Dimensional analysis of metal fatigue life through deep neural networks

Metal fatigue failure is one of the most dangerous types of failure which has greatly threatened many engineering applications, like automobiles, bridges, airplane parts, suspension equipment for vehicles, furniture, and so on. It starts with a crack initiation when the applied stress exceeds metal tensile strength, and the crack will then grow larger and larger and finally lead to fracture which shortens service life of metal components. So figuring out the parameters of metal fatigue failure and making a prediction of fatigue life are big parts of component validation.

But for now most equations used in relative studied are empirical. Like the fatigue life prediction equation, Basquin equation: $\frac{\Delta\sigma}{2} = \sigma_f^{'}(2N_f)^b$, its coefficients ($\sigma_f^{'}$ and b) come from experimental fitting data. However, it cannot put the other parameters like surface finish, corrosion, and temperature into consideration. So in this project, mechanistic data science (referred to as MDS) is applied to solve this problem.

First of all, experimental data can be collected from previous literature and relative databases to gather raw data. Second, identifying the available features of data (load, cycles, roughness, etc.) and extracting features to form a database. Third, based on the extraction of features, we use dimension reduction to reduce random variables to better process the further data analysis. Fourth, reduced order surrogate models is make via dimension reduction. Fifth, we use deep neural network (DNN) to process training of machine learning and make prediction of the input parameters. Finally, all of the above processes together form System and Design and we will add details in the final presentation.