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卷积和离散过程神经网络及其在航空发动机排气温度预测中的应用

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Convolution Sum Discrete Process Neural Network and Its Application in Aeroengine Exhausted Gas Temperature Prediction

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摘要 针对航空发动机排气温度的变化过程受复杂非线性时变因素的影响而难以用精确数学模型描述的问题,提出了卷积和离散过程神经网络(CSDPNN)模型,并将其应用于航空发动机排气温度(EGT)预测。该模型以离散样本作为直接输入,采用卷积和算法实现对时间累积效应的处理。相较于以连续函数作为输入的过程神经网络(PNN),不需要拟合离散样本得到连续函数后进行正交基展开,减少了精度损失,具有更高的预测精度。给出了卷积和离散过程神经网络模型的学习算法,并通过对Mackey-Glass混沌时间序列的预测对提出的方法进行应用说明和验证。通过航空发动机EGT预测实例,并与卷积和离散过程神经网络模型的连续函数输入过程神经网格以及传统人工神经网络(ANN)的预测结果进行了对比。结果表明,相较于连续函数输入过程神经网络以及传统人工神经网络,卷积和离散过程神经网络具有更高的预测精度,且对于EGT的预测具有较好的适应性,因而为航空发动机EGT预测提供了一种有效的方法。

关键词: 神经网络 卷积 离散输入 航空发动机 排气温度预测

Abstract: The changing process of aeroengine exhausted gas temperature (EGT) is affected by complicated nonlinear time varying factors, which make it difficult to construct its mathematic model. To cope with this issue, a convolution sum discrete process neural network (CSDPNN) model is proposed and used for EGT prediction. This model directly utilizes discrete sampling points as input, and uses the convolution sum to deal with the time accumulation process. Compared with the process neural network(PNN)with continuous function inputs, there is no need to fit the sampling points to get input functions and then to decompose them by orthogonal basis functions which can lead to precision loss. Therefore, this model can achieve higher prediction precision. A learning algorithm for this model is also developed, and the model is explained and validated via Mackey-Glass chaos time series prediction. Then, the model is adopted to predict a real EGT time series. The prediction results are compared with results obtained by the process neural network with function inputs and the traditional artificial neural network(ANN), which proves that CSDPNN model has higher precision than the other two networks, and it exhibits good adaptability to EGT prediction. This model offers an effective method for real EGT prediction.

Keywords: neural networks convolution discrete input aeroengine exhausted gas temperature prediction

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