Development of Digital Twin Concept to Detect Abnormal Changes in Structural Behaviour

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Abstract : Digital Twin (DT) technology is a new technology that appeared in the early 21st century. The DT is defined as the digital representation of living and non-living physical assets. By connecting the physical and virtual assets, data are transmitted smoothly, allowing the virtual asset to fully represent the physical asset. Although there are lots of studies conducted on the DT concept, there is still limited information about the ability of the DT models for monitoring and detecting unexpected changes in structural behaviour in real time. This is due to the large computational efforts required for the analysis and an excessively large amount of data transferred from sensors. This paper aims to develop the DT concept to be able to detect the abnormal changes in structural behaviour in real time using advanced modelling techniques, deep learning algorithms, and data acquisition systems, taking into consideration model uncertainties. finite element (FE) models were first developed offline to be used with a reduced basis (RB) model order reduction technique for the construction of low-dimensional space to speed the analysis during the online stage. The RB model was validated against experimental test results for the establishment of a DT model of a two-dimensional truss. The established DT model and deep learning algorithms were used to identify the location of damage once it has appeared during the online stage. Finally, the RB model was used again to identify the damage severity. It was found that using the RB model, constructed offline, speeds the FE analysis during the online stage. The constructed RB model showed higher accuracy for predicting the damage severity, while deep learning algorithms were found to be useful for estimating the location of damage with small severity.