**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 186

7.2. B-Mode image creation 189

7.3 3D high frequency plaque volumes 191

7.4 References 199

**Chapter 8 : Transcranial Doppler Monitoring of the Middle Cerebral Artery 200**

8.1 Physiological insights from transcranial Doppler 200

8.2. Methods to increase robustness of unstable data 202

8.2.1 Examination room protocol 202

8.2.1 Retrospective inspection 204

8.3 Microemboli and peak velocity results 207

8.4 References 212

**Chapter 9 : *In vivo* Quantification of Carotid Plaque Strain 215**

9.1 Hierarchical framework 215

9.1.1 Multi-level motion tracking 215

9.1.2 Search region refinement 218

9.1.3 Inter-level matching-block scaling 219

9.2 Displacement estimation 220

9.3 Strain estimation 223

9.4 Calculation of derived quantities 224

9.5 *In vivo* case studies 231

9.5.1 Hypoechoic plaque with high strain 231

9.5.2 Importance of morphology 233

9.5.3 Strain with turbulent flow 235

9.5.4 Strain at the plaque-adventitia interface 237

9.5.5 Calcified plaque with shadowing 239

9.5.6 Artifact from out-of-plane motion 241

9.6 References 243

**Appendix A : High-frequency 3D Data Analysis 246**

A.1 Collection and analysis of 3D RF data 246

A.1.1 VisualSonics Vevo 770 system 246

A.1.2 File storage and metadata extraction 249

A.1.3 Scan conversion and volume concatenation 254

A.1.4 Data streaming. 257

A.2 Future Work 224

**Appendix B : In vivo Plaque Strain Estimates 261**

**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 High-frequency plaque scanning apparatus. 187

Fig. 7.2 RF signal and its envelope. 189

Fig. 7.3 Subject 142 gross pathology and 3D ultrasound. 192

Fig. 7.4 Subject 144 gross pathology and 3D ultrasound. 193

Fig. 7.5 Subject 154 gross pathology and 3D ultrasound. 196

Fig. 7.6 Subject 158 gross pathology and 3D ultrasound. 198

Fig. 8.1 TCD velocity waveforms. 205

Fig. 8.2 Example content of Multidop-L2 *TX?* file. 207

Fig. 9.1 Scale-space images for multi-resolution motion tracking. 217

Fig. 9.2 Improvements in *SNRe* from inter-level matching-block scaling. 220

Fig. 9.3 Displacement estimation parameter configuration file. 223

Fig. 9.4 Strain estimation parameter configuration file. 224

Fig. 9.5 Subject 157 ROIs. 225

Fig. 9.6 Axial strain curves from Subject 157. 226

Fig. 9.7 Shear strain curves from Subject 157. 227

Fig. 9.8 Lateral strain curves from Subject 157. 227

Fig. 9.9 Strain metric curves from Subject 157. 230

Fig. 9.10 Hypoechoic plaque with high strain. 232

Fig. 9.11 Importance of morphology. 234

Fig. 9.12 Strain with turbulent flow 236

Fig. 9.13 Strain at the plaque-adventitia interface 238

Fig. 9.14 Calcified plaque with shadowing 240

Fig. A.1 VisualSonics Vevo 770 246

Fig. A.2 Vevo 770 transducer and stepper motor. 248

Fig. A.3 Vevo 770 Digital-RF user interface. 250

Fig. A.4 Example data from a Vevo 770 .rdi file. 252

Fig. A.5 Transformation of header file into XML format. 253

Fig. A.6 Rendered html version of header file. 254

Fig. A.7 Vevo 770 transducer geometry. 256

Fig. A.8 Streaming of MRI images subject to an affine transform. 258

Fig. A.9 Peak memory usage when changing the number of frames per stream. 259

**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 8.1 TCD detected microemboli HITS per subject. 208

Table 8.2 MCA peak velocities. 211

Table 9.1 Downsampling schedule for multi-resolution image registration. 218

Table B.1 Maximum absolute principal strain estimates. 261

Table B.2 Maximum shear strain estimates. 265

Table B.3 Distortional energy estimates. 269

Table B.4 Total strain energy estimates. 272

Table B.5 Lateral strain estimates. 276

Table B.6 Shear strain estimates. 280

Table B.6 Axial strain estimates. 284