# ABSTRACT

In this work, the electromechanical impedance (EMI) method is utilized for structural health monitoring (SHM) of a range of engineering structures, including metallic beams and plates, composite beams, metallic bolted joints, and composite joints etc. The EMI technique involves measuring the impedance of a piezoelectric transducer usually made of lead zirconate titanate (PZT), which is attached to the structure of interest. The impedance signature is then analyzed to evaluate the health status of the structure i.e. to detect any damage or defects that may have occurred. At first, the forward problem of finding out the electro-mechanical impedance (EMI) responses at different frequencies for diverse damage scenarios in various engineering structures equipped with piezo-electric transducers has been addressed. This is accomplished through integration of numerical, experimental and analytical PZT-structure interaction models. This impedance data is used to form training and test sets for the inverse problem to be solved employing artificial neural network (ANN). Firstly, the issues of multiple damage detection within a structure have been addressed while using minimal number of sensors. This has been possible through addition of cross impedance based features along with traditionally used drive point impedance based features. Secondly, the focus is on the objective of achieving accurate damage detection for practical applications like detection of multiple bolt-loosening while minimizing sensor usage. This is crucial for real-life implementation of EMI-technique where optimum use of sensors can reduce cost and complexity while maximizing the efficiency. Furthermore, dedicated efforts have been made on developing efficient damage indices which can be extracted from simplified and rapid simulations and yet are capable of predicting damage status from experimental data accurately. This strategy has been tested on a composite lap joint. This significantly reduces the computational cost in generating sufficient training data.

**Keywords:** Structural Health Monitoring (SHM); Electro-mechanical Impedance (EMI) technique; artificial neural network (ANN), correlation coefficient (CC), lead zirconate titanate (PZT), root mean square deviation (RMSD), Regression (R); Conductance ($G$); Susceptance ($Y$); Electro-mechanical admittance ($Y$); Electro-mechanical Impedance ($Z$); Non-destructive evaluation (NDE)

Umakanta Meher.