ABSTRACT OF PHD THESIS VIVA-VOCE

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Tensegrities are self-stressed structures characterized by the presence of at least one infinitesimal mechanism stiffened by pre-stress present in the members. While in the absence of this pre-stress, tensegrities seize to exist, the variation in pre-stress can lead to different self-stressed states which must not be confused with a structural anomaly. This unique attribute renders structural health monitoring (SHM) of tensegrities a challenging task. In an attempt to develop a stochastic SHM approach for tensegrities, first, the self-equilibrium nature of tensegrity is studied. Accordingly, a novel form-finding technique ensuring global as well as local stability of tensegrity has been developed.

Since tensegrity's modal properties can change even in the absence of damage, an output-only time-domain and model-based SHM strategy has been adopted that takes the basis of the self-stressed state identified from form-finding. Further real-life uncertainties originating from modeling inaccuracies, measurement noise, etc. are required to be dealt with. Bayesian filtering-based SHM approaches have been perceived as better at addressing these issues. Therefore, an interacting particle ensemble Kalman filter (IPEnKF)-based SHM framework has been developed to handle uncertainties while efficiently estimating tensegrity health.

However, IPEnKF may under-perform due to erroneous measurement data due to faulty sensors, ambient temperature uncertainties, and ill-posedness owing to the high dimensionality of support predictor models. Thus, the developed IPEnKF framework has further been improvised targeting robustness against aforementioned uncertainties. Robustness against data uncertainty due to faulty sensors has been achieved by implementing a switching strategy that enables simultaneous detection of sensor fault and member damage.

Further, the impact of ambient temperature variation has been addressed by incorporating the effect of thermal variation on material and geometric properties in the state predictor model and introducing a multiple-parameter estimation strategy.

Finally, a substructuring technique has been employed to circumvent the effect of high dimensionality in the SHM problem formulation. The need for interface measurement between adjacent substructures has been tackled with an output injection approach, thereby making the proposed approach standalone. Substructuring enables localized subsystem-wise SHM reducing the required instrumentation density while simultaneously improving the developed approach's robustness against thermal variation. The developed methodologies have been numerically validated for different tensegrities, while their generalization capability has been experimentally validated on general civil structures as well.

Keywords – Bayesian filtering, form finding, high dimensionality, interacting particle ensemble Kaman filter, sensor faults, structural health monitoring, substructuring, switching, temperature uncertainty, tensegrity.