RECURRENT NEURAL NETWORKS FOR THE PREDICTION OF SEAT-TO-HEAD TRANSFER FUNCTIONS

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Abstract:

Drivers in vehicles are exposed to vibrations that are transmitted from the seat to the driver's body. Vehicle vibrations have the greatest impact on ride comfort, regardless of their intensity and shape. The transmission response function (STHT) between the seat and the head represents a strong connection between the vibration-induced head motion responses transmitted by the seat/head interface. The aim of this paper is to form a model of an artificial neural network (ANN) based on experimental measurements. Ten healthy male subjects participated in the experiment. They were exposed to vertical vibrations. Based on the obtained values of transfer functions, an artificial neural network was trained. The results showed that the developed model has the ability to predict the values of transfer functions in the range of trained values when changing the input parameters.

Keywords: artificial neural network, experimental measurements, vertical body vibration

1. Introduction

Exposure to vibrations affects a person in different ways, starting from ordinary disturbances, to reduced work performance and health damage [1]. The biodynamic response of the human body exposed to vibrations is influenced by a number of factors. The STHT function was used as a function to assess the biodynamic response [2]. The main contribution of this paper is the development of a recurrent neural network model based on the results of frequency response functions obtained by experimental measurements. A recurrent neural network is a class of ANN where connections between nodes form a directed graph along a temporal sequence. This allows it to exhibit temporal dynamic behaviour. They are distinguished by their "memory" as they take information from prior inputs to influence the current input and output [3]. Developed model in this paper is able to predict the frequency response functions of the STHT in different seating angles (90º and 100º) under different excitation (0.45 and 0.8 m/s^2 r.m.s) and different anthropometric characteristics of the subjects.

2. Dataset and Methods

In order to test the robustness of the models, the dataset was split into training, validation and test sets, where eight randomly selected subjects were used for training, one for validation and one for the test phase. The Long short-term memory (LSTM) with 30 neurons in the first hidden layer and one neuron in the output layer for predicting STHT were defined for the selected subject. The input shape was one time step with 10 features (including one-hot encoding for categorical variables), where a subject personal data (height, weight, seating height, years and BMI) were combined with the three considered amplitudes and three seating angles. The Mean Absolute Error was used as loss function and the efficient Adam version of stochastic gradient descent. The model was fit for 50 training epochs with a batch size of 20.

3. Results

Time series forecasts on the test set, and in this case the frequency response function seat-to-head, for each frequency and angle separately, is shown in Figure 1. More specifically, the original and predicted values of STHT for one user are shown.

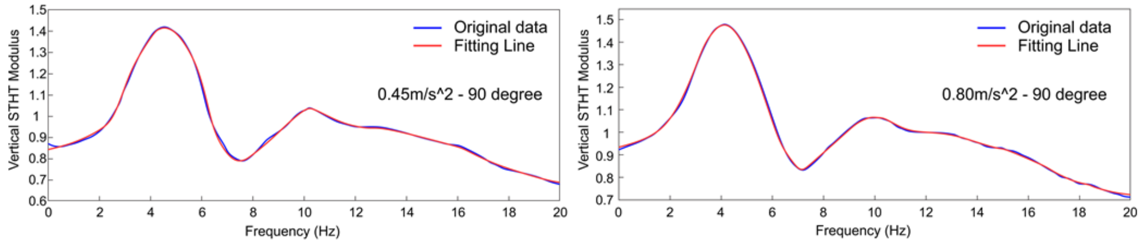

Fig. 1. Original and predicted values for one subject

The regression in training, validation and testing demonstrated an accuracy of over 96% with respect to the R correlation coefficient. This shows that the accuracy of the model was in acceptable range.

3. Conclusions

The Root Mean Square Error (RMSE) for the four combinations for the LSTM model was 0.05, which shows very high accuracy of the trained model. It could be seen that machine learning applied to time series data is an efficient and effective way to analyse the data, apply a forecasting algorithm, and derive an accurate forecast.

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