Liver tumour segmentation from 3D Radio-Frequency Ultrasound images

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Liver tumours

Approximately 40,000 patients are diagnosed each year with either primary or secondary liver cancers in the UK. Curative surgery is only suitable in 10-25%, with chemotherapy forming the mainstay of treatment. In order to achieve sustained therapeutic effect whilst minimising drug toxicity, this is usually given at regular time interval according to a physician prescribed treatment schedule.

Tumour response to chemotherapy

Since only one third of patients respond to treatment, it would be advantageous if physicians can detect non-responders early during a course of treatment, and potentially offer salvage therapy to these patients.

Liver tissue characterisation

Medical ultrasound images can be analysed either by characterising the local spectrum or the envelop distribution of the backscattered signal. In this work, we focus on the latter by modelling it with a Nakagami distribution for its capability to represent the various backscattering conditions from image texture. Fig. 1 shows the capability of the Nakagami distribution to model different scattering conditions related to Rayleigh distribution.

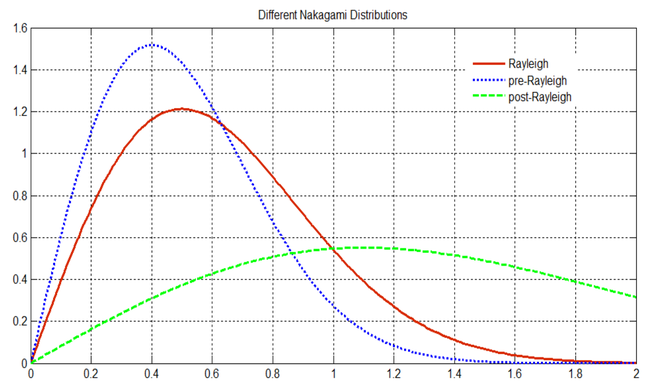

Fig. 1 Varying the Nakagami probability density function shape (μ) while fixing the scale parameter (ω) to 1 to represent pre-Rayleigh ($\mu < 0.5$), Rayleigh ($0.5 \leq \mu \leq 1$), and post-Rayleigh or Rician ($\mu > 1$) distributions.

3D Ultrasound liver tumour volume segmentation

Volumetric ultrasound scans of liver tumours were acquired using a free-hand sweeping motion whilst maintain a stable skin contact position. Manual segmentation of sequential images were performed prior to processing. The Nakagami distribution was fitted to the distributions in each sliding-cuboid in a voxel per voxel based approach and parametric maps were generated (see Fig. 2-a), followed by multiscale segmentation using a Gaussian self-similar non-stationary process called fractional Brownian motion (see Fig. 2-b).

Conclusion

Nakagami parametric voxel-based tumour regions analysis at multiscales via fractional Brownian motion can provide better segmentation of liver tumour regions, and hence could assist in better administration of chemotherapy treatment.

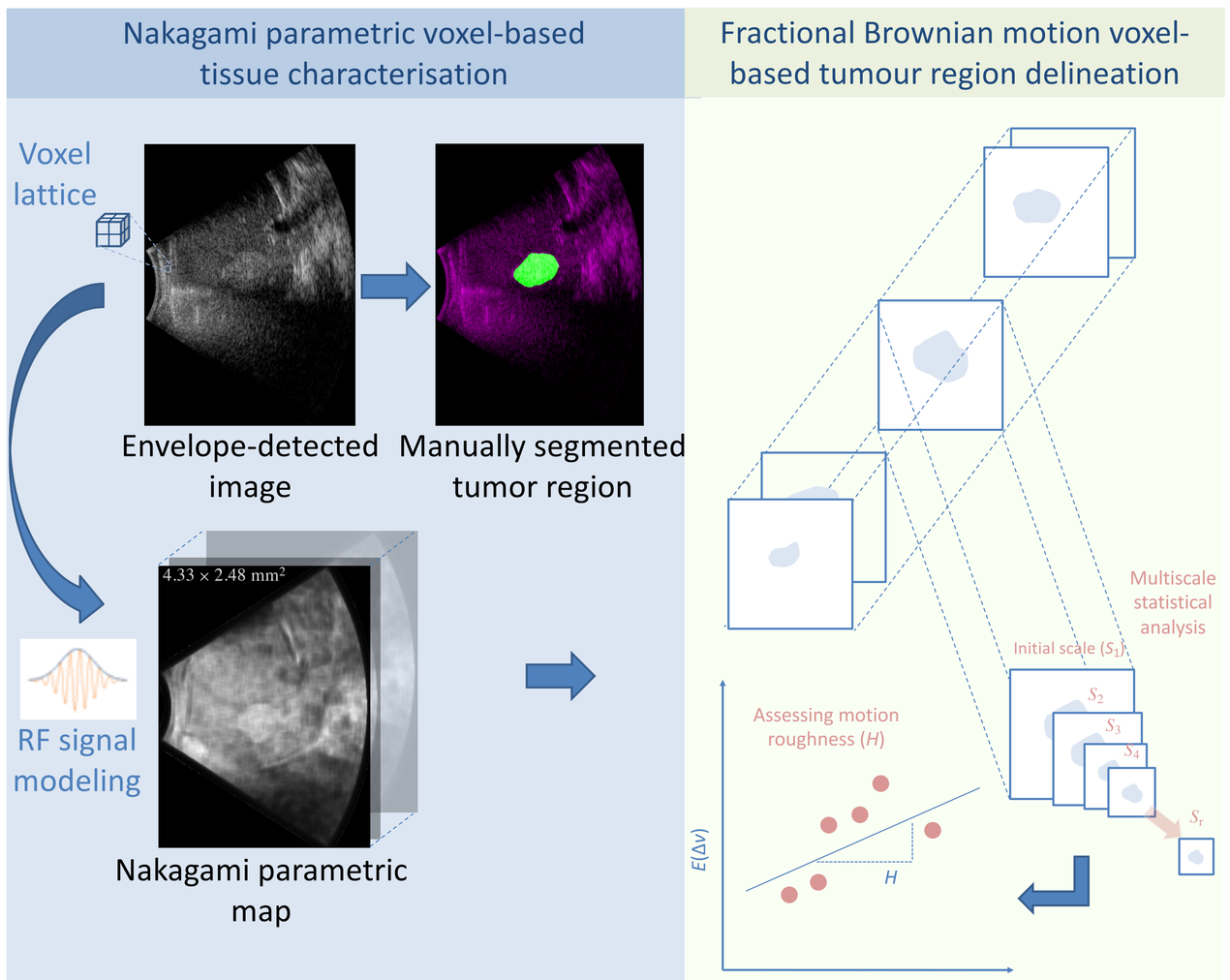

Fig. 2 Two-stage segmentation process by (a) Nakagami distribution for tissue characterisation, & (b) fractional Brownian motion for multiscale region delineation.

Results

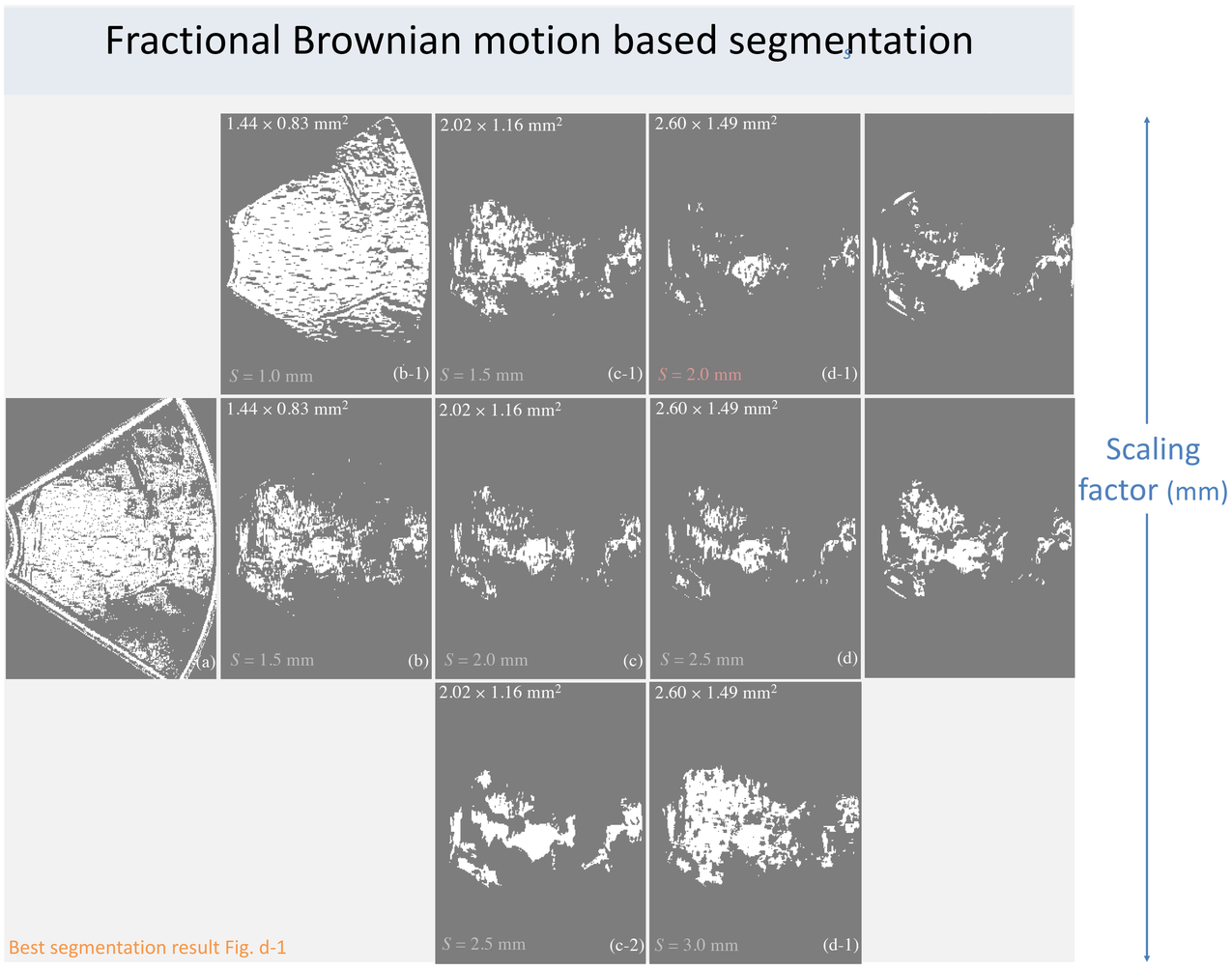

Fig. 3 Segmentation preliminary results with best results shown in (d) with cuboid size 2.60 x 1.49 x 2.00 mm^3 at 2 mm scale depth.

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