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Particle Filtering Based Structural Assessment with Acoustic Emission Sensing

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Nuclear structures are designed to withstand severe loading events under various stresses. Over time, aging of structural systems constructed with concrete and steel will occur due to corrosion of reinforcement [1], alkali-silica reaction [2], and other mechanisms. This deterioration of structural integrity, if not detected in time, may reduce service life of nuclear facilities and/or lead to unnecessary or untimely repairs. For this reason, online monitoring of structures in nuclear power plants and waste storage has drawn significant attention in recent years [3]. Of many existing non-destructive evaluation (NDE) approaches, acoustic emission is promising for assessment of structural damage because it is non-intrusive and is sensitive to corrosion and crack growth in reinforced concrete elements.

To provide a rapid, actionable, and graphical means for interpretation of acoustic emission data, Intensity Analysis plots have been developed [1]. This approach provides a means for classification of damage. Since the acoustic emission measurement is only an indirect indicator of structural damage, potentially corrupted by non-genuine data, it is suitable to estimate the states of corrosion and cracking in a Bayesian estimation framework. In this paper, we will utilize the structural accelerated corrosion data from a specimen at the University of South Carolina to develop a particle filtering-based diagnosis and prognosis algorithm [4]. The promising features of the proposed algorithm will be demonstrated from two aspects: one is that it is able to provide a more accurate estimation of corrosion state; and the other is that it is able to predict the service time when the structural strength, defined by cross-sectional area reduction, degrades to a predefined threshold. The paper will formulate the structural health monitoring problem with a particle filtering algorithm, investigate the corrosion degradation modeling, design the diagnostic and prognostic algorithms, and define performance metrics for verification and validation. The results will also be compared with the Intensity Analysis plot approach.

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