機器學習第二次報告
題目: Fast evaluation of crack growth path using time series forecasting

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我選擇閱讀的論文

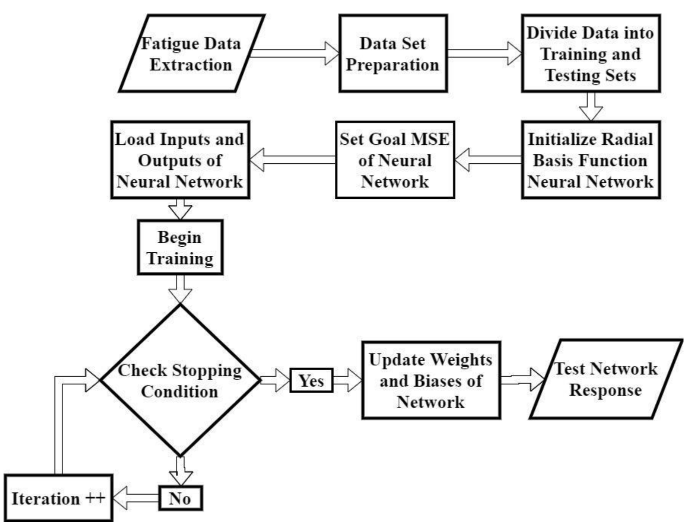
1.Prediction of fatigue crack growth rate in aircraft aluminum alloys using radial basis function neural network, Hassaan Bin Younis, Khurram Kamal, Muhammad Fahad Sheikh, Amir Hamza, and Tayyab Zafar, 2018 Tenth International Conference on Advanced Computational Intelligence, 2018.

2.Fatigue crack growth assessment method subject to model uncertainty, Yan-Hui Lin, Ze-Qi Ding, Enrico Zio, Engineering Fracture Mechanics, 2019.

(一)Prediction of fatigue crack growth rate in aircraft aluminum alloys using radial basis function neural network

＊這篇論文利用 RBFNN 去處理非線性在疲勞裂縫增長速率預測的時候於 2324-T39、6013-T651、7055-T7511 三種鋁合金 (這 3 種是飛機常用的鋁合金)。

RBFNN 流程圖



(1) 疲勞數據提取主要是提取 $\frac{da}{dN}$(會輸入 Δk: 應力強度因子幅度、R: 應力比，然後輸出 $\frac{da}{dN}$: 裂縫增長速率)

(2)MSE(均方誤差) 是對於無法觀察的參數 θ 的一個估計函數 T，其定義為：MSE(T)=$E((T-\theta)^2)$，即它是「誤差」的平方的期望值。誤差就是估計值與被估計量的差。均方誤差滿足等式 MSE(T)=var(T)+$(bias(T))^2$，其中 $bias(T)$=$E(T)$-θ，也就是說，偏差 bias(T) 是估計函數的期望值與那個無法觀察的參數的差。

(3)Following steps are followed to train the network(以下是訓練網路的過程)

1. Initialization of weights by random assignments of values
2. If stopping condition is not met, do
3. Receive input signal by each input unit,x_j(where j=1,2, ⋯,n)
4. Calculate RBFNN
5. Choose Radial Basis function centers through input vectors. The number of centers must be designated accordingly for adequate sampling of input vector space.
6. The output of j_n unit $v_j(y_j)$ in hidden layer can be written as $v_j(y_j)=e^{-\sum_{i=1}^{r}\frac{[y_{ij}-y^{ij}]^2}{\sqrt{u}}}$ where y_{ij}= RBFN unit center for input variables, u_j=width of j^{th} RBFN unit and $y_{ij}=i^{th}$ input variable pattern
7. Initialize weights in output layer by random assignments of values
8. Calculate the output of network $O_{net}=\sum_{j=1}^{Q} w_{jn}v_j(x_j)+z_0$, where Q=number of hidden layer nodes,O_{net}=output value of n_{th} output layer nodes for m_{th} incoming pattern, w_{jn} = weight between n_{th} output layer node and j_{th} RBF unit and Z_0 = biasing value at n_{th} output layer node.
9. Calculate error and check for the stopping condition if it is met.

在實作方面，如果縫隙是非線性的，我應該會直接套用這個方法來實作，因為它們只是目標不同而已。

(二)Fatigue crack growth assessment method subject to model uncertainty

TSLS estimation method

總共分成兩個步驟:

In the first step, the random multiplier is neglected and the unknown parameters in the deterministic FCG model are estimated from all the obtained data. δ_{L-S}=$\arg\min_{\delta}\sum_{k=1}^{K}\sum_{i=1}^{I^k}[log(\frac{da(t)}{dt}|_{a(t)=a_i^k})-log(G(a_i^k,\delta))]^2$

In the second step, the random multiplier of each crack growth path is estimated as $\widehat{z}_k$=$\arg\min_z \sum_{i=1}^{I^k}[log(\frac{da(t)}{dt}|_{a(t)=a_i^k})$-$log(G(a_i^k,\widehat{\delta}_{L-S}))-z]^2$, k=1,2,$\cdots$,K. $\widehat{x}_k$=$e^{\widehat{z}_k}$, k=1,2,$\cdots$,K, where the $\widehat{x}_k$ is the estimate of the random multiplier for the k-th crack growth path，最後再相乘就可以得到我們需要的答案了。

∗ Example

Power function(冪函數)

$$\frac{da(t)}{dt}=XQ[a(t)]^b$$

The parameters which need to be estimated are Q and b in power function,
$(\widehat{Q}_{L-S},\widehat{b}_{L-S})$=$\arg\min_{(Q,b)}\sum_{k=1}^{K}\sum_{i=1}^{I^k}[log\ (\frac{da(t)}{dt}|_{a(t)=a_i^k})-blog(a_i^k)-log(Q)]^2$
$\widehat{z}_k$=$\arg\min_z\sum_{i=1}^{I^k}[log(\frac{da(t)}{dt}|_{a(t)=a_i^k})-\widehat{b}_{L-S}log(a_i^k)-log(\widehat{Q}_{L-S})-z]^2$,k=1,2,$\cdots$,K, $\widehat{x}_k$=$e^{\widehat{z}_k}$, k=1,2,$\cdots$,K，最後再相乘就可以得到我們需要的答案了。

未來在做實作時，如果有未知的參數就可以運用這個方法去求它，非常方便。