DeepMB: A deep learning framework for high-quality optoacoustic imaging in real-time

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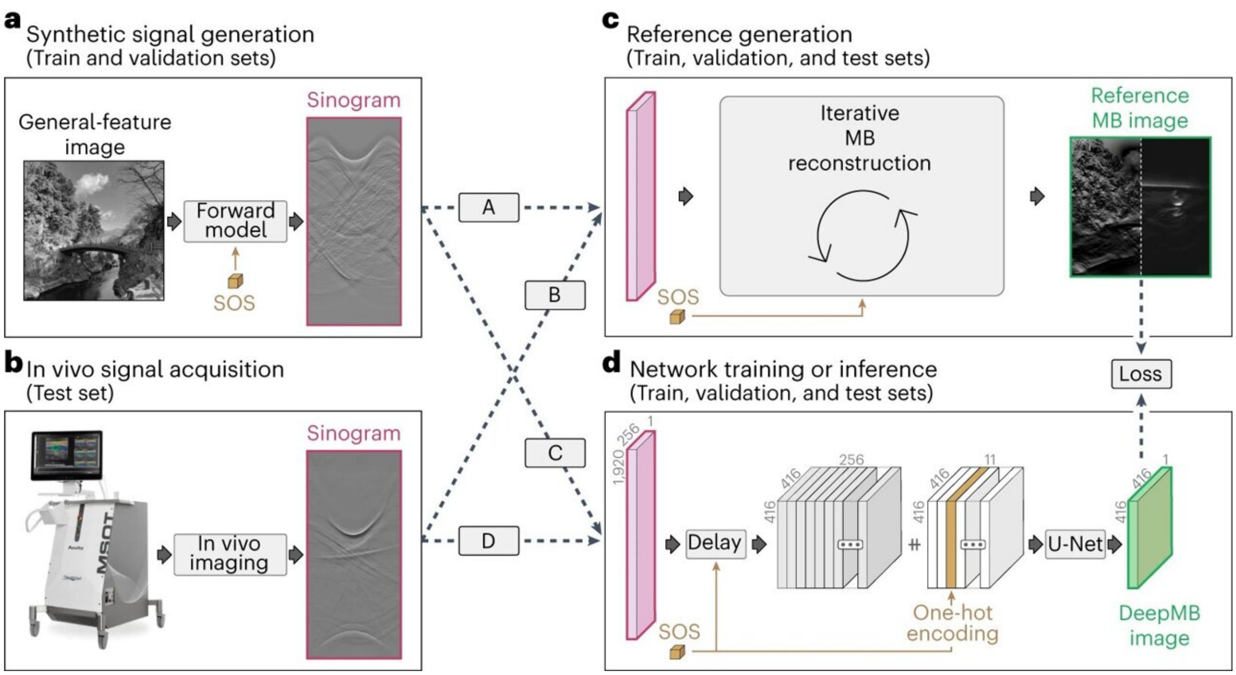

DeepMB pipeline. **a**, Real-world images—obtained from a publicly available dataset—are used to generate synthetic sinograms by applying an accurate physical forward model of the scanner. SOS, speed of sound. **b**, In vivo sinograms are acquired from six participants at diverse anatomical locations. **c**, Optoacoustic images are reconstructed via iterative model-based (MB) reconstruction to generate reference images for the synthetic (A) and in vivo (B) datasets. **d**, A deep neural network is trained using the synthetic data as training and validation sets (C), and the in vivo data as test set (D). In the network, input sinograms are first mapped into the image domain using a delay operation. Then, the SOS is one-hot encoded and concatenated as additional channels (represented by the ? symbol). Finally, the output image is regressed from the channel stack using a U-Net convolutional neural network. The loss is calculated between the network output and the corresponding reference image (see 'Network training' section in the Methods for further details about the network training). Credit: *Nature Machine Intelligence* (2023). DOI: 10.1038/s42256-023-00724-3

In order to understand and detect diseases scientists and medical staff often rely on imaging methods such as ultrasound or X-ray. However, depending on the tissue the resolution and depth of the resulting image is limited or insufficient.

A relatively new method called optoacoustic imaging combines the principles of both ultrasound and laser-induced optical imaging and is, therefore, a powerful medical imaging tool to non-invasively assess a wide variety of diseases, including breast cancer, Duchenne muscular dystrophy, inflammatory bowel disease, and many more.

This technology would greatly benefit patients in the clinic, however, its practical use is hampered because high-quality images require prohibitively long processing times. A team of researchers from the Bioengineering Center and the Computational Health Center at Helmholtz Munich and the Technical University of Munich have developed a deep-learning framework (DeepMB) allowing clinicians to obtain high-quality optoacoustic images in real-time, a major step towards the clinical translation of this technology.

Their research is published in the journal *Nature Machine Intelligence*.

The research focuses on multispectral optoacoustic tomography (MSOT), an optoacoustic imaging method developed by Prof. Ntziachristos and his research team at Helmholtz Munich and the

Technical University of Munich, distributed by and continuously jointly advanced together with his spin-off company, iThera Medical GmbH. An MSOT scanner works by taking advantage of the optoacoustic effect, where sound waves are generated when light is absorbed by a material.

The instrument collects these sound waves, which are translated into images displayed on the scanner monitor with the help of so-called reconstruction algorithms. Unfortunately, the simpler algorithms that can reconstruct images quickly enough to display them in real-time can only deliver low-quality images, while the more complex algorithms that can produce high-quality images take far longer than what would be practical in a clinical setting.

Optoacoustic imaging accelerated for faster results without compromising image quality

The new neural network DeepMB is capable of reconstructing high-quality optoacoustic images about a thousand times faster than the state-of-the-art algorithm with virtually no loss in image quality. The critical innovation unlocking this achievement was the training strategy used for DeepMB. The training strategy was based on optoacoustic signals synthesized from various pictures of the real world paired with optoacoustic images reconstructed from the corresponding signals.

The resulting framework also overcomes one of artificial intelligence's (AI) major challenges: generalization. This means that DeepMB can accurately reconstruct all scans acquired from any patient, regardless of the part of the body being targeted or the disease being analyzed.

Facilitating the clinical application of optoacoustic tomography

By using DeepMB, clinicians will have direct access to optimal MSOT image quality for the first time. This represents a major leap forward for this technology, positively impacting clinical studies and ultimately helping patients receive better care.

The core principles of DeepMB are also readily adaptable and can be applied to many other reconstruction methods in optoacoustic imaging, including other research efforts at Helmholtz Munich. More broadly, the researchers believe this framework can also be applied to other imaging modalities such as ultrasound, X-ray, or magnetic resonance imaging (MRI).

More information: Christoph Dehner et al, A deep neural network for real-time optoacoustic image reconstruction with adjustable speed of sound, *Nature Machine Intelligence* (2023). DOI: 10.1038/s42256-023-00724-3
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