A prediction method of crack initiation lifetime in fretting fatigue

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Introduction of background and method

Fretting fatigue is a kind of destructive failure form, which easily occurs on the assembly parts in the aerospace field.

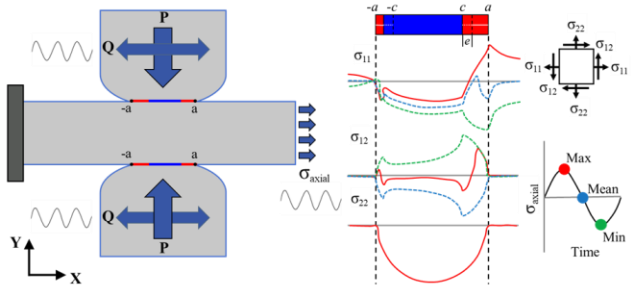
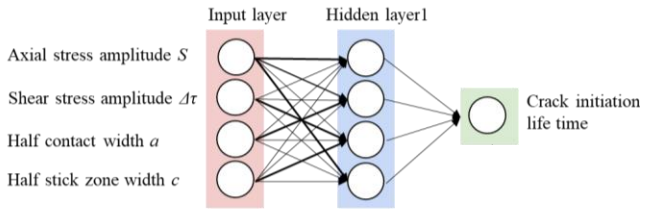


Fig.1. Schematic of fretting fatigue test and stress field along the contact surface

This work selects four parameters from analytical solutions as input features of artificial neural network (ANN). All these features have both global and local characteristics, they are deduced from the loading parameters imposed on the components, and can also deduce these mechanical parameters near the crack initiation location.

Artificial neural network (ANN)



Balancing composite motion optimization (BCMO) algorithm [1,2]

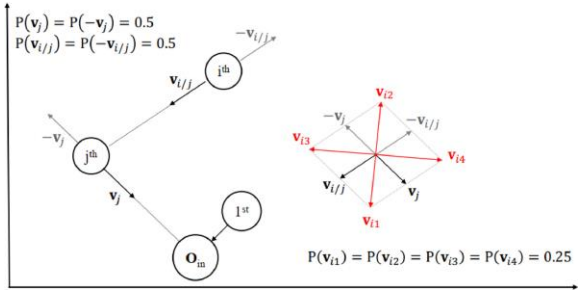


Fig.2. Schematic of artificial neural network and Balancing composite motion optimization algorithm [1,2]

Results and discussion

ANN searches for the best value by calculating gradient descent in a local zone, while ANN-BCMO obtains the best prediction based on global search [3,4].

Different data-process methods are used for ANN and ANN-BCMO according to the characteristics of algorithms, which makes the loss of training located in different scales.

With support of the BCMO optimization algorithm, ANN-BCMO could provide stable predictions which are similar to the best prediction from ANN.

The predictions of ANN-BCMO are closer to the experimental value, and the computation time of ANN-BCMO is less than that of FEM. Therefore, ANN-BCMO has more advantages in the prediction of crack initiation lifetime in fretting fatigue.

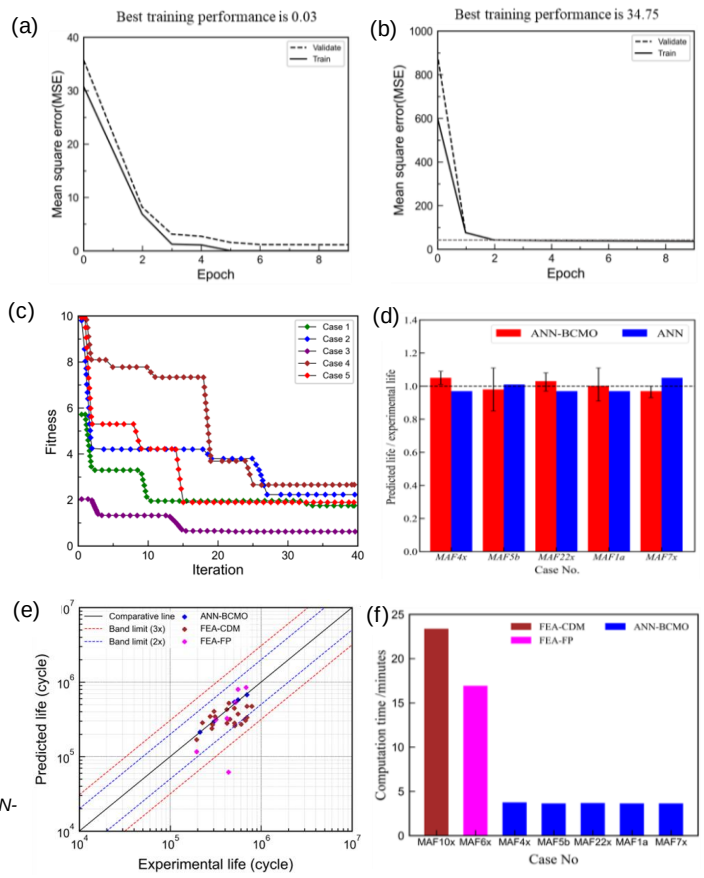


Fig.3. Results: (a) training process of ANN,(b) training process of ANN-BCMO, (c)fitness of ANN-BCMO, (d) comparison between ANN and ANN-BCMO, (e) comparison of prediction accuracy from ANN-BCMO and FEM method, (f) comparison of computation efficiency of ANN-BCMO and FEM method

Conclusions and references

Although the combination of numerical and theoretical models can already predict the fretting fatigue crack initiation life, its accuracy is limited. Taking the advantage of theoretical solutions, a higher prediction accuracy with higher robustness has been realized by ANN-BCMO.

Compared with the currently popular numerical methods, machine learning has higher prediction efficiency and is more friendly for engineering applications.

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[2] Le-Duc T, Nguyen Q H, Nguyen-Xuan H. Balancing composite motion optimization[J]. Information Sciences, 2020, 520: 250-270.

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[4] Liu B, Vu-Bac N, Rabczuk T. A stochastic multiscale method for the prediction of the thermal conductivity of Polymer nanocomposites through hybrid machine learning algorithms[J]. Composite Structures, 2021, 273: 114269.