DTU Library

Sparse measurement-based estimation of fatigue-induced crack growth in joints of jacket structures

Al-Hagri, Ammar; Stang, Henrik; Kolios, Athanasios; Katsanos, Evangelos

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

Sparse measurement-based estimation of fatigue-induced crack growth in joints of jacket structures

Ammar Al-Hagri, Henrik Stang, Athanasios Kolios and Evangelos Katsanos

Offshore jacket structures face daily operational and safety challenges stemming from exposure to adverse environmental conditions, including excessive wave heights, structural aging, and other deterioration mechanisms primarily driven by fatigue-induced crack propagation within structural joints. Furthermore, the remote placement of the offshore installations, often located miles from the coastline, yields obstacles to efficient inspection and maintenance schemes. Furthermore, the marine environment disfavors the proper monitoring of those structures since the reliable and continuous operation of sensors is hindered, especially in the submerged part of the structure. These constraints heighten the risk of structural damages and their progression to critical failures, collectively endangering the functionality, integrity, and safety of these infrastructures. To address these challenges, this project is dedicated to developing a data-driven framework oriented to predict fatigue-induced damage in structural joints, especially for those located in hard-to-access locations (e.g., submerged joints). The methodology to be developed aims to identify the accumulated fatigue-induced damage at structural joints by fusing: i) a Kalman Filter (KF)-based state estimation scheme, ii) a multi-fidelity finite element (FE) analysis, iii) a supervised Machine Learning (ML) algorithm. Concerning the multi-fidelity FE analysis, it will consist of a low-fidelity FE model simulating the response of the entire offshore jacket structure (at a global level). Additionally, a high-fidelity FE model will be developed to simulate the response of the joints (at a local level) and the gradual fatigue-induced damage development, i.e., crack propagation data. Such a multi-fidelity simulation scheme will allow for generating data to train the ML algorithm, for which various joint configurations will be considered under exposure to different load conditions. After the training phase of the ML algorithm, the KF-based state estimation coupled with the low-fidelity FE model will be exploited to estimate via sparse measurements the structural response in locations of the structure where sensors are not expected to be placed. Then, the estimated responses of the structure will be used as input to the trained ML algorithm, predicting, in turn, the damage development, namely fatigue-induced crack growth at the joint. Such a combination of advanced state estimation technique, a multi-fidelity FE analysis, and the ML algorithm is anticipated to allow for accurate identification of damage resulting from fatigue loads.