**CAROTID PLAQUE CHARACTERIZATION WITH MEDICAL ULTRASOUND**by  
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**Abstract**

The most common cause of episodic stroke and cerebral ischemia is thought to be microemboli from carotid plaque. The bifurcation at the carotid bulb is a location prone to atherosclerosis. Some carotid plaques may be prone to rupture, which generates thrombi or plaque particulate that produce neural infarction. There is a significant clinical need for a method to determine which plaques are vulnerable to disruption so that surgical intervention or other prophylactic actions can be taken. In this dissertation, advances in diagnostic ultrasound imaging tools to address this need are proposed.

Focus is placed primarily on non-invasive, *in vivo* strain imaging techniques to quantify plaque vulnerability. It is hypothesized that strain, the mechanical distortion of tissue, is a direct measure of the tissue’s proximity to fatigue failure. A hierarchical block-matching motion tracking algorithm is developed. Displacements are estimated with improved robustness and precision by utilizing a Bayesian regularization algorithm and an unbiased subsample interpolation technique. A modified least-squares strain estimator is proposed to estimate strain images from a noisy displacement input while addressing the motion discontinuity at the wall-lumen boundary. Methods to track deformation over the cardiac cycle incorporate a dynamic frame skip criterion to process data frames with sufficient deformation to produce high signal-to-noise displacement and strain images. Algorithms to accumulate displacement and/or strain on particles in a region of interest over the cardiac cycle are described. New methods to visualize and characterize the deformation measured with the full 2D strain tensor are presented.

Other diagnostic ultrasound techniques, high-frequency 3D ultrasound and transcranial Doppler ultrasound, which have the potential to support the strain findings, are also studied. Experimental methods to characterize the high-frequency acoustic properties of a tissue-mimicking reference phantom are shown to be effective. The reference phantom is used to create 3D integrated backscatter coefficient images of excised carotid plaques. Transcranial Doppler is studied as method to detect intracranial microemboli and blood flow-dynamics.

Initial results from patients imaged prior to endarterectomy suggest that strain imaging detects conditions that are traditionally considered high risk including soft plaque composition, unstable morphology, abnormal hemodynamics, and shear of plaque against tethering tissue that can be exacerbated by neoangiogenesis. Non-invasive carotid strain imaging is a potentially useful tool for detecting unstable carotid plaque.

**Contents**

**Abstract**

**Acknowledgements**

**Contents**

**List of Figures**

**List of Tables**

**Chapter 1 : Objectives 1**

* 1. Research Statement 1
  2. Organization of the Dissertation 1

**Chapter 2 : Human Health Significance 3**

2.1 Etiology of stroke and the role of atherosclerotic plaque 3

2.2 Clinical carotid ultrasound and plaque characterization 7

2.2.1 Vulnerable plaque 7

2.2.2 Plaque characterization with other methods and imaging modalities 9

2.2.3 Plaque characterization with diagnostic ultrasound 16

2.3 References 30

**Chapter 3 : Recursive Bayesian Regularization Applied to Ultrasound Strain Imaging 47**

3.1 Improvement of strain image quality with regularization 48

3.2 Prior efforts in regularization 50

3.3 Recursive Bayesian regularization 54

3.3.1 Algorithm 55

3.3.1 Implementation 58

3.4 Experimental methods and results 59

3.4.1 Uniform strain simulations and phantoms 59

3.4.2 Circular inclusion simulations and phantoms 62

3.4.3 Optimal SRS 67

3.4.4 Addressing a carotid reverberation 70

3.4.5 Improvement of carotid strain images 76

3.5 Discussion 79

3.6 Summary 82

3.7 References 83

**Chapter 4 : Unbiased Subsample Displacement Interpolation 87**

4.1 Previously explored methods for subsample tracking 88

4.1.1 Methods that use properties of cross-correlation 88

4.1.2 Parametric and non-parametric methods 89

4.2 2D sinc interpolation with numerical optimization 91

4.3 Numerical properties of 2D sinc interpolation 92

4.3.1 Motion tracking algorithm used in testing 92

4.3.2 Tissue-mimicking phantom 94

4.3.3 Ultrasound mechanics simulation 94

4.3.4 Behavior of optimization methods 95

4.4 Applications of this method 102

4.5 References 104

**Chapter 5 : Calculating Strain From Displacement 108**

5.1 The strain tensor 108

5.1.1 Mechanical model 108

5.1.2 Application in ultrasound 121

5.2 Methods for estimating strain from displacement 125

5.2.1 Finite difference based methods 129

5.2.2 Derivative of Gaussian 133

5.2.3 A modified least-squares strain estimator 135

5.2.4 B-spline fitting 139

5.3 Useful quantities derived from the strain tensor 142

5.3.1 Principal strains 142

5.3.2 Representation of the 2D strain tensor as an ellipse 143

5.3.3 Combination of normal strains and shear strain into a single strain index146

5.4 Generating accumulated strain from a time series 148

5.4.1 Dynamic frame skip 148

5.4.2 Eulerian approach to accumulated strain 151

5.5 References 153

**Chapter 6 : High Frequency Phantom Characterization 157**

6.1 Tissue-mimicking phantoms 158

6.2 Attenuation characterization 159

6.3 Phase velocity characterization 169

6.4 Absolute backscatter estimation 173

6.4.1 Generation of spectra 174

6.4.2 Faran scattering model 179

6.4.3 Backscatter coefficient results 180

6.5 References 183

**Chapter 7 : High-frequency Plaque Characterization 186**

7.1 Creation of parametric images of excised plaque 124

7.2. B-Mode image creation 127

7.3 3D high frequency plaque volumes 134

7.4 References 181

**Chapter 8 : Transcranial Doppler Monitoring of the Middle Cerebral Artery 183**

8.1 Physiological insights from transcranial Doppler 184

8.2. Methods to increase robustness of unstable data 187

8.2.1 Examination room protocol 192

8.2.1 Retrospective inspection 192

8.3 Microemboli and peak velocity results 190

**Chapter 9 : *In vivo* Quantification of Carotid Plaque Strain 221**

9.1 Strain estimation algorithm 221

9.1.1 Hierarchical framework

9.1.2 Displacement estimation

9.1.3 Strain estimation

9.1.4 Calculation of derived quantities

9.2 Subject case studies

9.2.1 Subject 999

9.3 References

**Chapter 10 : Contributions of this Dissertation & Future Work 221**

9.1 Contributions of this Dissertation 221

9.2 Future Work 224

**List of Figures**

Fig. 3.1 *SNRe* for different regularization methods. 62

Fig. 3.2 Phantom axial strain images for different regularization methods. 65

Fig. 3.3 Simulation axial strain images for different regularization methods. 65

Fig. 3.4 Inclusion MARD for different regularization methods. 66

Fig. 3.5 Error measure versus SRS. 68

Fig. 3.6 SRS variation with algorithm parameters. 69

Fig. 3.7 Matching-block and search region in a carotid B-Mode. 71

Fig. 3.8 Probability image for the matching kernel’s displacement. 72

Fig. 3.9 Carotid ROI at iteration 0. 73

Fig. 3.10 Carotid ROI at iteration 1. 73

Fig. 3.11 Carotid ROI at iteration 2. 74

Fig. 3.12 Carotid ROI at iteration 3. 74

Fig. 3.13 Carotid axial strain for different regularization methods. 76

Fig. 3.14 Liver ablation axial strain for different regularization methods. 78

Fig. 4.1 *SNRe* performance of subsample interpolation methods. 97

Fig. 4.2 Subsample interpolation methods on axial inclusion strain image. 99

Fig. 4.3 Sinc window type and lateral *SNRe*. 100

Fig. 4.4 Sinc window radius and lateral *SNRe.* 101

Fig. 4.5 Convergence verse initial simplex offset. 102

Fig. 5.1 Solid body displacement. 109

Fig. 5.2 Solid body segment displacement. 110

Fig. 5.3 Solid body two differential segments. 112

Fig. 5.4 Solid body change in inner product. 114

Fig. 5.5 Solid body segments orthogonal in the reference configuration. 115

Fig. 5.6 Solid body identical segments in the deformed configuration. 119

Fig. 5.7 Diagnostic linear ultrasound array. 123

Fig. 5.8 Mechanical model of cylindrical inclusion. 126

Fig. 5.9 Inclusion ideal input displacements. 127

Fig. 5.10 Inclusion ideal input strain. 127

Fig. 5.11 Inclusion Pre- and post-deformation RF images. 128

Fig. 5.12 Inclusion tracked displacements. 129

Fig. 5.13 Inclusion central difference strains. 130

Fig. 5.14 Inclusion higher-order accurate strain. 133

Fig. 5.15 Inclusion derivative of Gaussian strain. 135

Fig. 5.16 Inclusion strain linear least-squares strain. 137

Fig. 5.17 Discontinuity in carotid displacement. 138

Fig. 5.18 Modified linear least-squares and carotid displacement discontinuity. 139

Fig. 5.19 Inclusion B-spline strains. 140

Fig. 5.20 Inclusion strain tensor ellipses. 146

Fig. 5.21 Dynamic frame skip. 150

Fig. 6.1 Phantom glass bead size distributions. 159

Fig. 6.2 High-frequency narrowband substitution apparatus. 160

Fig. 6.3 Substitution method transducers’ impulse responses. 162

Fig. 6.4 Narrowband waveform averaging. 163

Fig. 6.5 Narrowband waveform amplitudes changes with frequency. 164

Fig. 6.6 Narrowband spectrogram. 165

Fig. 6.7 Saran transmission coefficient changes with frequency. 167

Fig. 6.8 High-frequency attenuation coefficients. 169

Fig. 6.9 Velocity delay locations. 171

Fig. 6.10 5000E phase velocity vs. frequency. 173

Fig. 6.11 Phantom and reflector power spectra. 175

Fig. 6.12 Reflector spectrum harmonics. 176

Fig. 6.13 Phantom and reflector waveforms. 178

Fig. 6.14 Vevo 770 Digital-RF mode screenshots. 178

Fig. 6.15 Absolute backscatter coefficients. 181

Fig. 7.1 B-mode image of *in-vivo* liver data for Patient 17 129

Fig. 7.2 Normalized power spectra vs. gated window size 131

Fig. 7.3 B-mode and attenuation estimation results for Patient 17 133

Fig. 7.4 B-mode and attenuation estimation results for Patient 33 138

Fig. 7.5 B-mode and attenuation estimation results for Patient 20 140

Fig. 7.6 B-mode and attenuation estimation results for Patient 27 142

Fig. 7.7 B-mode and attenuation estimation results for Patient 32 144

Fig. 7.8 B-mode and attenuation estimation results for Patient 21 146

Fig. 7.9 B-mode and attenuation estimation results for Patient 19 148

Fig. 7.10 B-mode and attenuation estimation results for Patient 18 150

Fig. 7.11 B-mode and attenuation estimation results for Patient 22 152

Fig. 7.12 B-mode and attenuation estimation results for Patient 30 154

Fig. 7.13 B-mode and attenuation estimation results for Patient 35 156

Fig. 7.14 B-mode and attenuation estimation results for Patient 31 158

Fig. 7.15 B-mode and attenuation estimation results for Patient 13 160

Fig. 7.16 B-mode and attenuation estimation results for Patient 23 163

Fig. 7.17 B-mode and attenuation coefficient images for Patient 23 164

Fig. 7.18 B-mode and attenuation estimation results for Patient 28 166

Fig. 7.19 B-mode and attenuation coefficient images for Patient 28 167

Fig. 7.20 B-mode and attenuation estimation results for Patient 29 169

Fig. 7.21 B-mode and attenuation coefficient images for Patient 29 170

Fig. 7.22 B-mode and attenuation estimation results for Patient 36 172

Fig. 7.23 B-mode and attenuation coefficient images for Patient 36 173

Fig. 7.24 B-mode image of *in-vivo* liver hemangioma 176

Fig. 7.25 Attenuation estimation results of the patient with liver hemangioma 177

Fig. 7.26 Logarithm of power spectra of reference and sample and center

frequency changes vs. depth 180

Fig. 8.1 B-mode images of 10 consecutive RF frames 188

Fig. 8.2 Full frame averaged B-mode image obtained 10 consecutive frames 189

Fig. 8.3 B-mode and attenuation estimation results for Patient 9 194

Fig. 8.4 B-mode and attenuation estimation results for Patient 12 196

Fig. 8.5 B-mode and attenuation estimation results for Patient 13 198

Fig. 8.6 B-mode and attenuation estimation results for Patient 21 200

Fig. 8.7 B-mode and attenuation estimation results for Patient 29 201

Fig. 8.8 B-mode and attenuation estimation results for Patient 38 204

Fig. 8.9 B-mode and attenuation estimation results for Patient 15 205

Fig. 8.10 B-mode and attenuation estimation results for Patient 31 206

Fig. 8.11 B-mode and attenuation estimation results for Patient 32 208

Fig. 8.12 B-mode and attenuation estimation results for Patient 20 with DCIS 210

Fig. 8.13 B-mode and attenuation estimation results for Patient 27 213

Fig. 8.14 B-mode and attenuation estimation results for Patient 33 214

Fig. 8.15 B-mode and attenuation estimation results for Patient 35 215

Fig. 8.16 B-mode image of *in-vivo* breast mass 217

Fig. 8.17 Logarithm of power spectra of reference and sample and center

frequency changes vs. depth 219

**List of Tables**

Table 4.1 Sinc window functions 92

Table 4.2 Interpolation times. 102

Table 5.1 Higher order accurate derivative coefficients. 130

Table 6.1 Phantom power law attenuation fits. 169

Table 4.4 Estimated attenuation coefficients of TM phantom 69

Table 5.1 Estimated attenuation coefficients and standard deviations 93

Table 7.1 Attenuation coefficients measured in normal and diffuse liver tissue 125

Table 7.2 Attenuation coefficients measured in liver tumors 126

Table 7.3 Pathological results obtained after biopsy for the patient *in-vivo*

liver data 136

Table 8.1 Representative values of attenuation coefficient for breast tissue 185

Table 8.2 Attenuation properties for breast tumors based on qualitative

B-mode analysis from Rotstein and Neerhut 186

Table 8.3 Pathological results obtained following biopsy from *in-vivo*

breast data 191