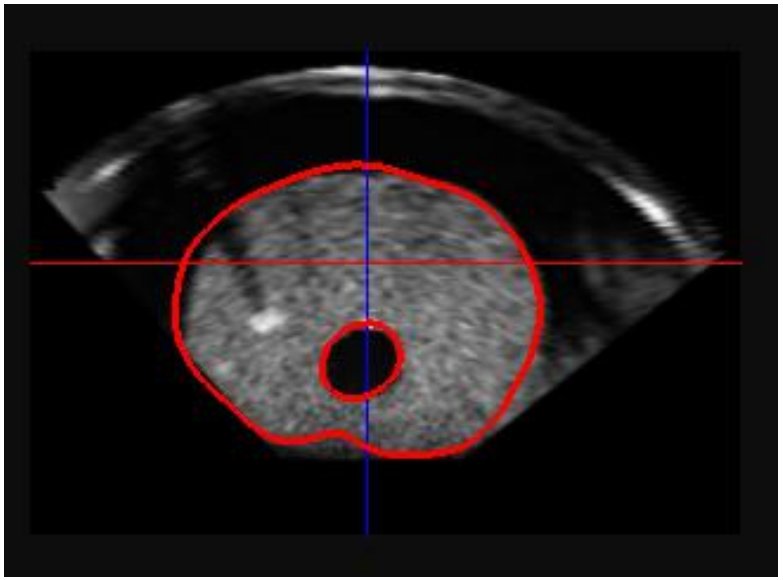
Ultrasound tracking

Challenges in fast imaging



Based on a sequence of volumes, the challenge is to determine the forces acting on the contour.



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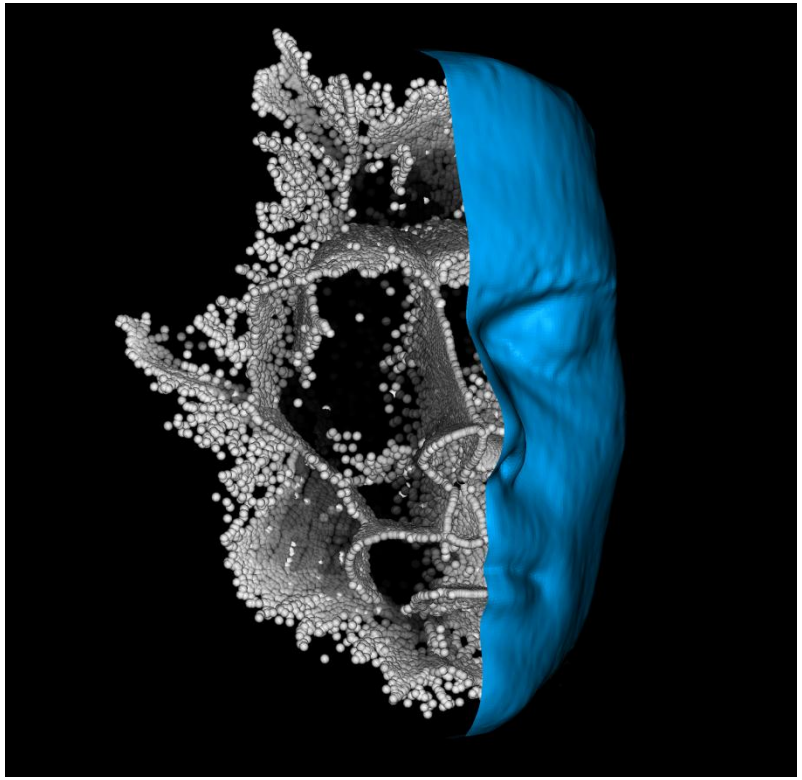
One step further: Towards a better understanding of shapes

How do we represent shapes?



- Volumetric
  - Binary Masks
  - Implicit Surfaces
- Boundary Sampling
  - Point clouds
  - Polygonal

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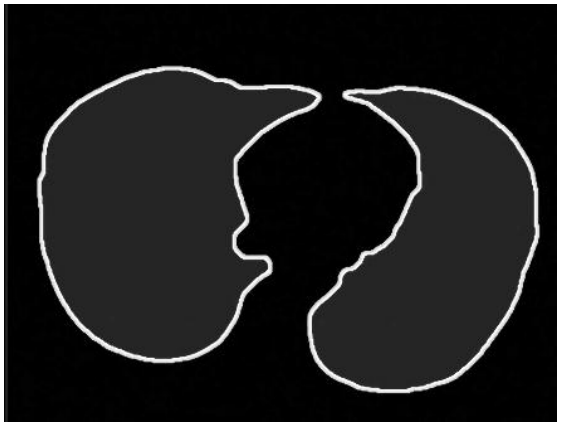
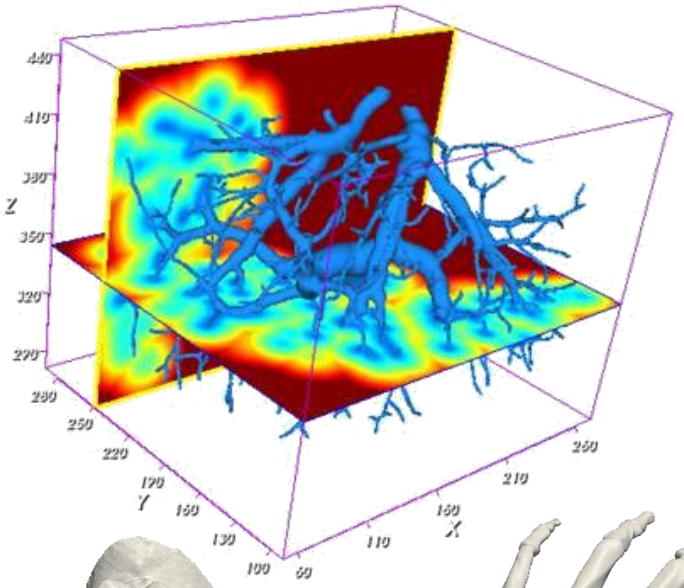
Understanding shape representation

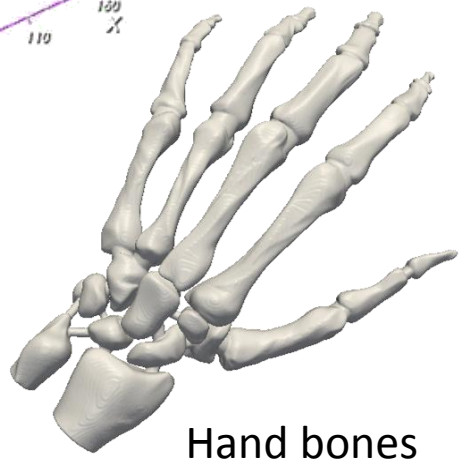
Shape representation examples



Lung 2D cross section segmentation



Dental cast



Hand bones

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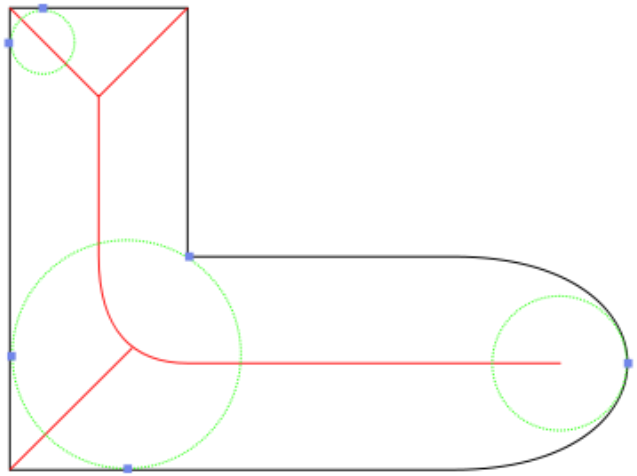
Shape Representation

The Medial Domain

- Medial axis, as defined by Henry Blum (1967) provide shape descriptors for several applications: robotics, healthcare, computer animation, etc.



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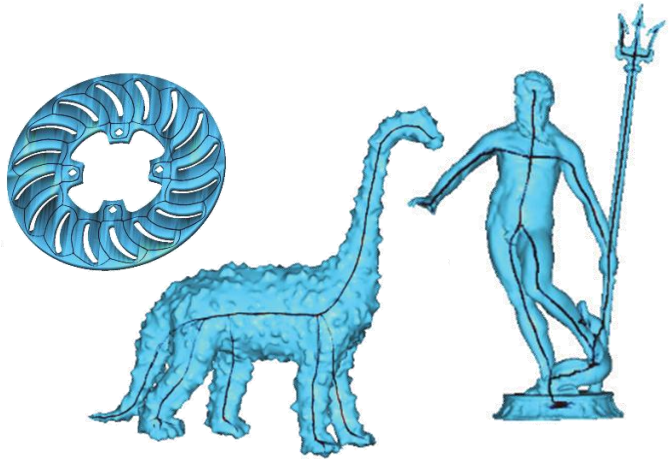
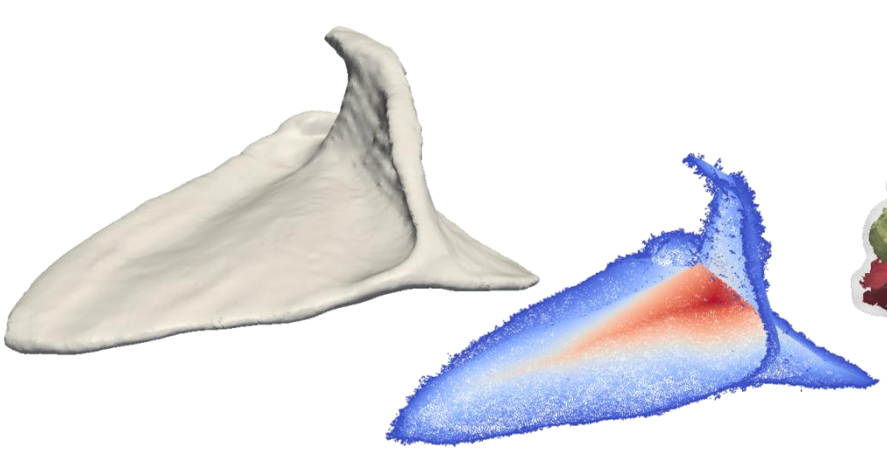
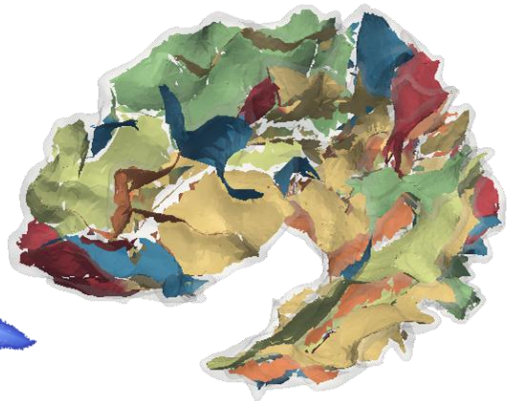
In 3D… it becomes more challenging!

- In 3D an object admits two types of skeletons:
  - **Surface**
    - **loci of maximally inscribed spheres**
  - Curve skeletons
    - 1D locally centered in the shape.







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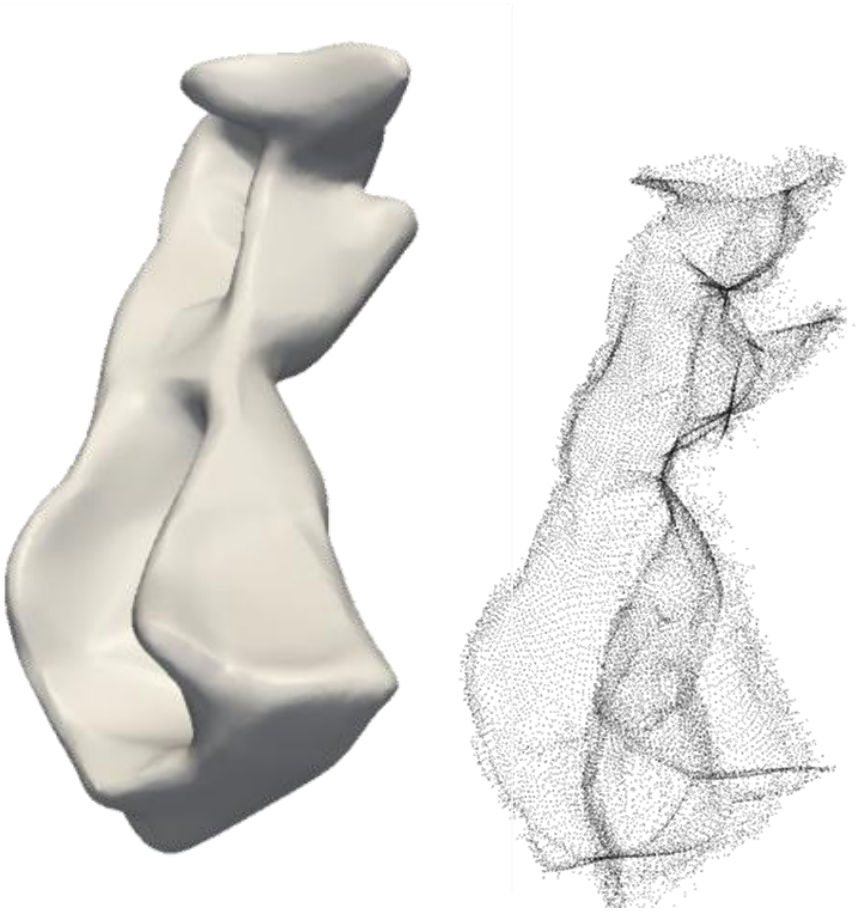
Sounds interesting…

… but can it be actually used for practical purposes?

- Requirements :
  - Fast and accurate computation
  - Good Regularization
  - Extraction of shape features



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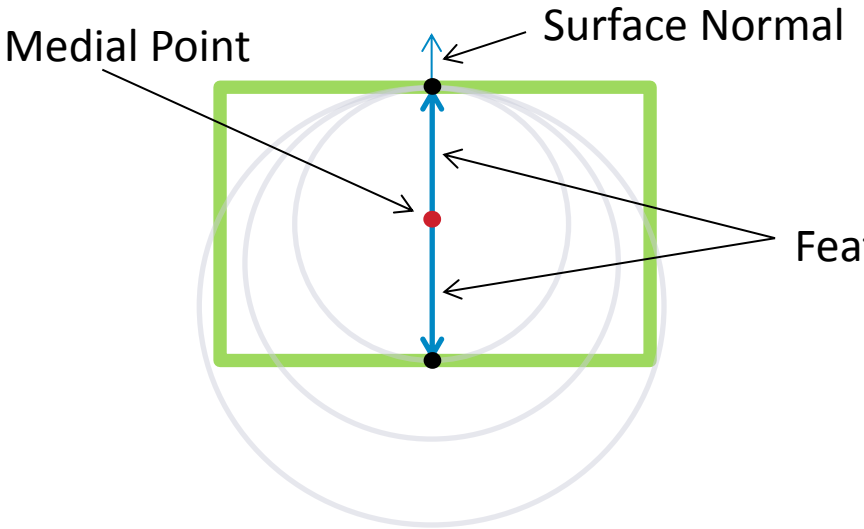
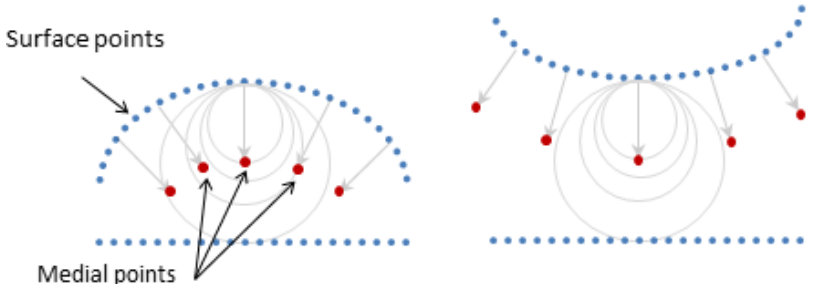
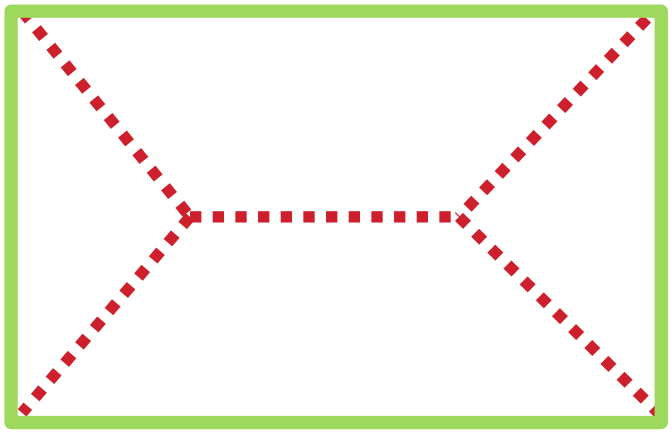
Computing 3D surface skeletons

A ball-shrinking approach







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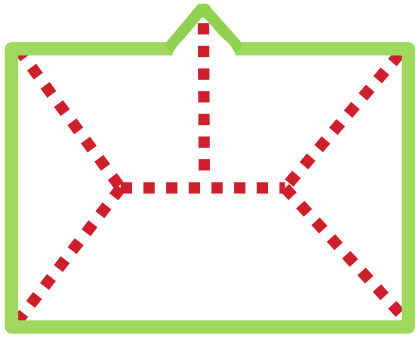
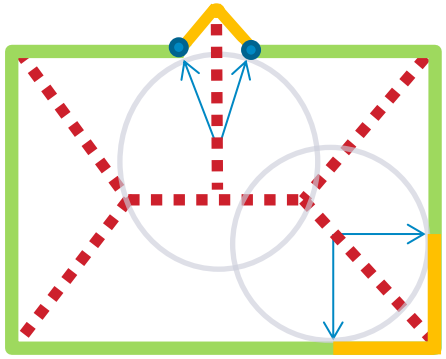
The medial surface

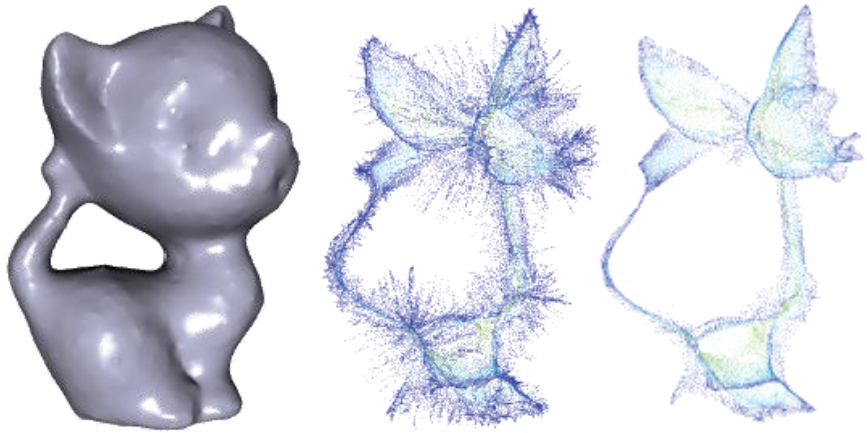
An unstable transform

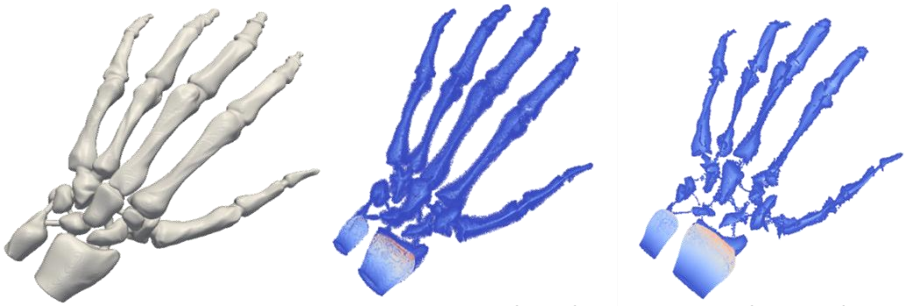


Small surface perturbations cause large changes in the skeleton



Importance assigned based on geodesic surface distance





Surface | *Raw point cloud skeleton* | *Regularized skeleton*

Andrei Jalba, **Jacek Kustra**, and Alexandru Telea (2012) *Surface and Curve Skeletonization of Large 3D Models on the GPU.* IEEE Transactions of Pattern Analysis and Machine Intelligence, 2012

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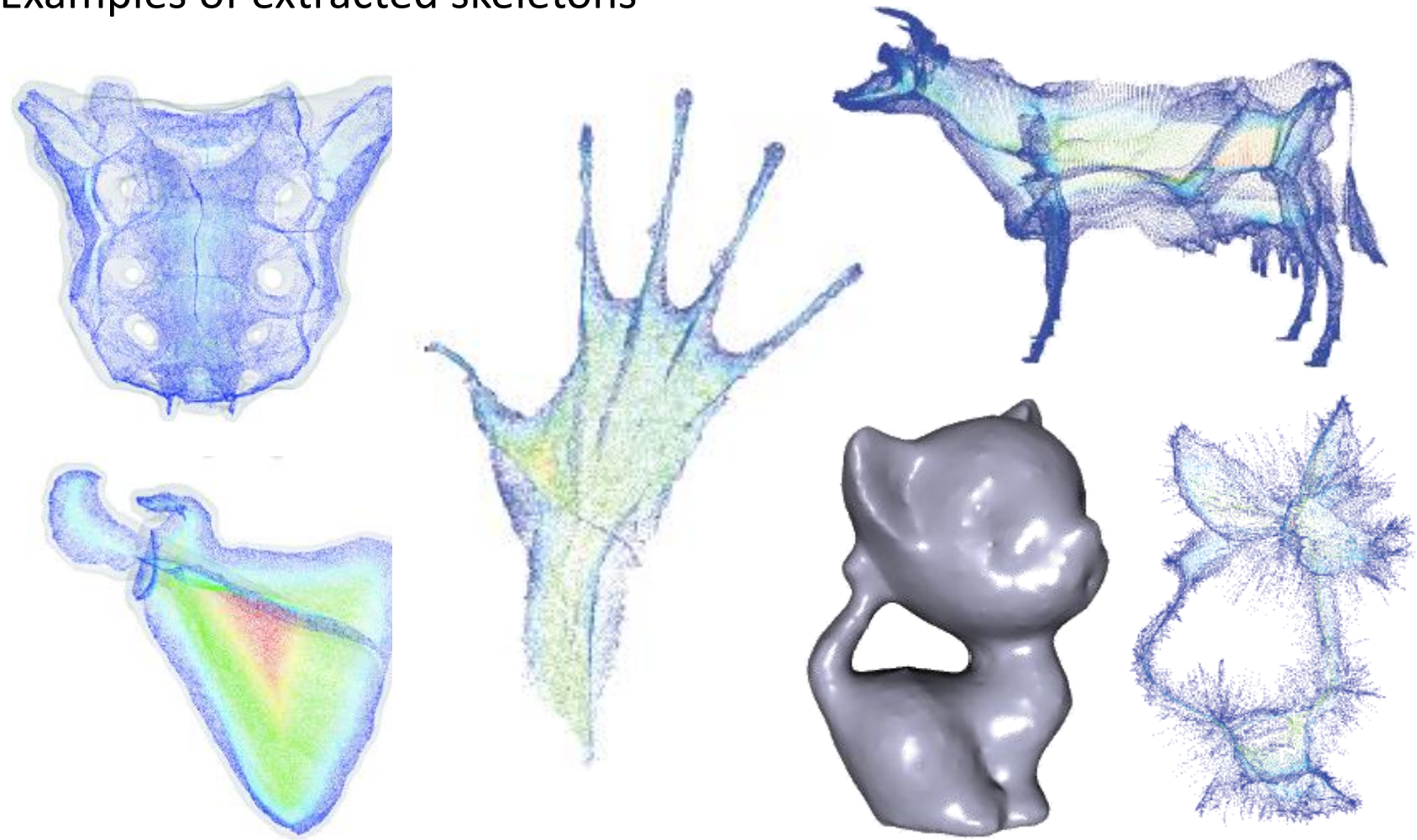
Computing 3D surface skeletons

Examples of extracted skeletons



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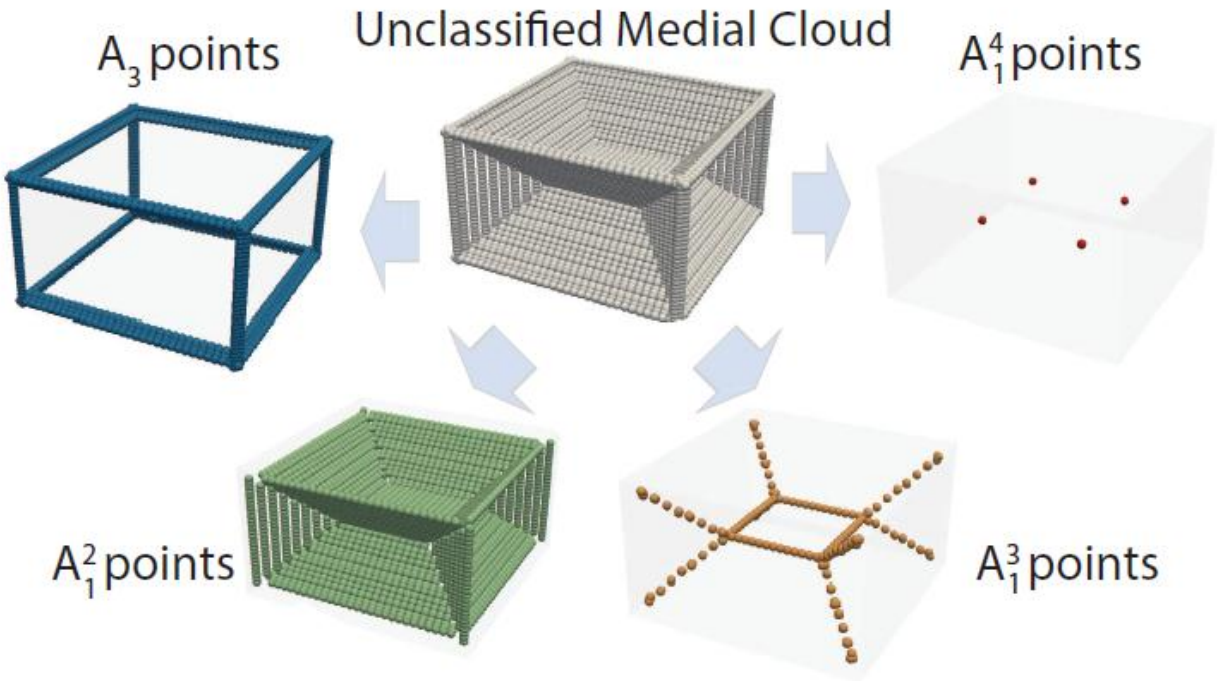
The medial surface

Feature Extraction



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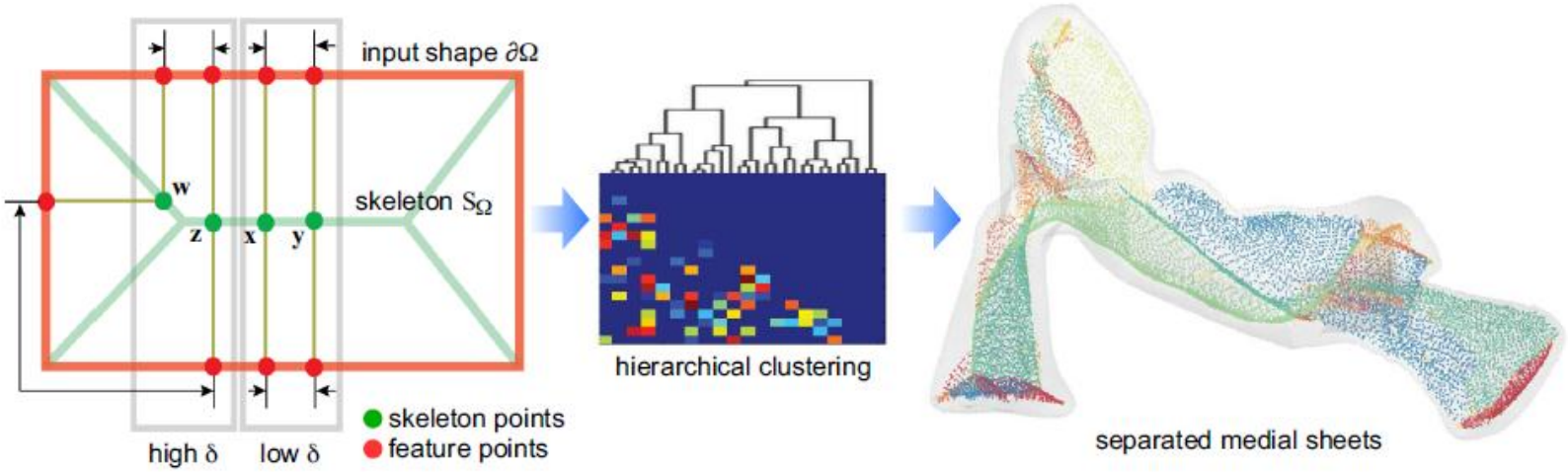
The medial surface

Feature Extraction



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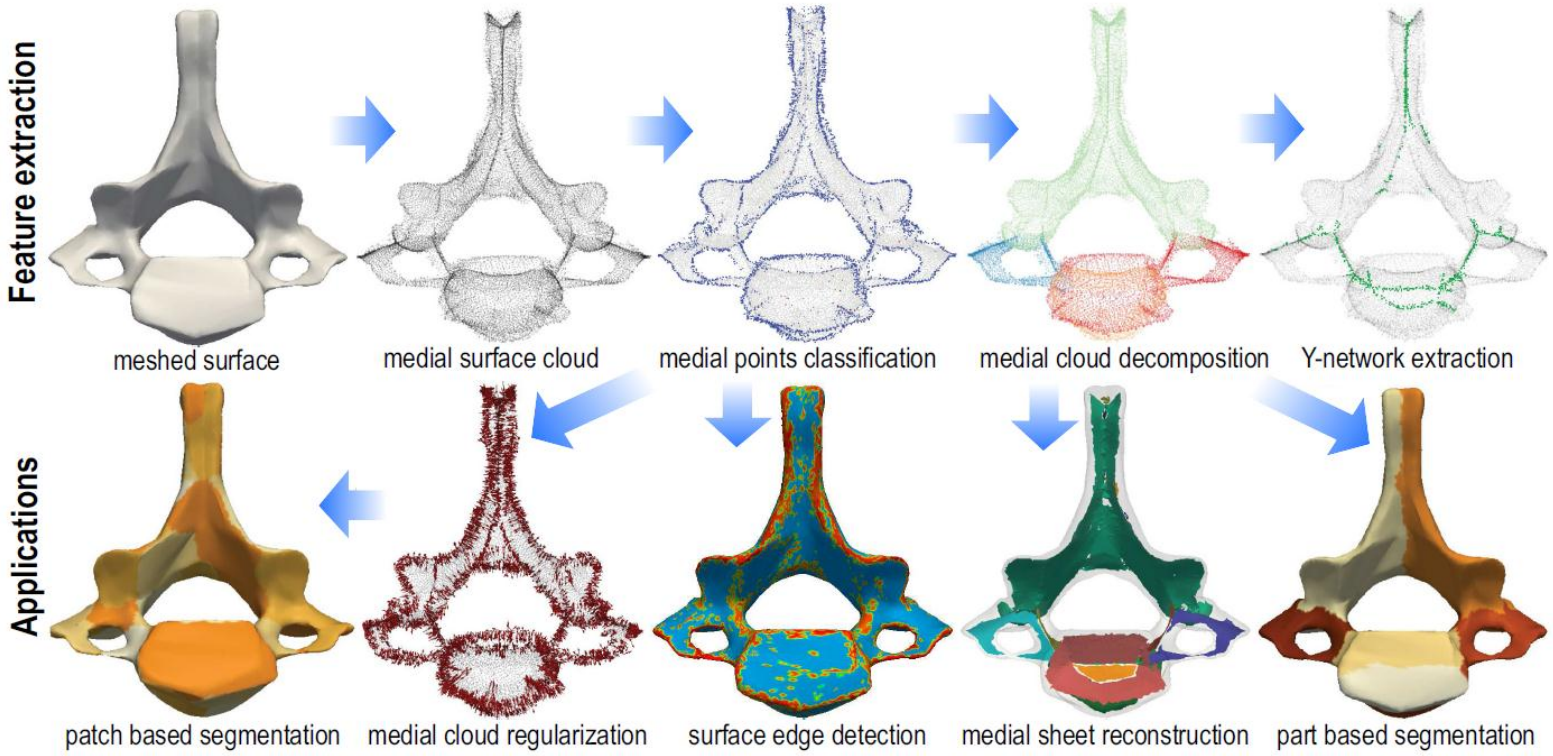
The medial surface

Feature Extraction



Andrei Jalba, **Jacek Kustra**, and Alexandru Telea (2015) *Computing refined skeletal features from medial point clouds*. Pattern Recognition Letters

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Shape analysis applications

A simple indirect imaging system for Oral Healthcare

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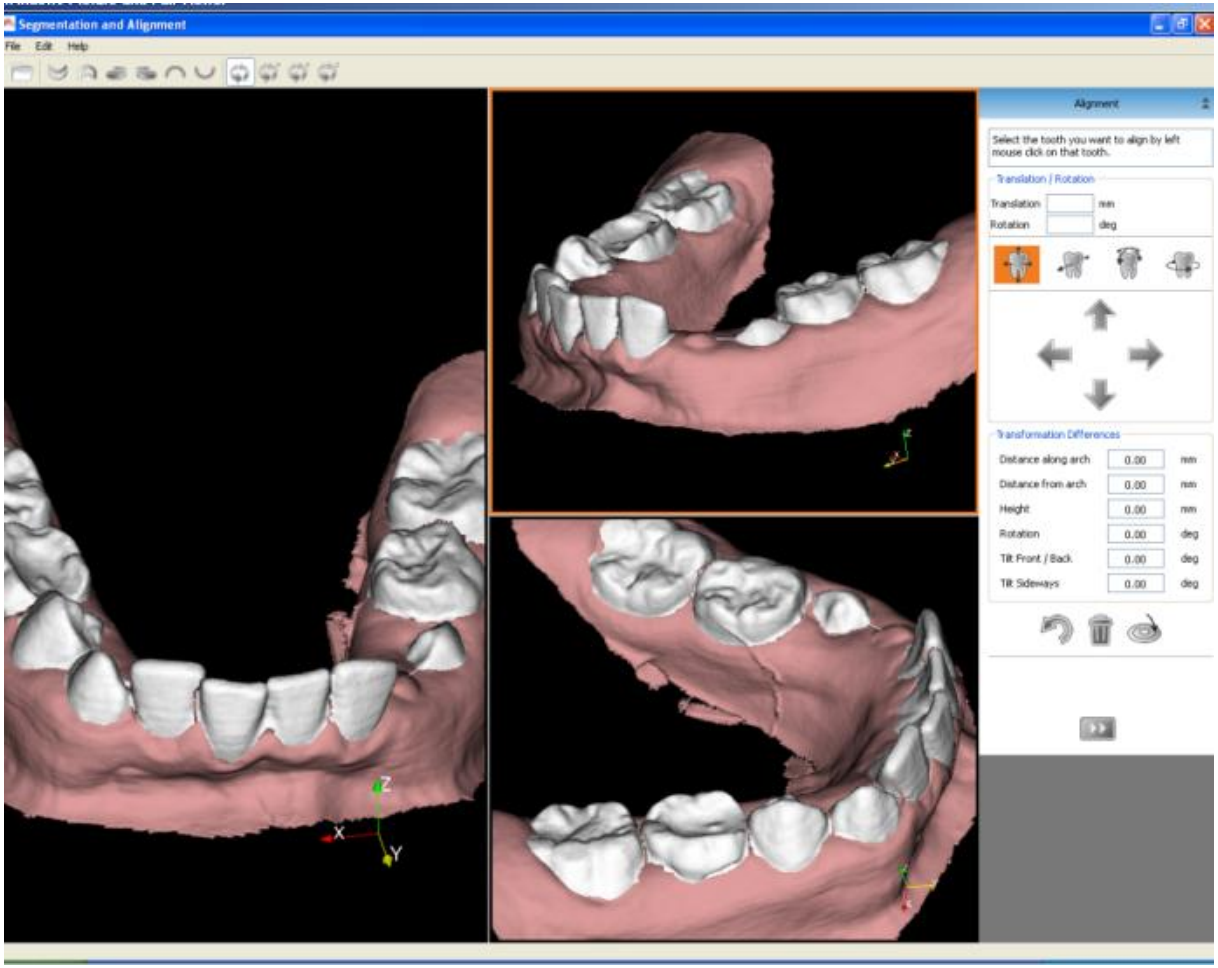
Shape analysis applications

The simplest imaging system?



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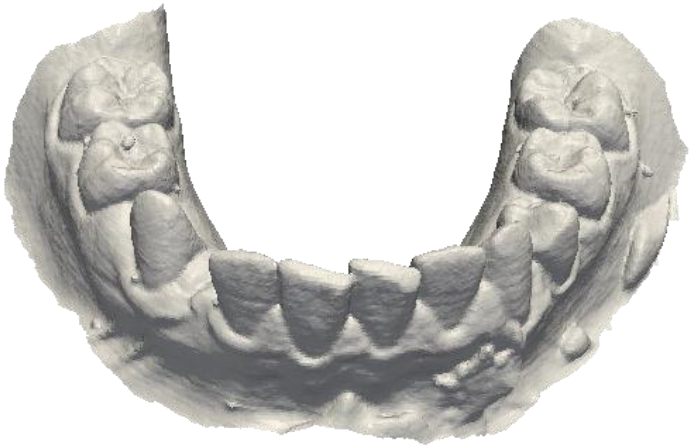
Shape analysis applications

The simplest imaging system?



Raw Manifold

Segmented Manifold

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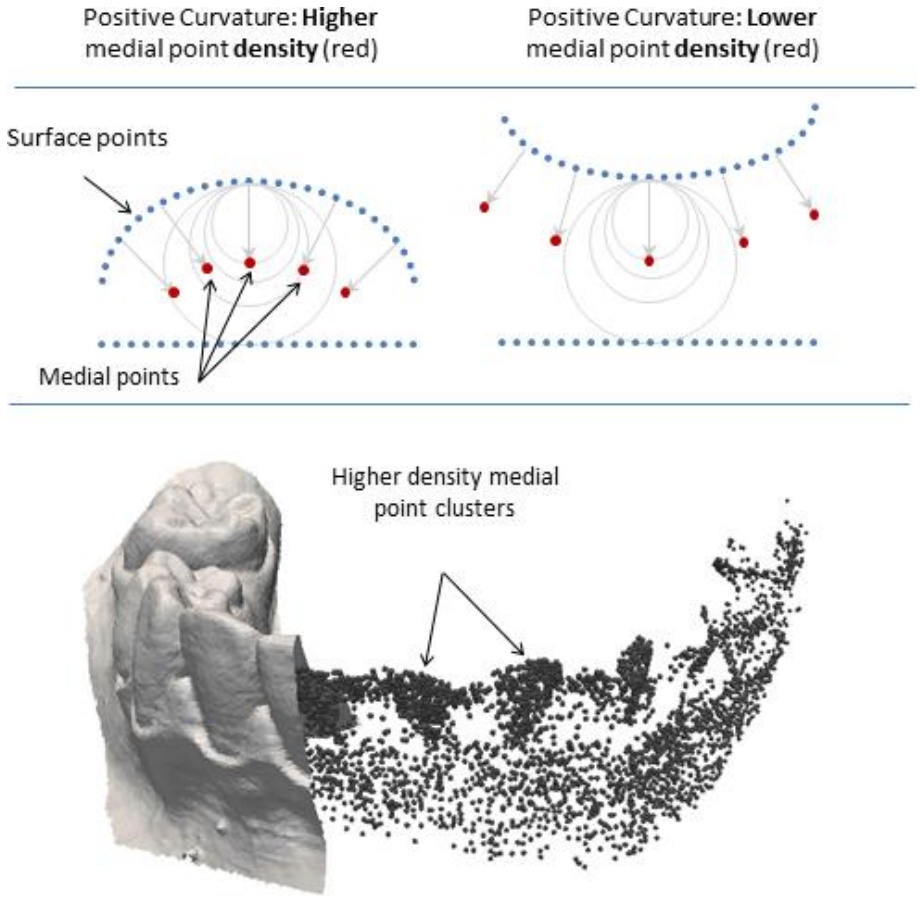
Shape analysis applications

Oral Healthcare



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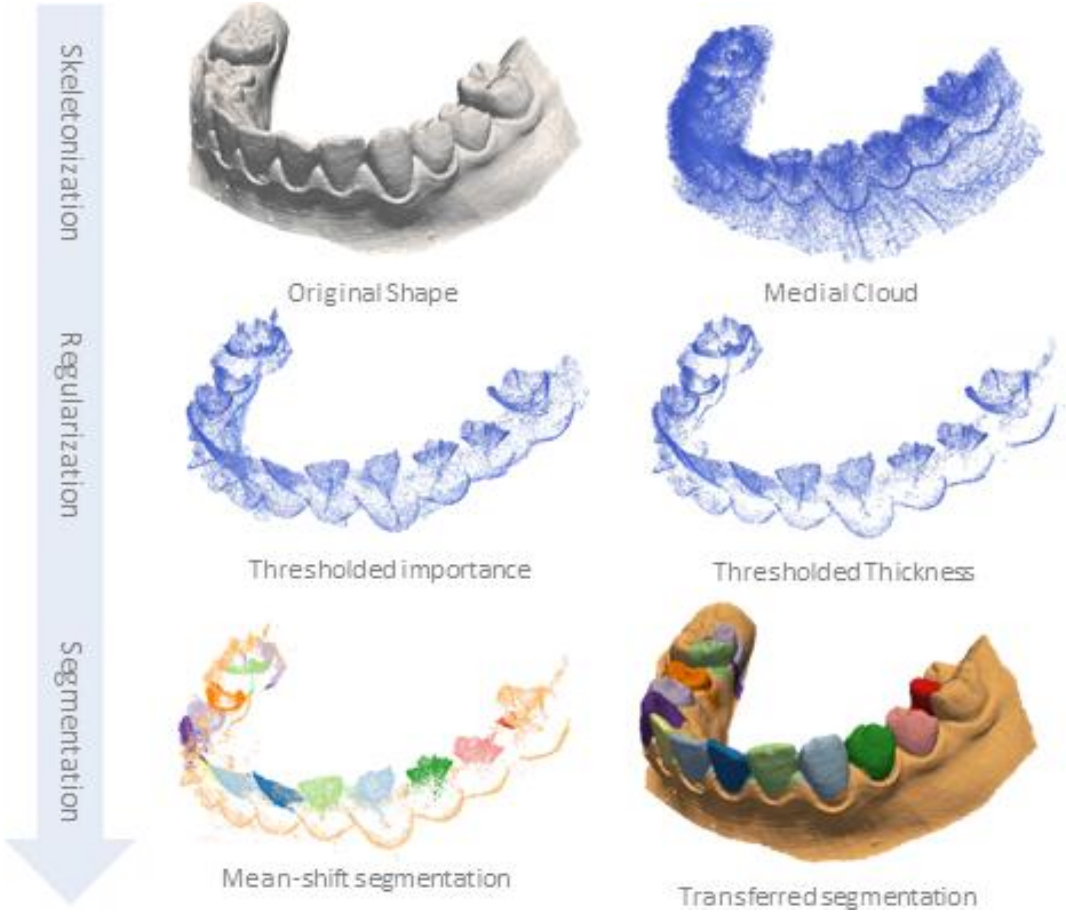
Shape analysis applications

Oral Healthcare



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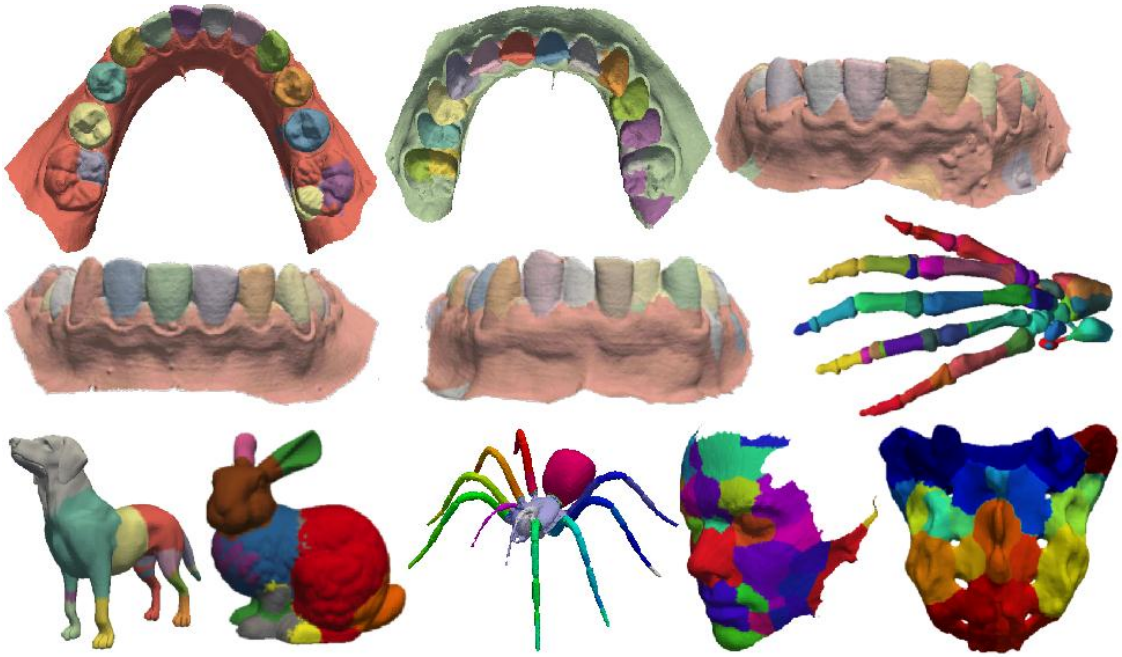
Shape analysis applications

Medial point density based segmentation



Jacek Kustra, Andrei Jalba, and Alexandru Telea *, Shape Segmentation using Medial Point Clouds with applications to Dental Cast Analysis,* VISAPP Lisbon 2014. *accepted*

Jacek Kustra, Marko de Jager, Andrei Jalba, and Alexandru Telea *, Teeth Shape Modeling Pipeline for Oral Healthcare Appliances Development,* ICCE 2014 Las Vegas. *accepted*

Jacek Kustra, Marko de Jager, Andrei Jalba, and Alexandru Telea *, A Medial Point cloud based algorithm for Dental cast Segmentation,* ICCE Las Vegas 2014. *accepted*

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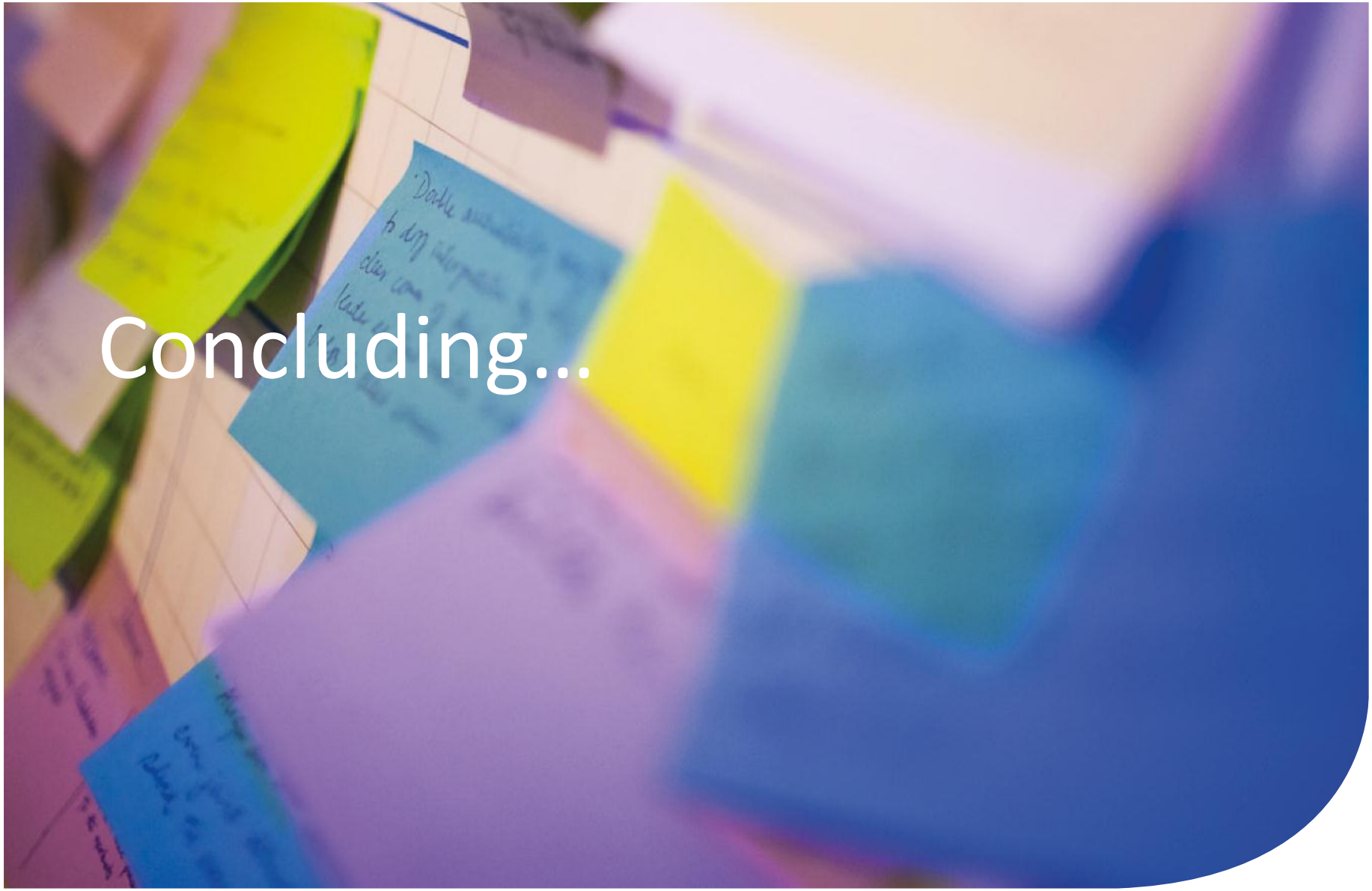

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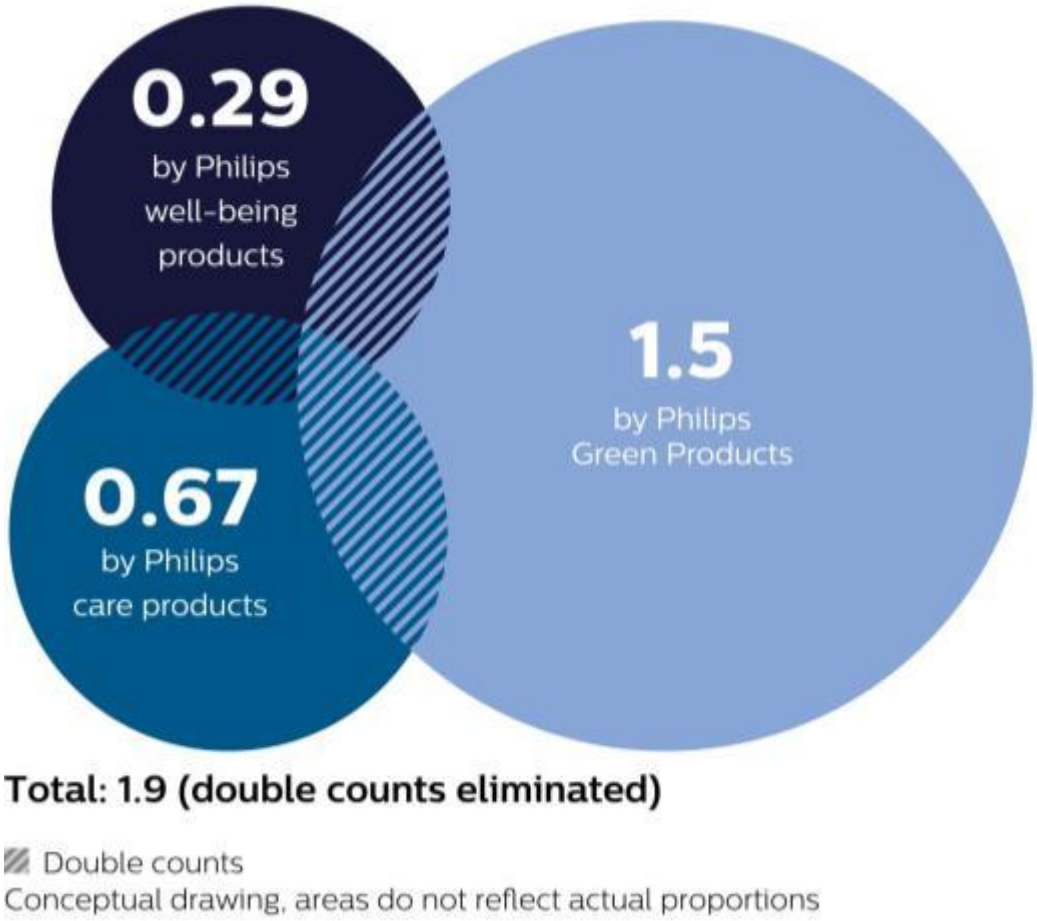
We aim to improve 3 billion lives by 2025



We improved the lives of 1.9 billion people in 2014.

Our Lives Improved model guides our efforts and measures our progress on improving people's lives.

We calculate the number of Lives Improved based on the quantity of Green, Care and Well-being products sold multiplied by the average lifetime of these products

Today, we are improving the lives of every 4th person on earth!

Note: Numbers in billions

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Thank You!