AP 4 - Image Segmentation

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Heidelberger Institut für Theoretische Studien



Overview

New features

- Labeling in any axis
- Removing outliers
- Supporting Amira label files
- 3D printer
- Uncertainty localization
- Fourier Transform for image registration
 - Removing sample holder
 - Merging Objects
- Deep learning for image segmentation



BIOMEDIST The Biomedical Image Segmentation App



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Contact	method, which configuration.
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Арр	reasonable tim visualize both
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Biomedisa

cal Image Segmentation App (Biomedisa) is an online application for segmentation of nography (CT) scans, magnetic resonance images (MRI) or any other volumetric images. ne of the most challenging tasks in computer vision, image segmentation is important in simulation, surgical planning, and decision-making, and in biology, for phylogenetics and alysis. As an universal application, Biomedisa can be used in addition to any segmentation ra, Fiji, ImageJ or MITK. Its segmentation process is based on a highly scalable diffusion h is free of hyperparameters and thus eliminates the need for an elaborate and tedious . The high scalability enables the use of massively parallel computer architectures such as cessing units (GPUs) which allows you to segment even large images (8GB and more) in a me. You can upload your image data and labeled slices, run the segmentation process, and the images and the results using 3D rendering software and a 2D slice viewer. Biomedisa with the support of the Federal Ministry of Education and Research (BMBF), Germany, piects ASTOR and NOVA.

Partners

ANKA - Synchrotror Radiation Source, KIT





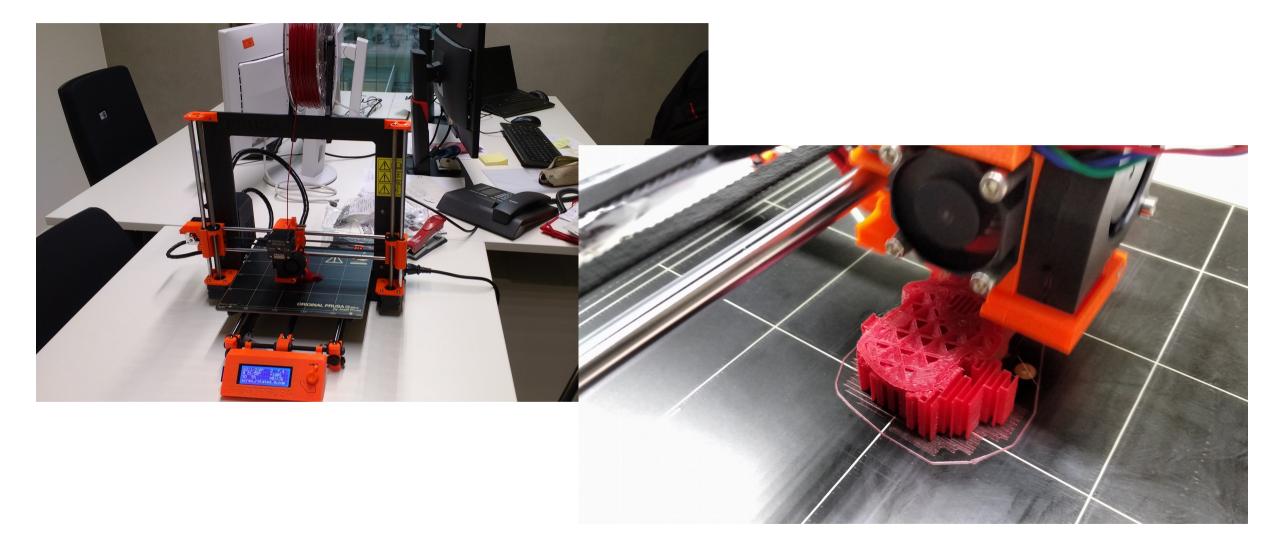
The ICTMS 2017, from 26 June to 30 June, will bring together an international group of scientists, from universities, research organisations and industry, to discuss a broad range of issues related to the use of 3D tomographic imaging in materials and structures. We will

give a talk in the analysis session. An abstract can be found here.



3D Printer

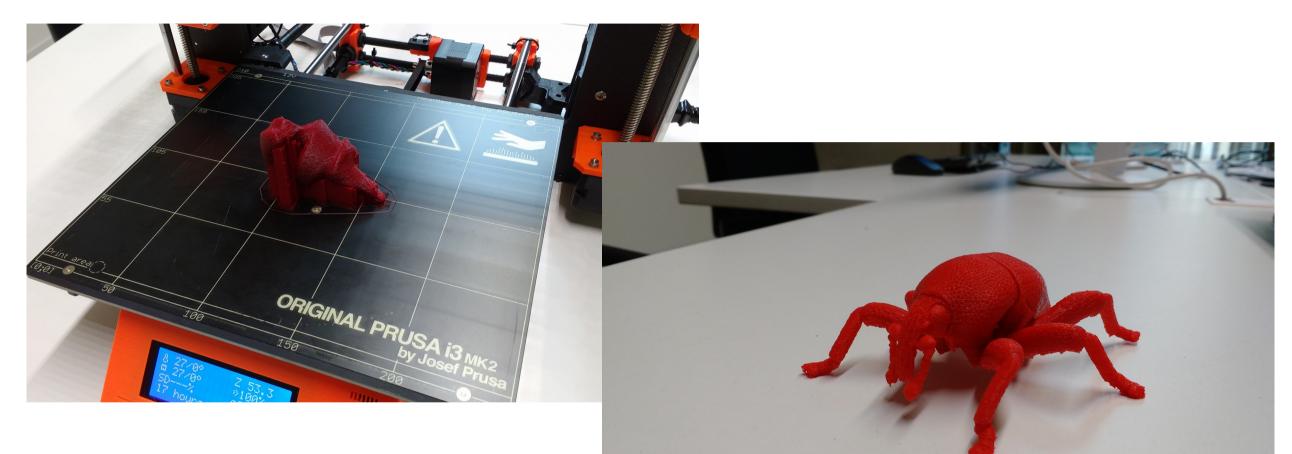






3D Printer



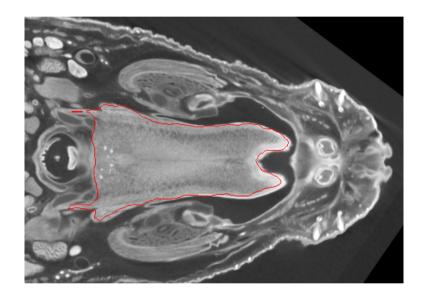


Evaluation of image segmentation by means of a 3D print?

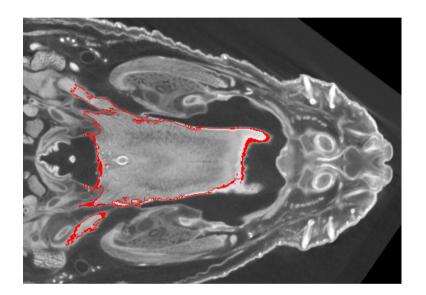


Uncertainty localization

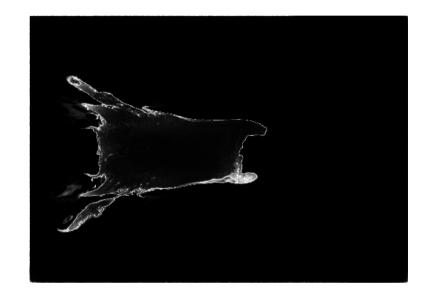




Inaccurate labeld slice 125.



Biomedisa result (slice 133).



Uncerctainty of segmentation result (slice 133).



Q: Why is "Shazam" so fast in recognizing a song? A: It uses the Fourier Shift Theorem.

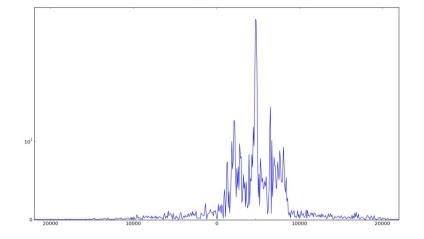
The discrete Fourier Transform is defined as:

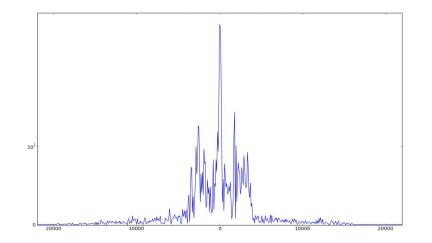
$$F(u) = \sum_{x=0}^{N-1} f(x) e^{-\frac{2\pi i u x}{N}}$$
 for $u = 0, ..., N-1$.

A shift in x direction $f_2(x) = f_1(x + \Delta x)$ can be expressed as

$$F_{2}(u) = \sum_{x=0}^{N-1} f_{1}(x) e^{-\frac{2\pi i u(x+\Delta x)}{N}}$$

= $\sum_{x=0}^{N-1} f_{1}(x) e^{-\frac{2\pi i u x}{N}} e^{-\frac{2\pi i u \Delta x}{N}}$
= $F_{1}(u) e^{-\frac{2\pi i u \Delta x}{N}}.$





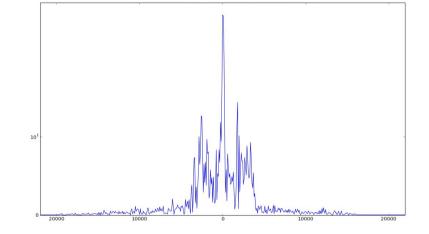


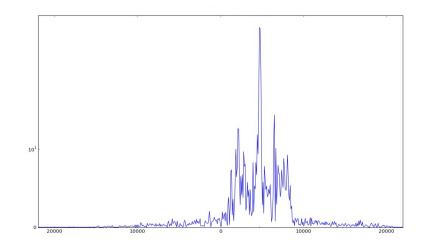
The translation Δx can be isolated by computing

$$e^{\frac{2\pi i u \Delta x}{N}} = \frac{F_1 F_2^*}{|F_1 F_2^*|}$$

where F_2^* is the complex conjugate of F_2 . The inverse FT of this function has its maximum value at (Δx) .

That means: Instead of computing the correlation for each possible shift, one can use the Fourier Transform which can be computed in a fast way.

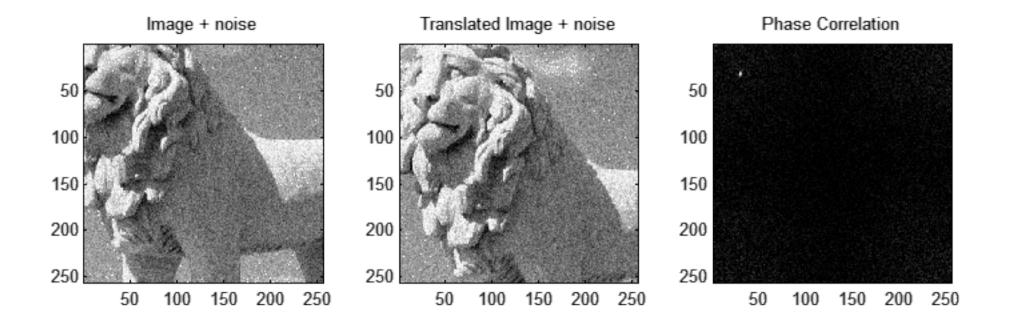








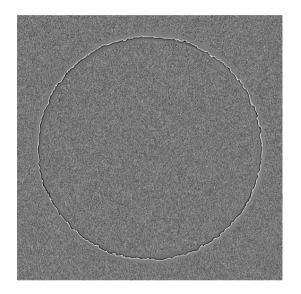
The same property applies across **multiple dimensions** and is **robust to noise**







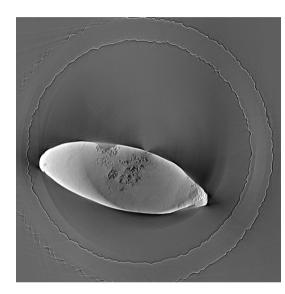
Detect and remove a cylindric sample holder in a CT scan

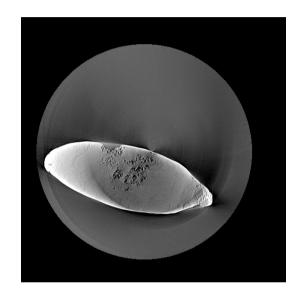


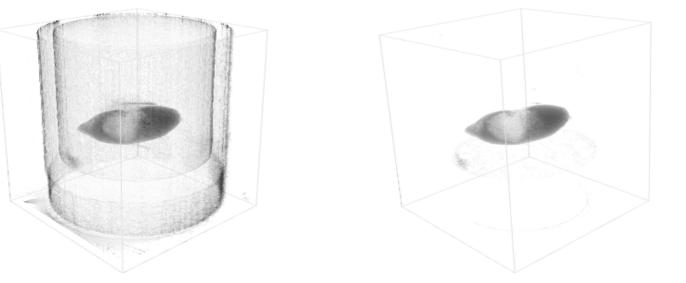
"Reference cylinder"

To match the image, the reference must be shifted by

$$x = -18$$
$$y = -3$$
$$z = 0$$





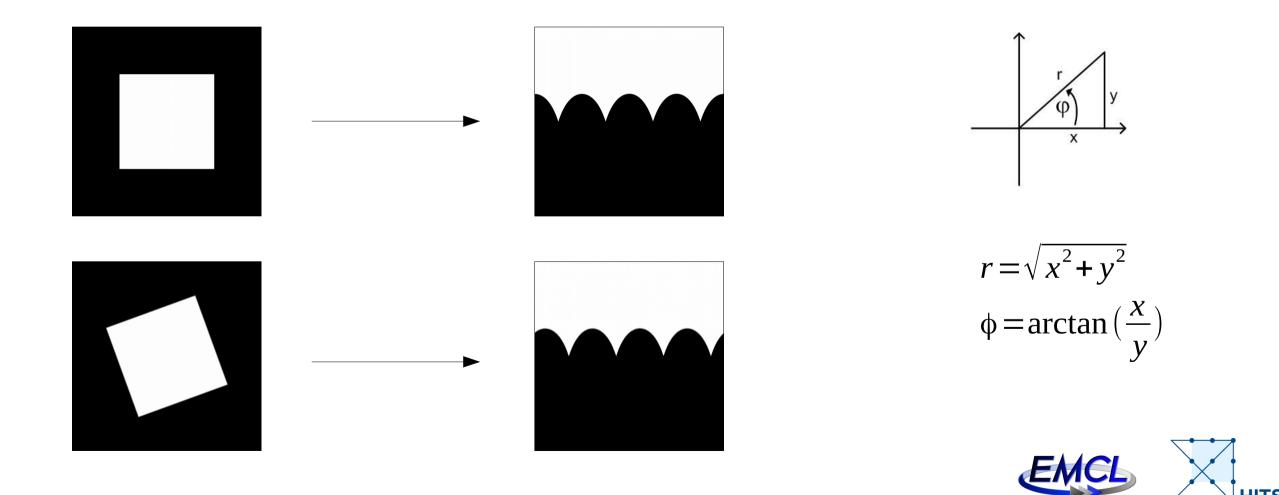


Removing frequencies?



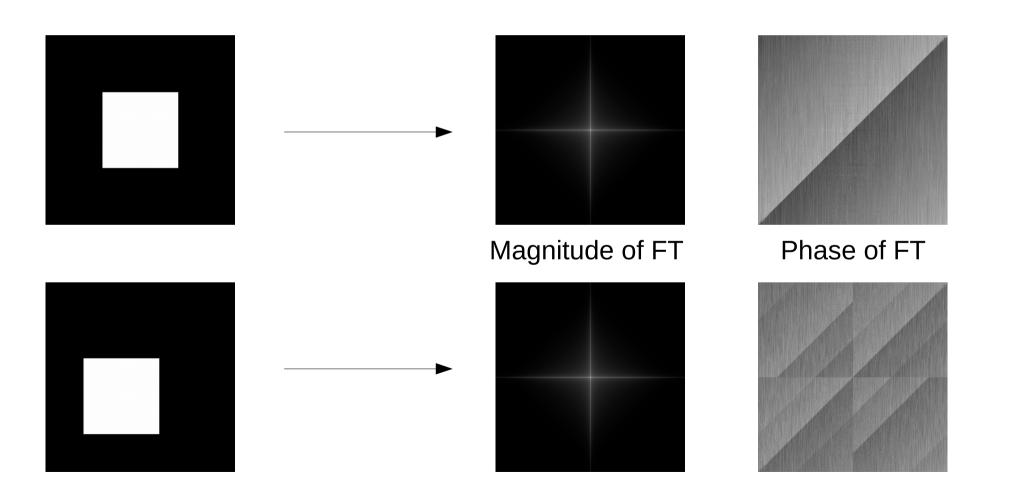
Q: What if images are rotated?

A: Projection in polar coordinates. Rotation corresponds to a shift in x-direction.



Q: What if images are rotated and translated?

A: (1) Translation only changes the phase of the Fourier Transform.





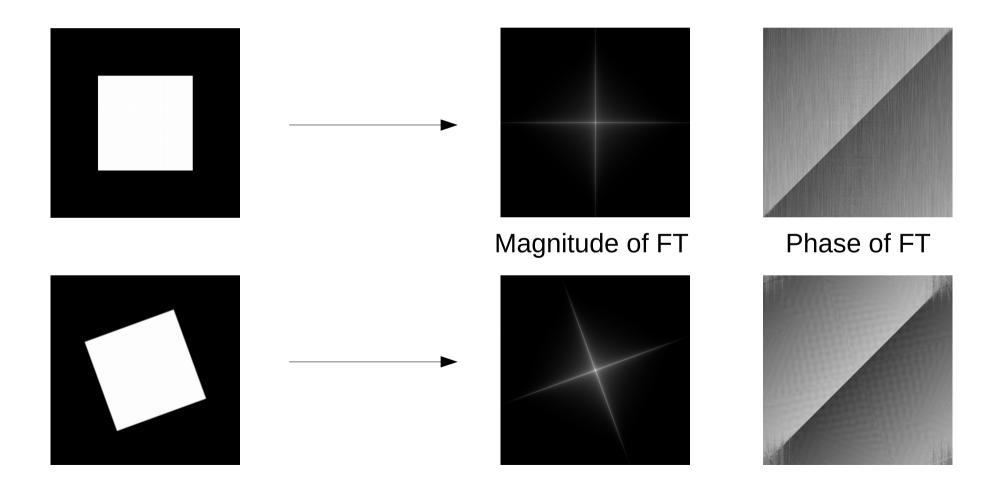




Q: What if images are rotated and translated?

A: (1) Translation only changes the phase of the Fourier Transform.

(2) Rotation of an image results in a corresponding rotation in its FT.

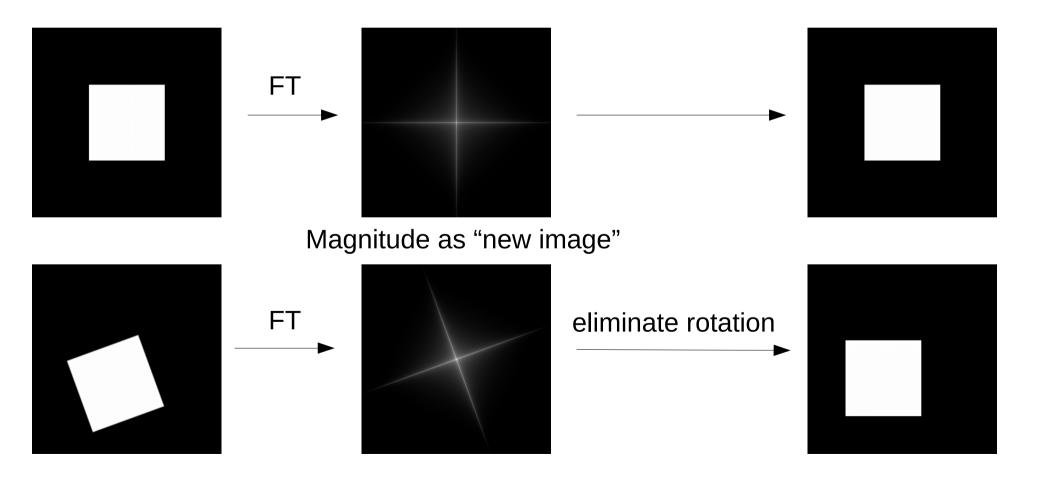






Bringing all together:

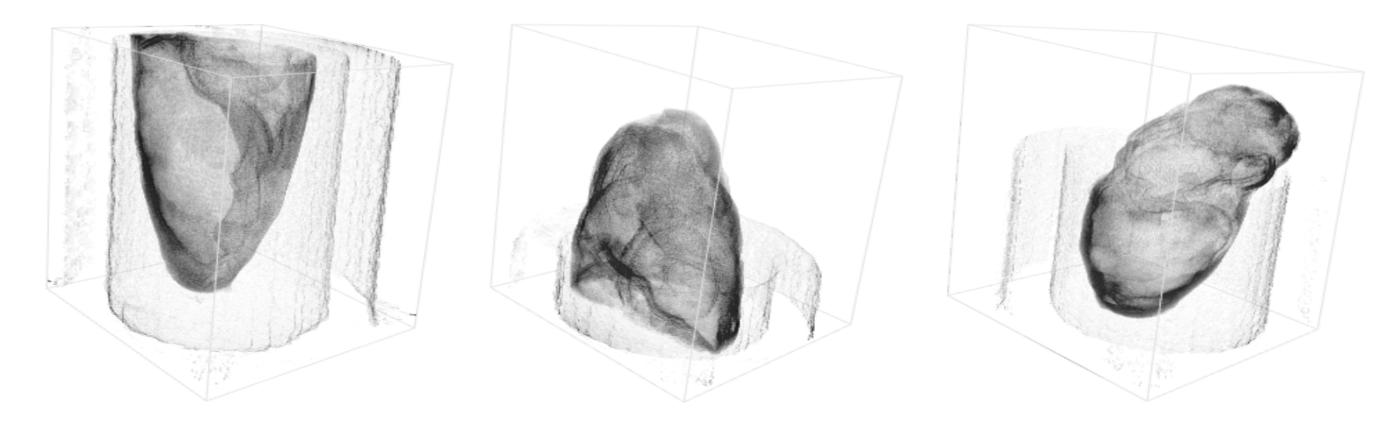
- (1) Use the magnitude as a "new" image to find the rotation
- (2) Using the magnitude of the Fourier Transform "removes" the translation
- (3) Eliminate rotation and find translation







Find rotation and translation of two overlapping CT scans



To match the first image, the second image must be shifted by:

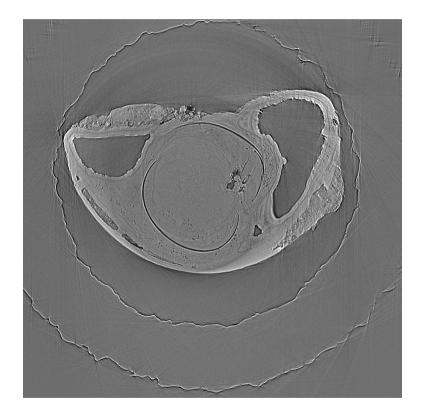
x=2y=15z=-2

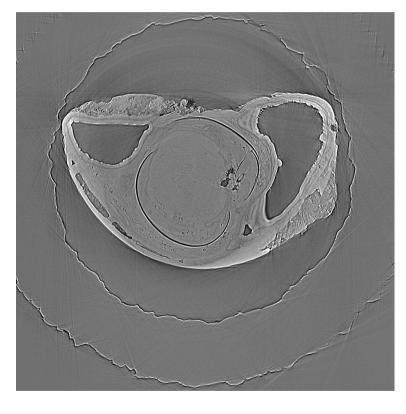
and rotated by:

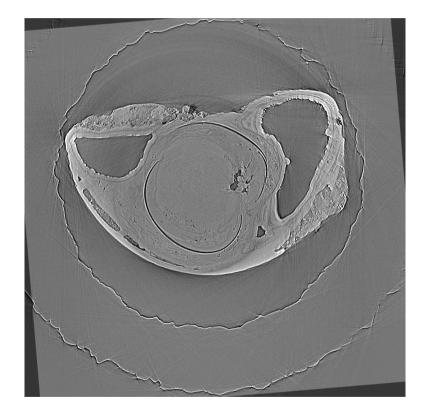
 $\phi = 4.84 \ degrees$



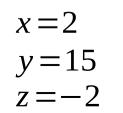
Find rotation and translation of two overlapping CT scans







To match the first image, the second image must be shifted by:

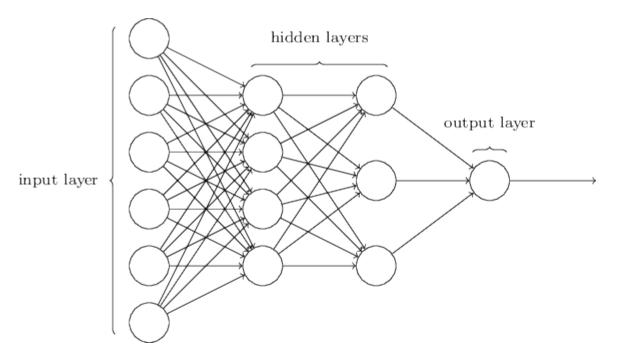


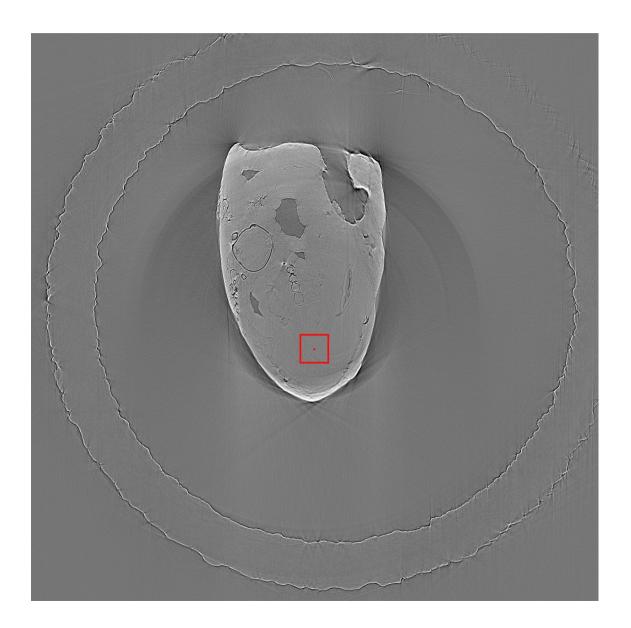
and rotated by:

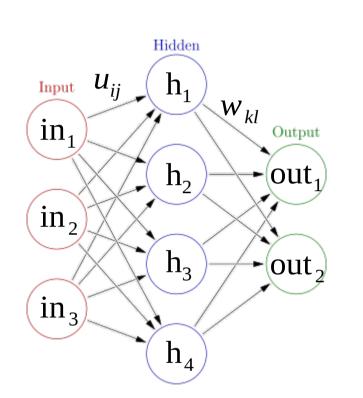
 $\phi = 4.84 \ degrees$



- Input layer: 2D patches
- Output layer: background / foreground







 $Input_1 = (23, 255, 0) \text{ and } R_1 = (1, 0)$

 $Input_2 = (15, 38, 55) \text{ and } R_2 = (0, 1)$

For Example:

Having a training data set with images $Input_1, ..., Input_N$ and corresdponding classifications $R_1, ..., R_N$ (real output values).

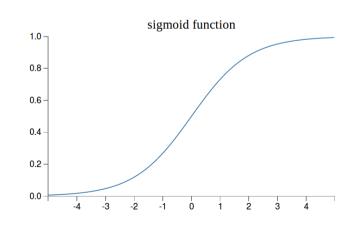
Then we want to find weights u_{ij} and w_{kl} in such a way that the function F is minimized for all our training data.

$$F(u, w) = \sum_{n=1}^{N} (out_1 - r_1)^2 + (out_2 - r_2)^2 \longrightarrow min$$

where

 $\operatorname{out}_k = \sigma \left(\sum_{l=1}^4 w_{kl} h_l \right)$

$$\mathbf{h}_i = \sigma \left(\sum_{j=1}^3 u_{ij} \operatorname{in}_i \right).$$



Universität

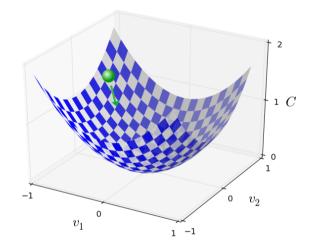
Heidelberg

Zukunft. Seit 1386.



Minimization by means of stochastic gradient descent:

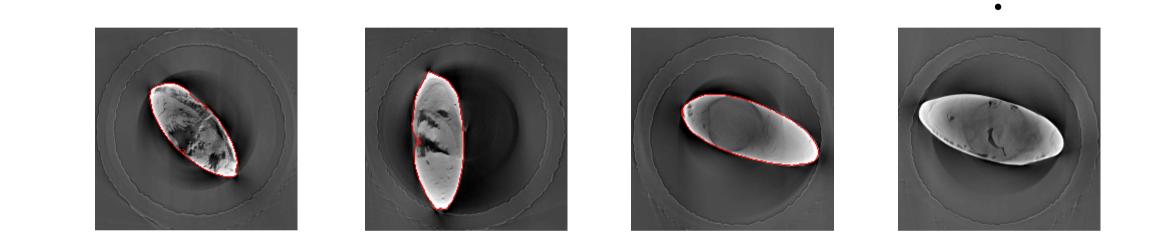
- Randomly select a batch of 10 input samples and take a small step towards the steepest descent.
- The so-called "Backpropagation" algorithm can be broken down to almost nothing as matrix-matrix multiplication.
- Can be calculated efficiently on GPUs.







7

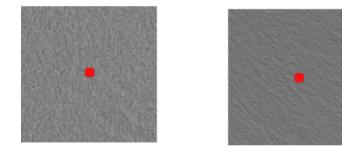


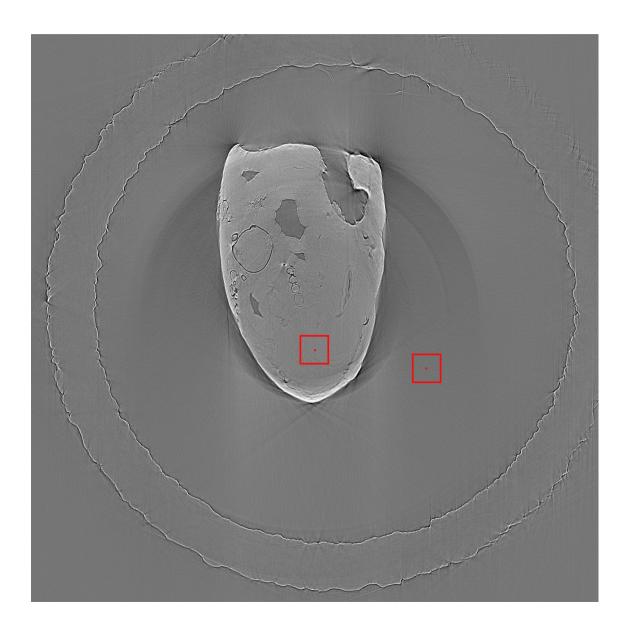
Three out of nine virtual cross sections of different puparia used for training a neural network and automatically segment 10th puparia.



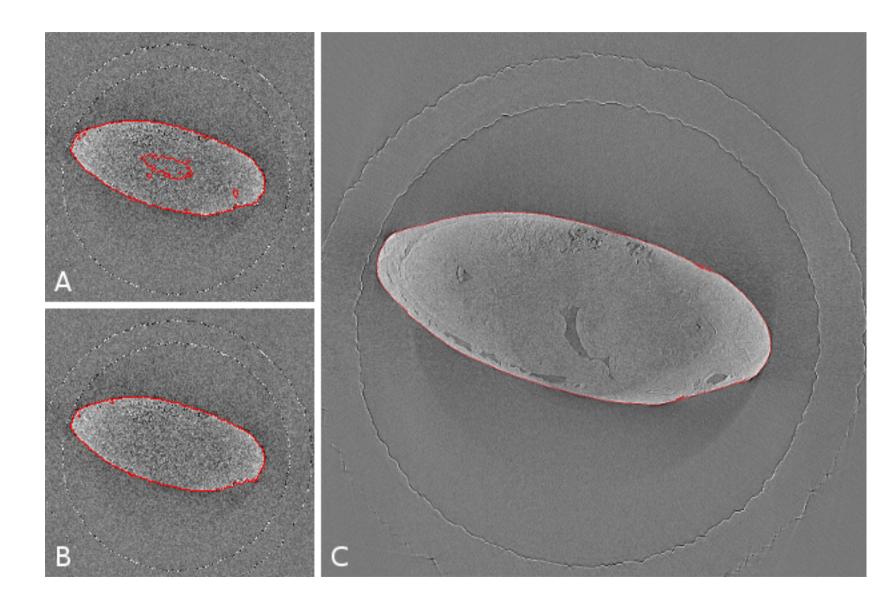


Foreground or background?









- **A** Result of the test image using a trained neural network.
- B Refinement of the result shown in(A) using Biomedisa.
- **C** Upsampling from resolution 202x202x202 (B) to full resolution 2016x2016x2016 using Biomedisa.



Outlook



- 1. Remote visualization
- 2. Subpixel image registration
- 3. Scale-invariant image registration
- 4. Fourier-based image segmentation using patches
- 5. Using random walks as input for a neural network







Thank you!



My special thanks go to:





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