



King's Research Portal

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Shi, M., Vercauteren, T., Xia, W., Bodian, S., & J. West, S. (2023). *Visualisation of medical needles using photoacoustic imaging with candle soot composites coatings and deep learning.*

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Visualisation of medical needles using photoacoustic imaging with candle soot composites coatings and deep learning



Mengjie Shi^{1*}, Semyon Bodian^{2,3}, Simeon J. West⁴, Sanjayan Sathasivam^{5,6}, Ross J. Gordon⁷, Paul Collier⁷, Tom Vercauteren¹, Adrien E. Desjardins^{2,3}, Sacha Noimark^{2,3}, Wenfeng Xia¹

¹ School of Biomedical Engineering and Imaging Sciences, King's College London, London SE1 7EH, United Kingdom;

² Department of Medical Physics and Biomedical Engineering, University College London, London WC1E 6BT, United Kingdom;

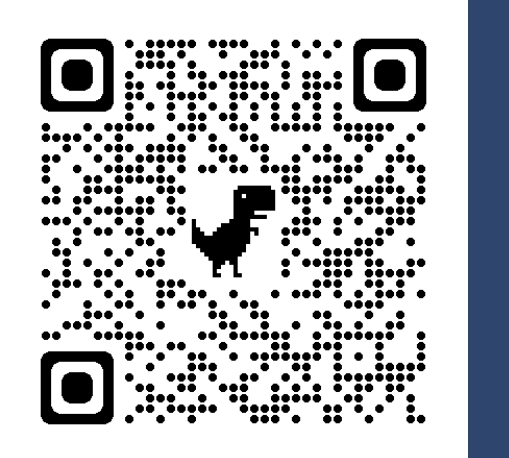
³ Wellcome/EPSRC Centre for Interventional and Surgical Sciences, University College London, London W1W 7TY, United Kingdom;

⁴ Department of Anaesthesia, University College Hospital, London NW1 2BU, United Kingdom;

⁵ Department of Chemistry, University College London, London WC1H 0AJ, United Kingdom;

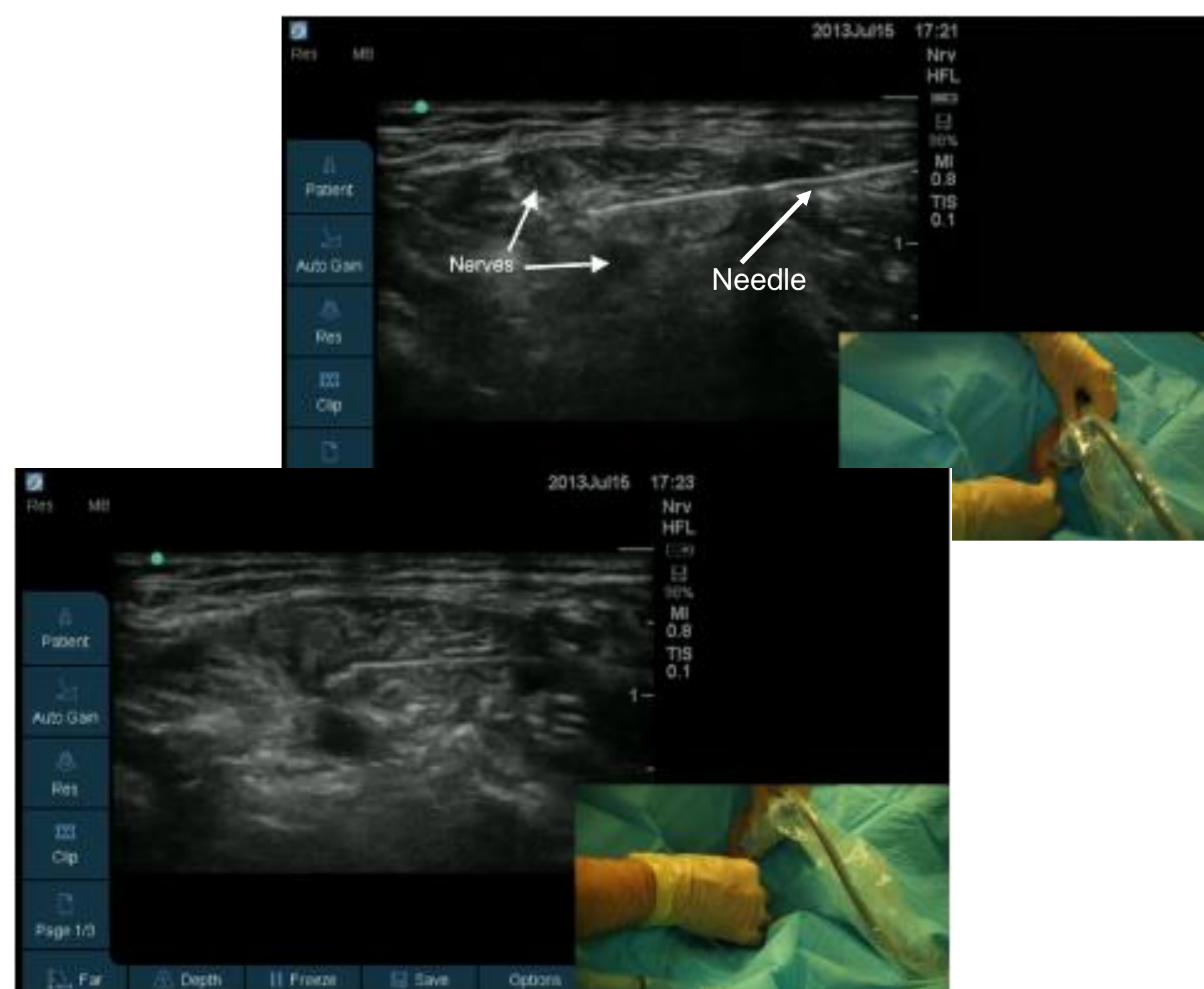
⁶ School of Engineering, London South Bank University, London SE1 0AA, United Kingdom;

⁷ Johnson Matthey Technology Centre, Sonning Common, Reading, RG4 9NH, United Kingdom



Clinical problem

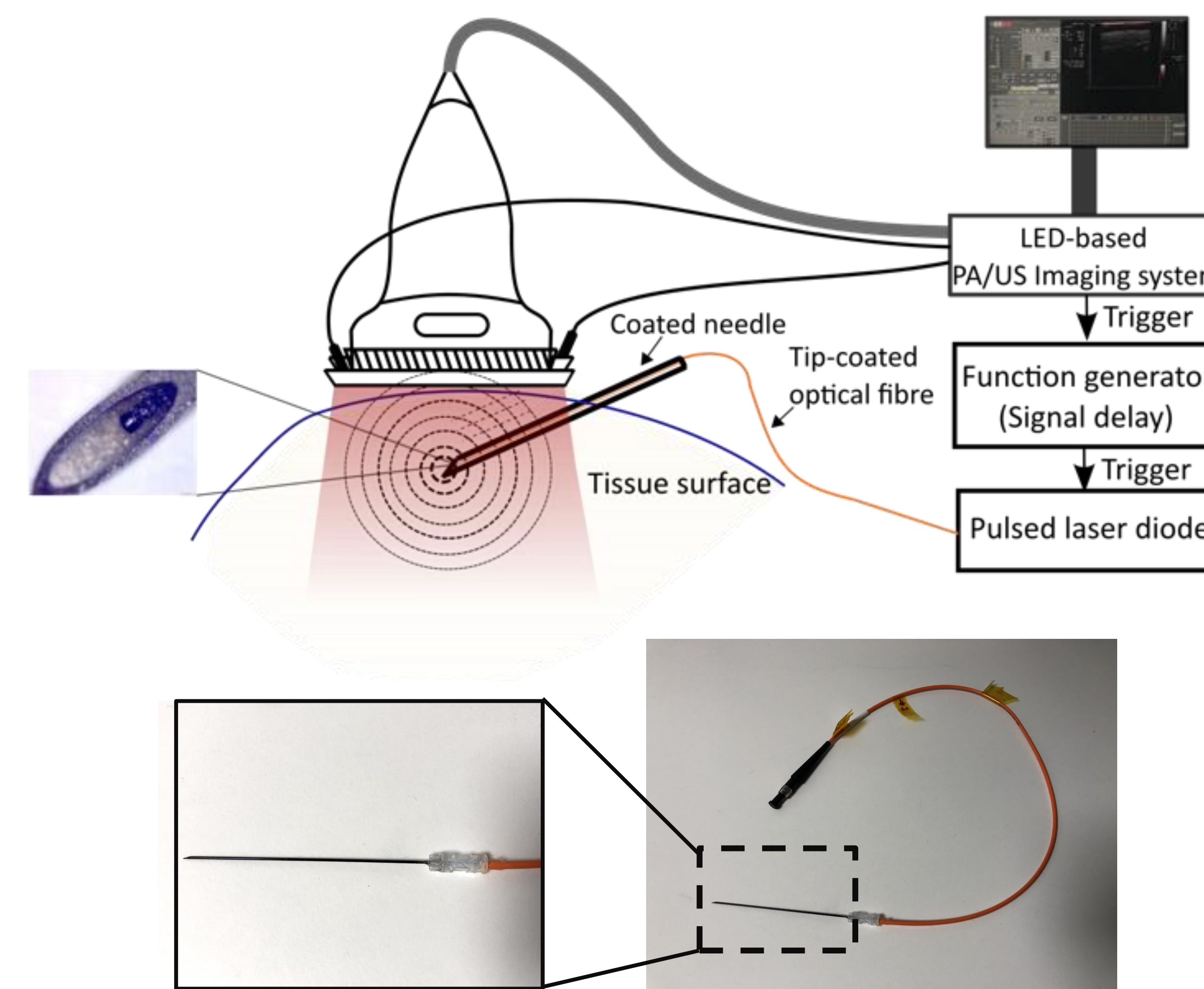
- Ultrasound (US) imaging is widely used for guiding minimally invasive procedures, but the visibility of the invasive medical devices such as metallic needles can be poor, thereby elevating the risk of complications [1].



- Photoacoustic (PA) imaging is promising for visualising invasive devices and peripheral targets. Low-cost PA excitation sources such as light-emitting diodes (LEDs) accelerate the clinical translation of PA imaging, but the image quality is sub-optimal due to the low pulse energy, leading to limited imaging depth for in vivo applications [2,3].

LED based PA/US needle imaging system

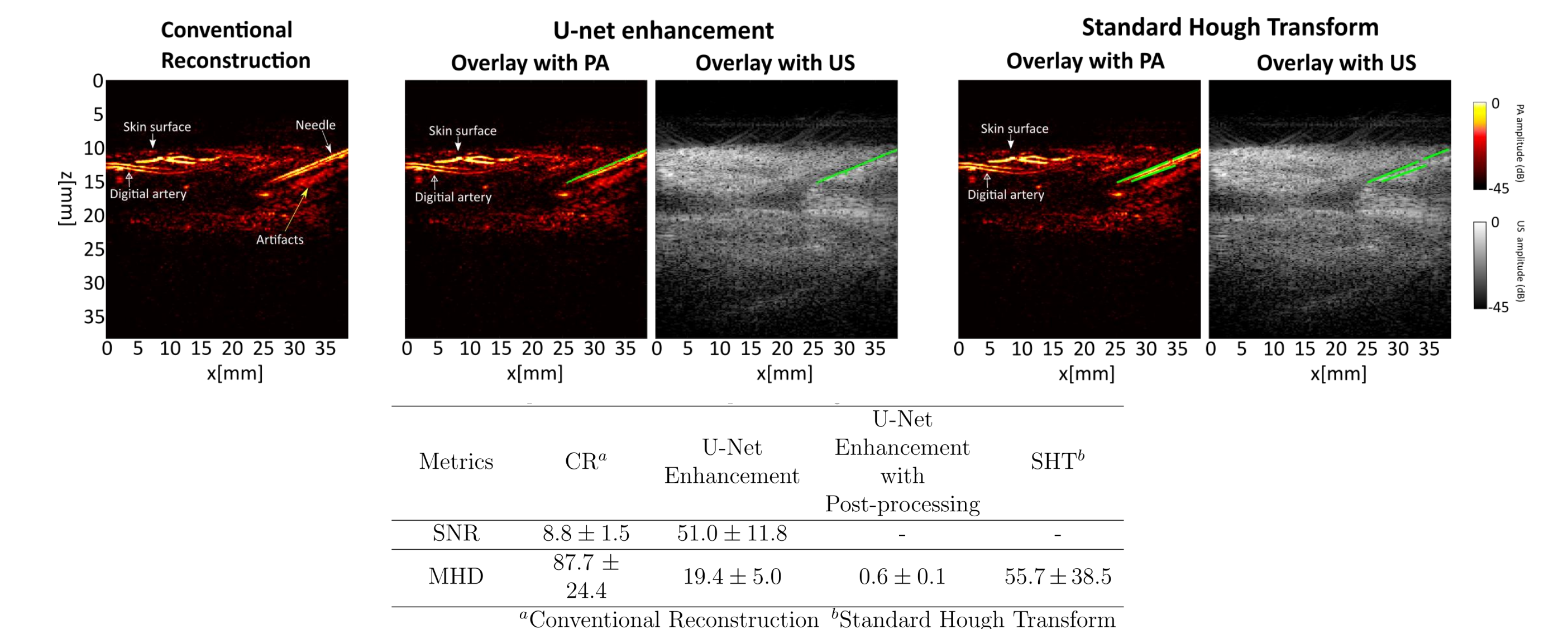
- The system was based on a commercially available LED-based PA/US imaging system (AcousticX, CYBERDYNE INC, Tsukuba, Japan).



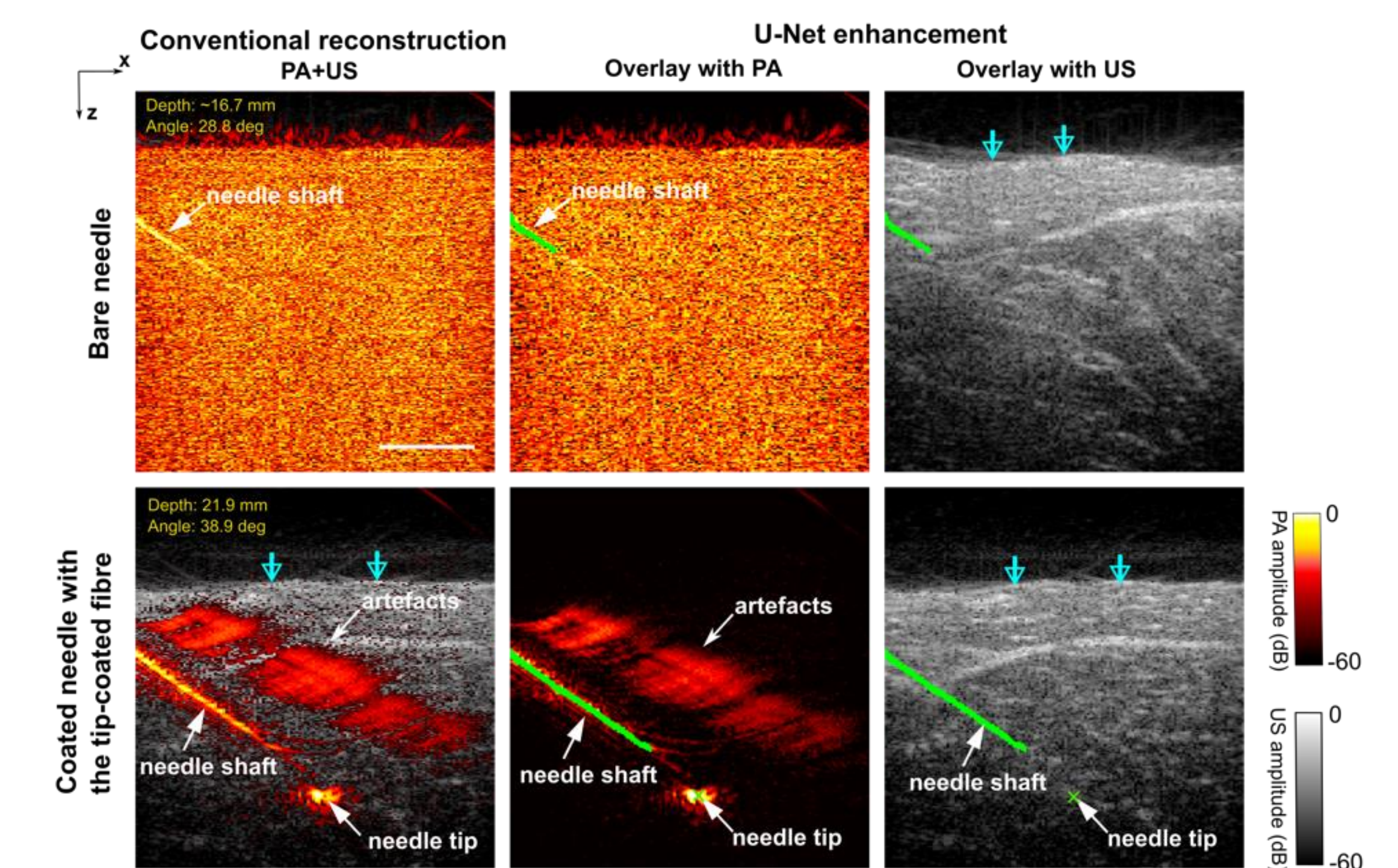
- Candle soot nanoparticle-polydimethylsiloxane (CSNP-PDMS) composites with high optical absorption and large thermal expansion coefficients were applied onto the needle exterior and the end-face of an optical fibre

Results

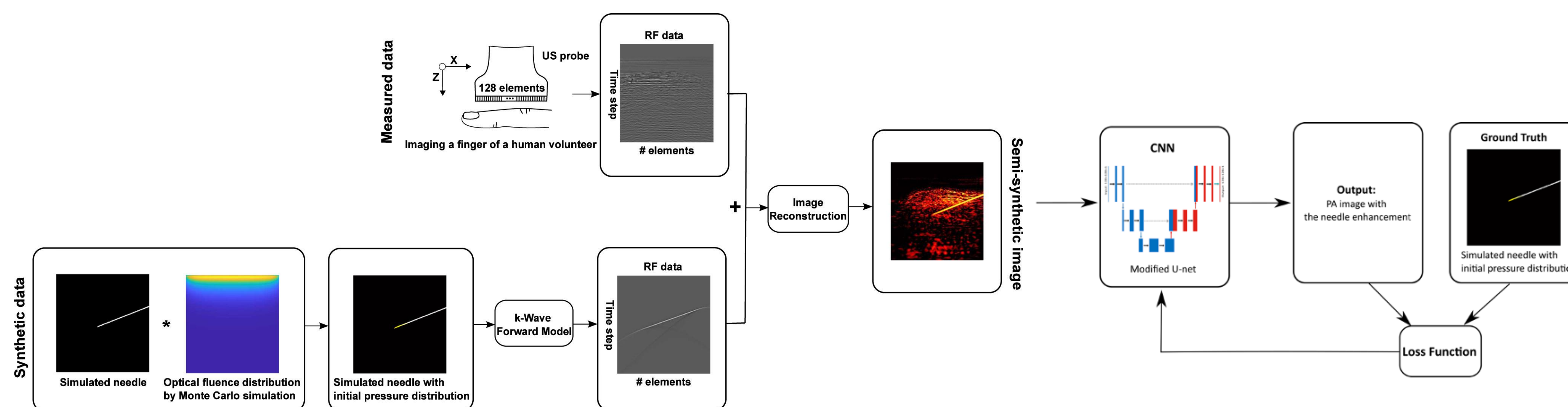
- The enhanced PA visualization of needle images (needle uncoated) with in vivo human fingers was achieved.



- With the robust PA enhancement via elastomeric coatings, the deep learning model resulted in 6.5- and 1.2-times improvement in SNR and MHD, respectively, indicating its high efficiency and accuracy of needle identification.



Deep learning-based needle enhancement



- A deep learning-based framework using semi-synthetic dataset was proposed for enhancing photoacoustic visualisation of clinical needles [5].

Conclusions

- Elastomeric coatings can be applied on the needle surface to improve its visibility; but the PA visualisation of the needle was degraded by the synchronous strengthened artefacts.
- The deep learning model based on semi-synthetic dataset further improved the needle visualisation in PA imaging with high robustness and sensitivity.
- The proposed method could be helpful in US-guided minimally invasive procedures by accurate visualisation of clinical needles

Acknowledgements

- The authors would like to acknowledge the funding support from Wellcome Trust [203148/Z/16/Z, WT101957], EPSRC (NS/A000027/1, NS/A000049/1) and King's – China Scholarship Council PhD Scholarship program (K-CSC).

References

- Agarwal, K. and Alfirevic, Z., Ultrasound Obstet Gynecol 40(2), 128–134 (2012).
- Xia, W. et al, Sensors 18(5), 1394 (2018).
- Kuniyil Ajith Singh, M. and Xia, W., Sensors 21(7), 2572 (2021).
- Xia, W. et al, Photons Plus Ultrasound: Imaging and Sensing 2019 10878, 299–303, SPIE (2019).
- Shi, M. et al, Photoacoustics 26, 100351 (2022).