Fatigue life prediction in plate structure based on crack propagation

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Abstract

The lifetime of most engineering structures and components is known to depend on the presence of defects, such as holes, cracks, or voids usually introduced during a manufacturing process. In this paper, a simple two-step method for plate structural with crack fatigue life prediction has been proposed. The first step is the application of the extended finite element method (XFEM) to mode the crack propagation and obtained the stress intensity factor (SIF). The second step is the employment of support vector regression (SVR) and the crack growth rate to predict the fatigue life from the severity cracks numerical model database. Currently, many numerical computation methods used in the study of fracture mechanics, such as finite element method, boundary element method, element-free method, numerical manifold method, and wavelet method, XFEM, etc. The present paper proposes the XFEM combined with the level set method to mode the fracture direction of propagation within a specimen, and to compute the stress intensity factor (SIF) for cracked plates under a cyclic tension load. The XFEM alleviates the challenges associated with the mesh conforming to the geometry by allowing discontinuities or other localized phenomena to be represented independent of the finite element mesh. In the XFEM method, a standard displacement based finite element approximation is enriched by additional functions as long as the partition of unity is satisfied. The goals and scope of this work are focused on accurate modeling of fatigue crack growth under constant and variable amplitude loading for complex geometries with computational efficiency and high accuracy. Support vector machine (SVM) is supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. SVR has been used for predictive data analysis with many applications in various areas of study. The SVR allows one to extrapolate ahead of the current data point, enabling the use of the method for the evaluation of both stress intensity factor and the fatigue life. Then, the numerical results provided by the XFEM are compared with the theoretical predictions from the handbooks.

Keywords: plate structure; XFEM; crack propagation; support vector regression; stress intensity factor; crack growth rate; life prediction.

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