MR Image Guided Composite Imaging Data Visualization

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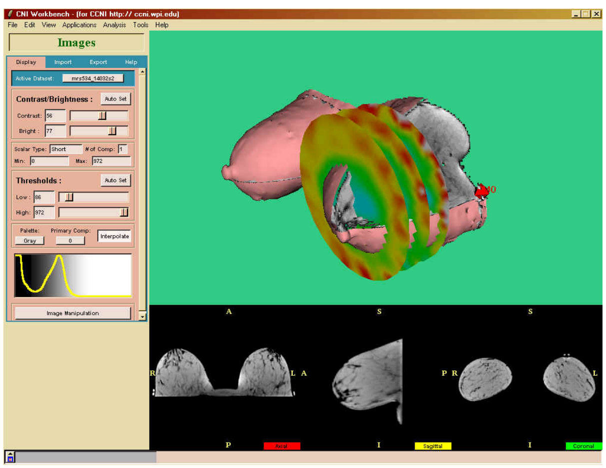
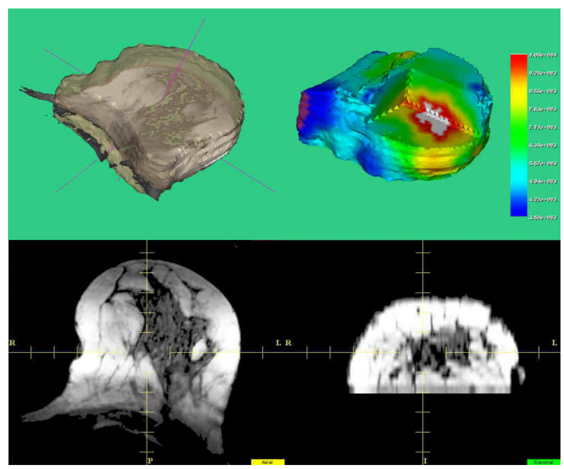
Introduction: New imaging modalities, such as magnetic resonance elastography (MRE), electrical impedance spectroscopy (EIS), microwave imaging and spectroscopy (MIS), near-infrared (NIR), are under development[1,2]. The physical properties, such as shear modulus, conductivity, etc., derived from these new imaging technologies help to classify tissue abnormality and identify tumor/cancer locations. Unlike traditional medical imaging modalities (MRIs, CT, US), these alternative imaging data are within their respective parameter spaces. In this study, composite datasets from different imaging modalities are visualized in a workspace combined with image and geometry spaces. MR Image data is used as the 'gold standard' for the registration processes. The composite data display for various physical properties reveals the correlations between imaging modalities for tissue classification.

Methods: The reference geometry is created initially based on MRI dataset through an interactive segmentation process that extracts the boundary profiles of the regions of interest. The surface mesh models are generated using Multiple-Material Marching-Cubes algorithm (M3C) that defines the boundary for the volume of interest (VOI) [3]. For datasets rendered in geometry space, tetrahedral mesh model is generated using an automatic mesh generator[4]. Subsequently, a registration process is applied to align all datasets into the workspace. Both automated and interactive registration routines are available for image/image and image/geometry registrations. Fiducial marks can be inserted into the reference model to facilitate the registration process. Once datasets are aligned, the composite data are rendered into the workspace for visualization. The visibility of the image datasets and geometric entities in the display list can be toggled individually. Clipping planes are used to visualize the internal scalar distribution within a solid geometry.

Results: Magnetic resonance elastography (MRE) and microwave imaging & spectroscopy (MIS) are alternative imaging modalities targeting breast cancer detection. To identify the location of tissue abnormality, MRI scans are taken as the reference dataset. The left figure displays the microwave imaging result wherein the permittivity of breast tissue is predicted and displayed on the concentric disks registered to the MRI volume[1]. Cutting planes through the volume depict the tissue property variations as do the axial, sagittal, and coronal views below the 3D rendering. Surface geometry was generated based on the images and fiducial marks strategically placed, i.e. the red dot on right side of the 3D rendering.





The right figure is the result from MRE measurements. T_2*-weighted breast MRI data (bottom row) were acquired for surface boundary extraction (upper left). The elastic properties of breast tissue are studied by measuring the tissue displacement when subject to periodic vibrations[2]. A tetrahedral mesh system was generated with 16,846 nodes and 89,075 elements. Shear modulus of the breast tissue was reconstructed from the FEM simulation. The volume mesh with the post-process result of shear modulus is displayed at upper right corner of the figure. The clipping function was turned on to show the internal distribution of the shear modulus.

Conclusions: Composite imaging data based on standard MRI were formed by registering each modalities and merging the results into a common workspace. The composite data visualization can reveal the correlations between the alternative imaging modalities and facilitate enhanced tissue characterization.

References: 1) K. D. Paulsen, P. M. Meaney, "Nonactive antenna compensation for fixed-array microwave imaging - Part I: Model development," *IEEE Transactions on Medical Imaging*, vol. 18, pp. 496-507, June, (1999). 2) Van Houten, E.E.W., Miga M.I., Weaver J.B., Paulsen K.D. ``A Three Dimensional Subzone Based Reconstruction Algorithm for MR Elastography," *Mag. Reson. in Med.* 45(5), 2001. 3) Wu, Z. and J.M. Sullivan, Jr., "Multiple material marching cubes algorithm", IJNME, V58, pg 189-207, (2003). 4) Zhang, J.Q., Sullivan, J.M. Jr. and Wu, Z., "Coupled 3D Mesh Generation and Registration for the Human Brain", 7th US Nat. Congress Comp Mechanics 2003, Aug. 2003.