Artificial intelligence technology accelerates super-resolution localization photoacoustic imaging of blood vessels

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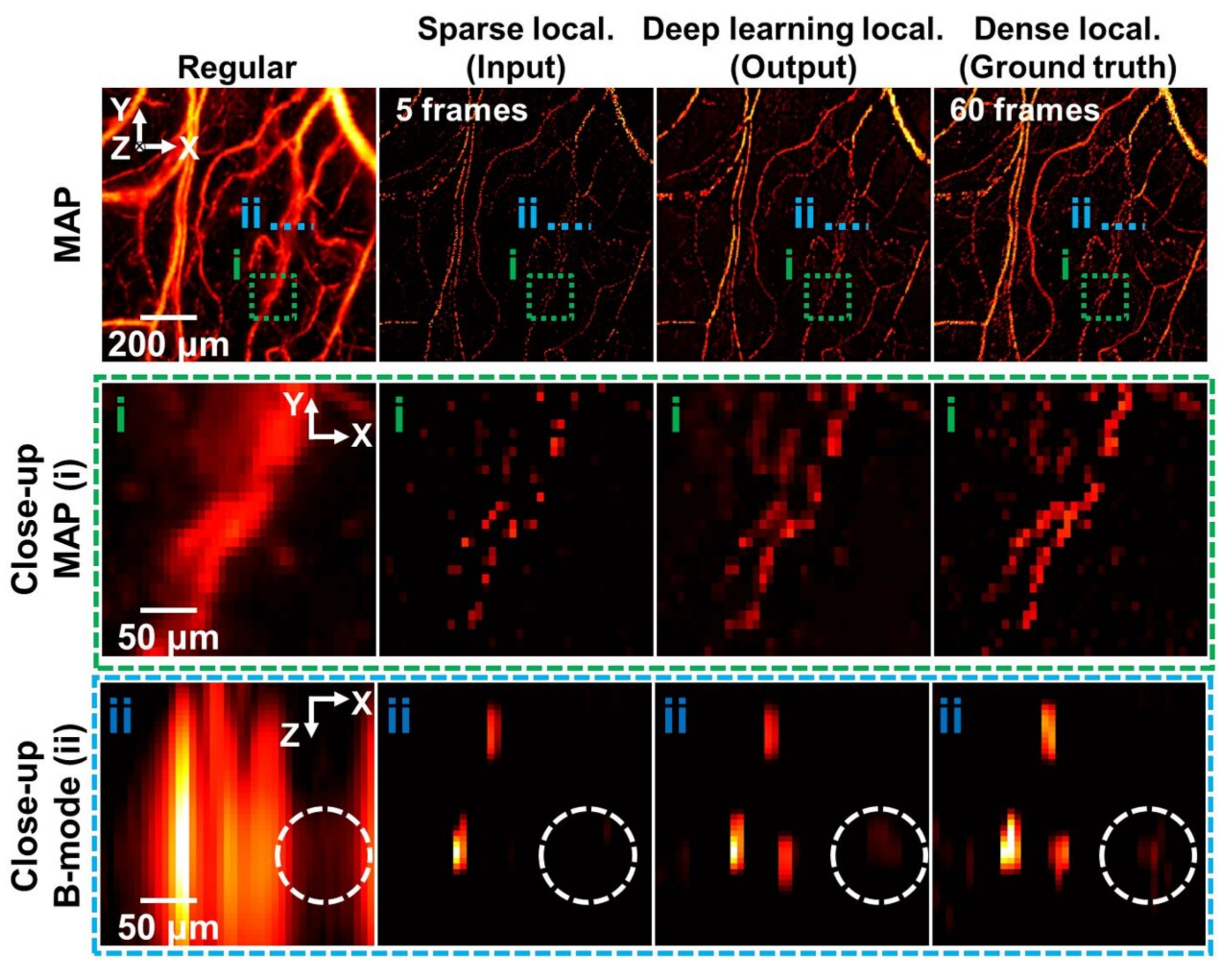
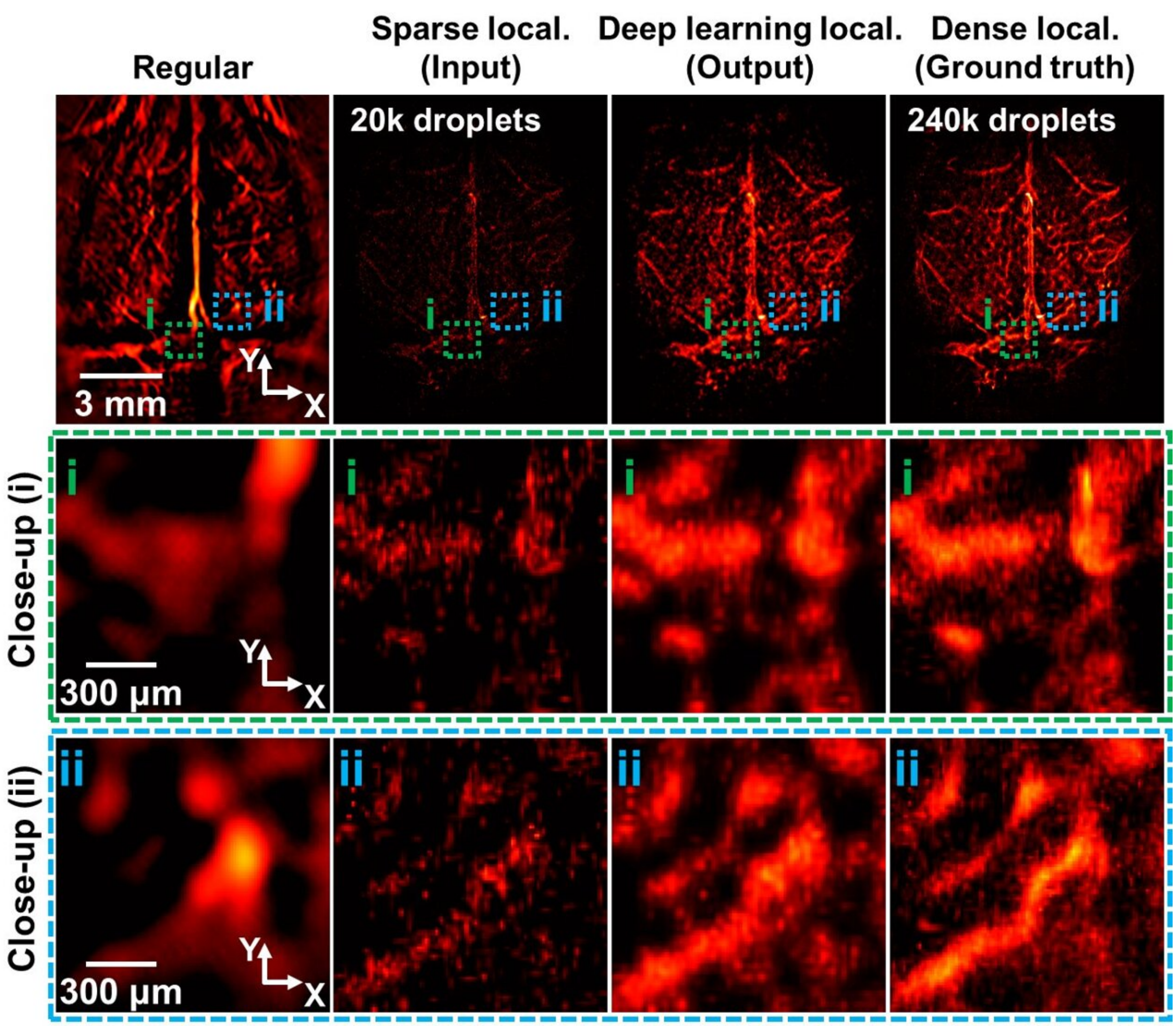


Frame counts of 60 and 5 are used for the dense and sparse localization-based images, respectively. Close-up views of the regions outlined by the green dashed boxes and cross-sectional B-mode images of the region highlighted by the blue dashed lines. The two adjacent blood vessels are clearly resolved in the deep learning and dense localization-based images, whereas they are not in the regular OR-PAM image in close-up MAP (i). In close-up B-mode (ii), a blood vessel highlighted by the white dashed circles, in which the sparse image has a low signal-to-noise ratio, is well-restored in the deep learning localization-based image. Even though the sparse image does not contain the vessels, they are restored in the deep learning localization-based image because our network is based on 3D convolutions, allowing for the reference of adjacent pixels in 3D space. Credit: Jongbeom Kim, Gyuwon Kim, Lei Li,Pengfei Zhang, Jin Young Kim,Yeonggeun Kim, Hyung Ham Kim, Lihong V. Wang, Seungchul Lee, Chulhong Kim

After a lightning strike, thunder can be heard for a short period of time. This is due to the fact that the surrounding material that was struck by lightning absorbs the light, and as a result of the conversion of this light into heat, the material expands and produces a sound. The imaging technique known as photoacoustic imaging (PAI), which uses this phenomenon to take photographs of the inside of the body, is being explored as a new medical imaging device in various preclinical and clinical applications.

PAI technology has been using the localization imaging method, which involves imaging the same area numerous times in order to achieve super high spatial resolution beyond the physical limitation regardless of the imaging depth. However, this superior spatial resolution is achieved by sacrificing temporal resolution since multiple frames, each containing the localization target, must be superimposed to form a sufficiently sampled high-density super resolution image. This has made it challenging to employ for research that needs to confirm an immediate reaction.

In a new paper published in *Light Science & Application*, a team of scientists, led by Professor Chulhong Kim and multi-institutional collaborators, has developed an AI-based localization PAI for solving the disadvantages of the slow imaging speed. By using deep learning to boost the imaging speed and reduce the number of laser beams used on the body, it has been able to address all three of these issues simultaneously: slow imaging speed, low spatial resolution, and burden on the body.



Droplet counts of 240,000 and 20,000 are used for the dense and sparse localization-based images, respectively. Close-up views of the regions outlined by the i green and ii blue dashed boxes. The connectivity of blood vessels can be compared in the magnified images: it is difficult to recognize the vascular morphology in the regular and sparse localization-based images, whereas the deep learning and dense images exhibit microvasculatures. Credit: Jongbeom Kim, Gyuwon Kim, Lei Li,Pengfei Zhang, Jin Young Kim,Yeonggeun Kim, Hyung Ham Kim, Lihong V. Wang, Seungchul Lee, Chulhong Kim

Using deep learning technology, the research team was able to reduce the number of images used in this method by more than 10 fold and increase the imaging speed by 12 fold. The imaging times of localization photoacoustic microscopy and photoacoustic computed tomography were reduced from 30 seconds to 2.5 seconds and from 30 minutes to 2.5 minutes, respectively.

This advancement opens up the new possibility of localization PAI techniques in various preclinical or clinical applications, which requires both high speed and fine spatial resolution, such as the studies of the instantaneous drug and hemodynamic responses. Above all, a major advantage of this technology is the fact that it significantly minimizes both laser beam exposure to the living body and the imaging time, which reduces the burden on patients.

More information: Jongbeom Kim et al, Deep learning acceleration of multiscale superresolution localization photoacoustic imaging, *Light: Science & Applications* (2022). DOI: 10.1038/s41377-022-00820-w

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