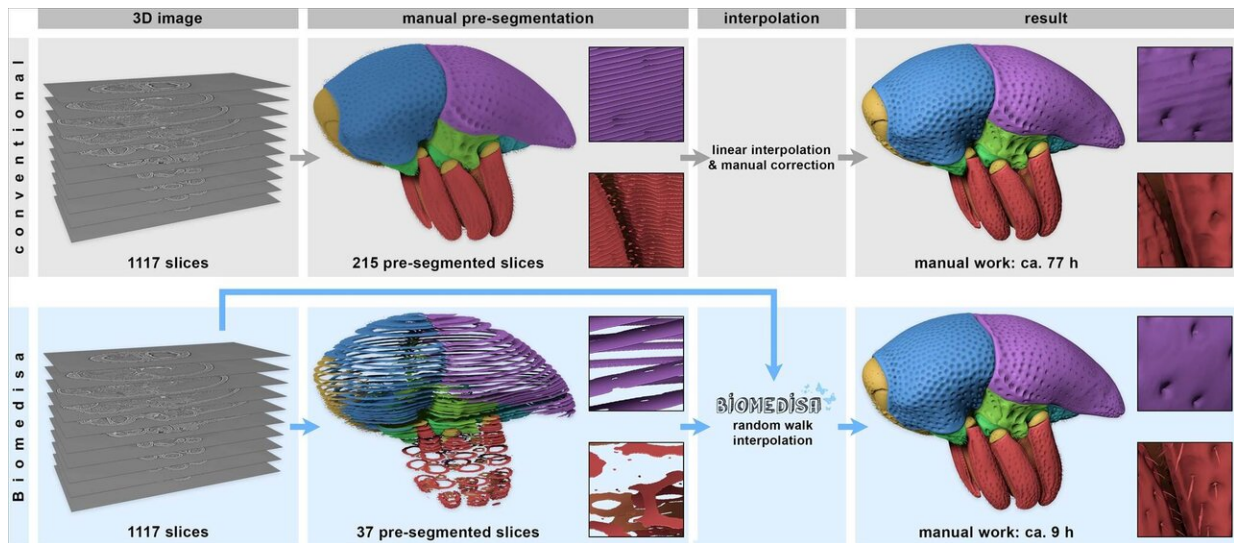# Making sense of what you see in biomedical images

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Comparison between a conventional segmentation approach (top row) and Biomedisa (bottom row): The conventional procedure requires 77 hours, compared to 9 hours with Biomedisa. Both procedures require manual pre-segmentation of the 3D image stack. While the widely used morphological interpolation solely considers labels on pre-segmented slices, Biomedisa takes both the underlying 3D image data and the pre-segmented slices into account, resulting in a significantly lower amount of required manual input. Moreover, interpolation artifacts are avoided and fine details like hairs, which are usually omitted during manual segmentation, are included. Credit: Lösel

Recent years have seen dramatic improvements in imaging technologies

that result in higher resolutions and faster acquisition times. Images of single cells, tissue and organs provide medical experts around the world with a myriad of information about their patients' state of health at a given time. But how do they gain understanding of what they see in these biomedical images?

The status quo: Time-consuming and prone to errors

To make these large volumetric images reveal their true information potential, manual segmentation—whereby a [digital image](#) is divided into various segments to enable or facilitate analysis—is often required. Labels, such as for example 'background' or 'object,' are assigned to various structures of interest with different intervals inside the 3-D volume. This is followed by an interpolation of the labels between the pre-segmented slices, where values at unknown points are estimated by using known data. In this process, the underlying image data is usually not taken into account, and the interpolation is therefore based exclusively on the segmented slices. Consequently, only a fraction of the real experimental information is utilized to derive the segmentation.

"Manual segmentation of large biomedical datasets of unknown composition is often very time-consuming and prone to errors. For analyzing three-dimensional image data, manual segmentation is still a very common approach. In fact, institutes employ armies of trained students just for this very task," says Philipp Lösel from the research group "Data Mining and Uncertainty Quantification" (DMQ) at HITS, who developed Biomedisa.

Biomedisa: Faster, user-friendly and and more accurate

And this is where the Biomedical Image Segmentation App Biomedisa

(biomedisa.org) comes in, a free and easy-to-use open-source online platform especially developed for semi-automatic segmentation. The segmentation is based on a smart interpolation of sparsely pre-segmented slices taking into account the complete underlying image data. This makes Biomedisa particularly valuable when little a priori knowledge is available. "Biomedisa can accelerate the segmentation process enormously, while at the same time providing more accurate results than the manual segmentation," says Thomas van de Kamp (KIT), a biologist with painful experience in manual image segmentation who provided micro-CT data and evaluated Biomedisa during its development.

The platform is accessible through a web browser and requires no complex and tedious configuration of software and model parameters. The one-button solution can be used for different 3-D imaging modalities and various biomedical applications.

"Our explicit aim," summarizes Vincent Heuveline, director of Heidelberg University's Computing Centre (URZ) and DMQ group leader at HITS, "was to create a widely-applicable and user-friendly tool to accelerate the segmentation of samples of unknown morphology while also improving the results."

"Biomedisa is an example for a software that benefits directly from the latest developments of GPU (Graphics Processing Unit) technology. The hardware-aware design utilizes graphics accelerators to handle the ever-increasing image data," adds Philipp Lösel.

On the way to fully automatic segmentation

Besides, Biomedisa offers a range of other functions, such as the removal of outliers or the filling of holes, surfaces can be smoothed and the uncertainty with which the result was obtained can be quantified. Furthermore, the data can be visualized with 3-D rendering software and

shared with other users.

Last but not least, Biomedisa enables machine learning techniques through training a deep neural network. This technique allows a fully automatic segmentation when a large number of similar structures, such as the human heart, is segmented. As a result, it allows numerical simulations based on a patient-specific heart model and thus assists clinicians with their surgical planning and decision-making.

All these features combined make Biomedisa an ideal platform for all those for whom a picture is worth more than a thousand words.

More information: Philipp D. Lösel et al. Introducing Biomedisa as an open-source online platform for biomedical image segmentation, *Nature Communications* (2020). DOI: 10.1038/s41467-020-19303-w

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