THE DEPARTMENT OF CIVIL ENGINEERING

AND

ADVISOR SOMNATH GHOSH, PROFESSOR

ANNOUNCE THE THESIS DEFENSE OF
Doctoral Candidate

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"Multi-Temporal Multi-Physics Computational Framework For Fully Coupled Electric, Magnetic and Mechanical Systems With Evolving Damage"

Multi-functional devices that integrate electromagnetic and mechanical fields are gaining importance in a wide variety of applications. The combined mechanical and electromagnetic regimes, encompassed in these structures, make it necessary to develop effective multi-physics analysis tools at a range of temporal scales. An important consideration is that the different fields governing multi-physics response may have large frequency discrepancies, e.g. the ultra-high electromagnetic frequencies and moderate vibration frequencies. Computational analyses of these discrepant frequency problems using conventional time integration schemes can become intractable.

This dissertation develops an accurate and efficient, multi-time scale computational framework for fully coupled multi-physics analysis involving transient electromagnetic (EM) and dynamic mechanical (ME) fields with evolving damage constitutive laws. The computational method provides a flexible and robust platform for

- Transient antenna simulations: Coupled transient electromagnetic (EM)-dynamic mechanical (ME) fields in finite deformation.
- Transient finite strain piezoelectricity: Coupled transient electrical- dynamic mechanical (ME) fields in finite deformation with damage constitutive equations.

The present model is capable of predicting time-dependent electromagnetic fields in a vibrating antenna for a range of high frequency electromagnetic fields and moderate frequency mechanical excitations. A key development in this dissertation is the wavelet transformation induced multi-time scaling or WATMUS method. This method is designed to overcome serious shortcomings of modeling coupled multi-physics problems that are governed by disparate frequencies.

The present model also provides a fully coupled 2-scale WATMUS-based FE model for simulating transient finite strain piezoelectric problems with evolving damage. The 2-scale WATMUS-based FE model facilitates computational modeling of transient piezoelectric applications undergoing sub-critical progressive damage for a large number of mechanical cycles with highly disparate electro-mechanical excitation frequencies, e.g. $\frac{\omega_e}{\omega_{me}} > 10^4$. This model accelerates the time-integrations in the high frequency oscillations regime using the 1-scale WATMUS following a subsequent WATMUS scheme to speed up the simulations in the low frequency regime.

Thesis Committee

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