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Communication of Multi-Modal Imaging: MRI, MSI, & Histology

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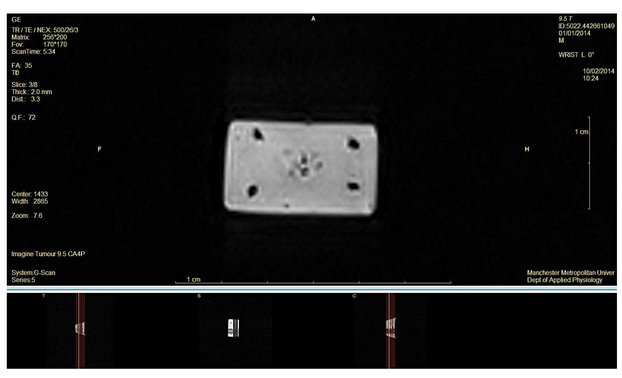
Introduction

MRI is now routinely used in the diagnosis of *in vivo* pathology. Identified lesions may be surgically removed where ex-vivo immunohistochemistry, and increasingly mass spectrometry are performed to confirm MRI findings. Communicating this imaging data is conventionally performed by modality; this research aimed to deliver a proof of concept for multi-modal image presentation and fusion, sensitive to the needs of different audiences.

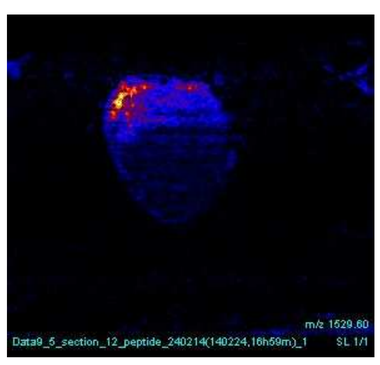
Methods

Tissue was surgically removed from subcutaneously transplanted mouse fibrosarcoma tumours, embedded in gelatin blocks and then frozen with location markers in each corner.

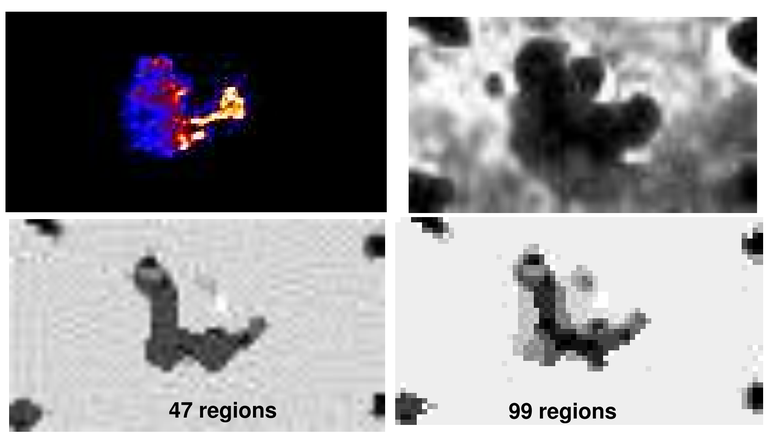
MRI images were acquired using the 0.25T Esaote G-Scan. The sample was centrally placed with a dedicated wrist coil and a range of sequences performed FOV (160x160). Optimal results were achieved from the T2 weighted Gradient Echo (3NEX) and XBone (4NEX) sequences; 2mm slices.



The block was then cryosectioned prior to MALDI MSI data capture. Peptide mass fingerprints and MALDI Images were performed using the Applied Biosystems Q-Star Pulsar I and SYNAPT G2 with ion mobility function. Finally, histological staining of the tissue section was carried out.

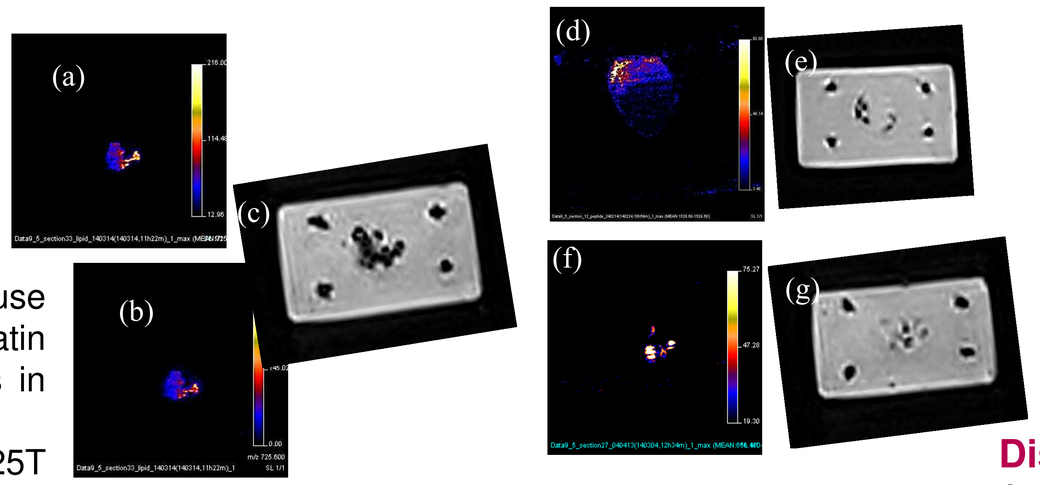


Hierarchical Clustering-based Segmentation[1] (HCS) processing with border pixel recognition was applied to the images.



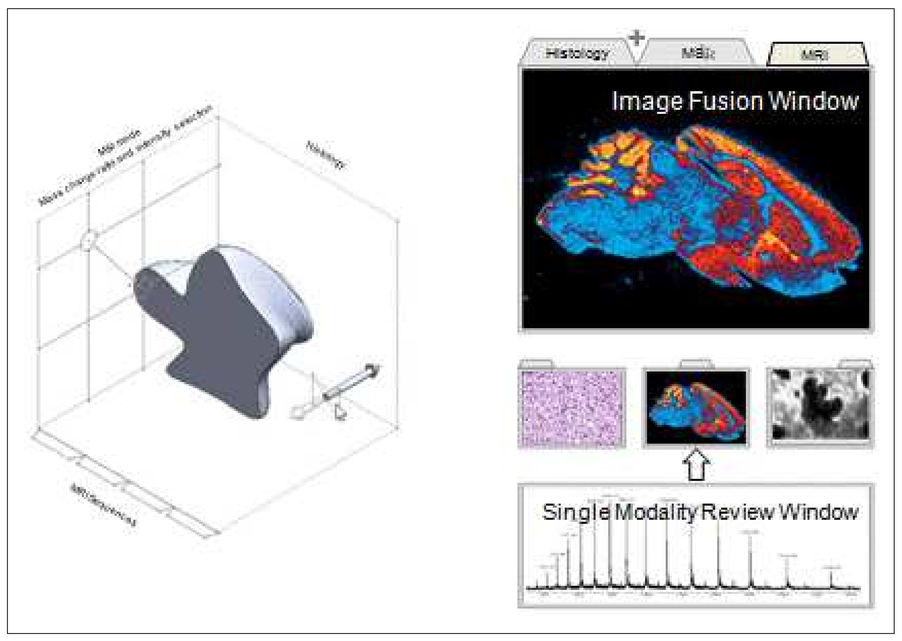
Correlation

Evaluating the multi-modal image slice by slice, possible correlations were identified between the MRI slice and MALDI-MSI data. Ions from abundant lipids (a/b) at m/z 725 and m/z 524 correlated with the MRI image (c). Similarly, the haemoglobin ion (d) with MRI image (e) and an unknown species at m/z 656 (f) correlated with MRI image (g).



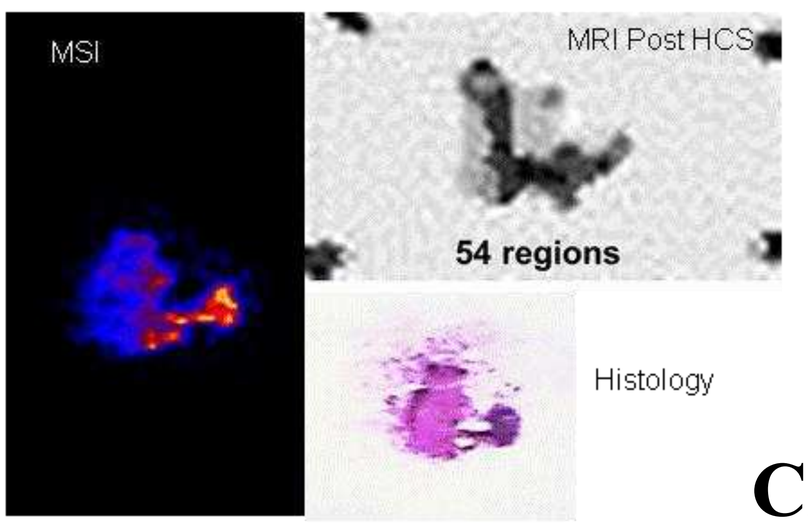
Display

Information can be conveyed in a number of ways and at a number of levels. In this model a 'plane' is assigned to each imaging mode to ground the three dimensional nature of the sample within a tangible environment and provide an interface by which aspects of each mode can be selected for a given slice through the sample.



The slices from each MRI sequence are selectable from the tabs at the bottom left of the model and then scroll through using the floating arrow. The operator can review each imaging mode individually or elect to merge selected slices.

Border pixel recognition, a feature of the HCS processing, simplifies the image fusion process by providing clear edges to similar tissue.



Discussion

As a proof of concept, the design has created a user friendly interface for the display of MRI, MSI & histology images. The next phase is to test acceptance with professional and lay audiences.

The evidence clearly demonstrates the heterogeneous nature of tumour tissue and identifies zone specific activity. The MRI images had a spatial resolution of 500micron dictated by the magnetic field strength.

Future studies will aim to utilise higher field strength devices capable of delivering 100micron which will improve post processing capability due to the reduced pixel size, and also consider the development of pulse sequences adapted for purpose. Additionally the potential to correlate in-vivo diagnostic MRI with the ex-vivo techniques.

Graphical communication is a key step in demonstrating the effectiveness of surgery, and/or drug or radiotherapy. The opportunity to visualise viable tissue from an excised treated tumour could provide medical professionals and patients with information relating to the success or failure of an anti-cancer treatment, as a complimentary test for tumour boundary analysis.

In an environment where patients are expecting increasingly more information about their condition and care pathway, this tool offers the potential for visual multi-model confirmation of findings. Both normal and abnormal tissue are clearly identified, confirmed by multiple tests, enabling the healthcare professional to easily demonstrate to the patient the effects of treatment.

Further development and research is ongoing.

References

[1] "Hierarchical Clustering-based Segmentation (HCS) Aided Diagnostic Image Interpretation and Monitoring" Doctoral dissertation, Faculty of Arts Computing Engineering and Sciences Sheffield Hallam Univ., Sheffield, UK, 2012.

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