# 13. ULTRASOUND BIONIC TECHNOLOGIES

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## LABORATORY OVERVIEW

The activities of the laboratory are primarily motivated by the current ability and future potential of ultrasound technology to help in the early diagnosis of cancer. The scope of the research is wide in the sense that fundamental as well as applied research is being conducted, the aim always being that these ends be integrated with each other. On the fundamental end of the spectrum, the question of how ultrasound images arise is studied. This activity is summarised in the next section of the document. One of the possible fruits of this research is the understanding of how the microstructure of various pathologies such as skin cancer is mapped to certain quantitative parameters and qualitative features on ultrasound images. This leads to research about how skin cancer can be diagnosed using ultrasound and what devices are suitable for this. Since this research is carried out in collaboration with the Department of Dermatology, a summary of this research can be found towards the end of this book, under the title "Ultrasound Technology in Dermatology" *(see pp. 89)*

## MODELLING OF ULTRASOUND IMAGE FORMATION

Although many models exist for describing the formation of ultrasound images, the validation of these models is lacking in the literature. The laboratory has conducted research that suggests that based on histology slides, the first-order statitistics of different ultrasound tissue types can be predicted [1]. It has also shown that the ultrasound image produced by distributions of inanimate scatterers can be correctly predicted (Figure 1, [3]).

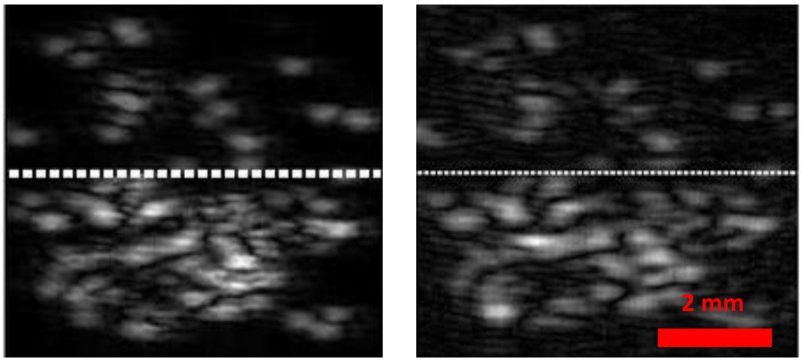


***Fig. 1*** *Comparison of simulated (left) and experimentally obtained (right) ultrasound images of a distribution of 49-$\mu m$-diameter polystyrene microspheres. Note that – despite the presence of noise in the experimentally obtained image – the features of both images show substantial agreement with each other. This agreement is particularly interesting in the case of the speckle pattern seen in the bottom half of the images that is produced by a high concentration of interfering scatterers. Work with Ákos Makra [3].*

The research of ultrasound scattering by inanimate scatterers helps two strands of research. Firstly, it is related to the aforementioned research of modelling scattering by tissue samples. This is helped by the construction of an acoustic microscope in our laboratory (Figure 2), where we are currently working to make scanning an order of magnitude faster, reducing typical 3D scanning times from 6 hours to 10 minutes. Once this is achieved, we will be able to validate our research regarding how to use tissue-based scattering models to achiever super-resolution images.

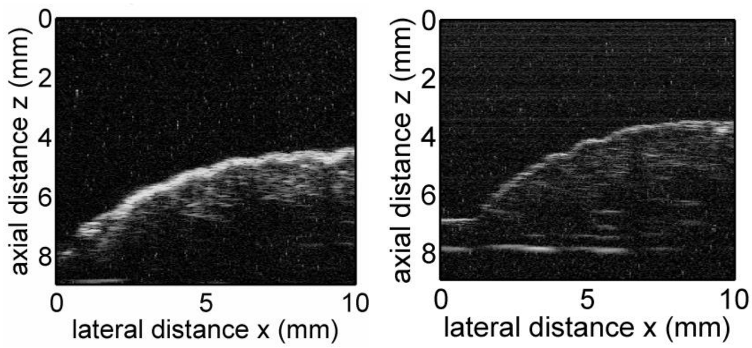


***Fig. 2*** *Acoustic microscope images of porcine skin using two different transducers. Left: 35 MHz. Right: 75 MHz.*

The second strand of research concerns the development of cost-effective and durable ultrasound phantoms that can be used to calibrate ultrasound imaging systems (Figure 3).

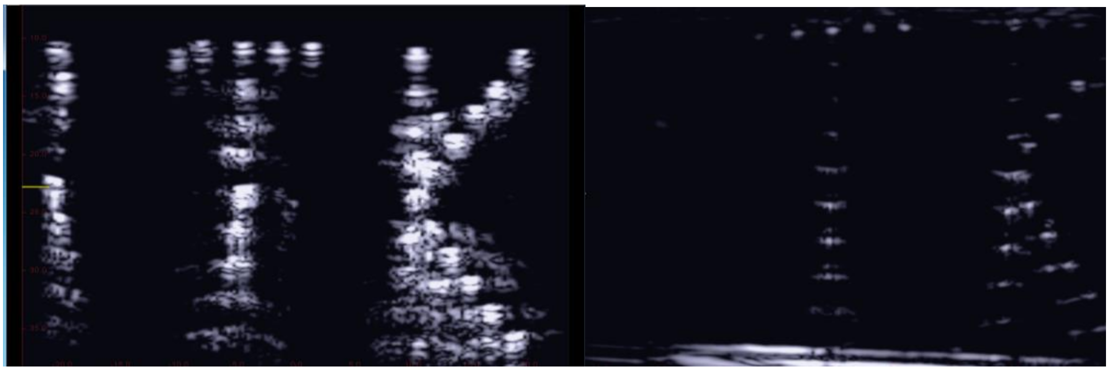

***Fig. 3*** *Phantoms with the abbreviation of our Faculty, "ITK". Left: phantom printed with fused filament printing. Right: phantom printed with DLP printing. It can be seen that DLP printing potentially provides higher resolution phantoms, however the lack of the letter "I" underscores the need for ensuring good focussing of the projected pattern. Work with Krisztián Füzesi.*

## PUBLICATIONS


[1] M Gyöngy, L Balogh, K Szalai, I Kallo, Histology-based simulations of ultrasound imaging: methodology, *Ultrasound in Medicine and Biology* **39**(10): 1925-1929 (2013).

[2] M Gyöngy, S Kollár, Variation of ultrasound image lateral spectrum with assumed speed of sound and true scatterer density, *Ultrasonics* **56**, 370-380 (2014).

[3] M Gyöngy, Á Makra, Experimental Validation of a Convolution-Based Ultrasound Image Formation Model using a Planar Arrangement of Micrometer-Scale Scatterers, *IEEE Transactions on UFFC* **62**(6): 1211-1219 (2015).

[4] J P Kemmerer, M L Oelze, M Gyöngy, Modeling of physically large weak scatterers in the beam of a single-element transducer, *Journal of the Acoustical Society of America* **137**(3), 1153-1163 (2015).