



APPLICATION OF RECURRENT NEURAL NETWORKS IN ASSESSING DRIVERS' OSCILLATORY COMFORT DURING FORE-AND-AFT VIBRATIONS

Igor Saveljic^{1,2}, Slavica Macuzic Saveljic³, Tijana Djukic^{1,2}, Branko Arsic^{2,4} and Nenad Filipovic³

¹ Institute for Information Technologies, University of Kragujevac, Jovana Cvijića bb, 34000 Kragujevac, Serbia

e-mail: isaveljic@kg.ac.rs

² Bioengineering Research and Development Center, Prvoslava Stojanovica 6, 34000 Kragujevac, Serbia

³ Faculty of Engineering, University of Kragujevac, Sestre Janjic 6, 34000 Kragujevac, Serbia

⁴ Faculty of Science, Department of Mathematics and Informatics, University of Kragujevac, Radoja Domanovica 12, 34000 Kragujevac, Serbia

Abstract:

Vibrations emanating from the environment subject vehicle occupants to conditions that significantly influence their comfort and safety. These vibrations, particularly those stemming from horizontal and vertical movements, are transmitted through the vehicle's structure, from the seat to the driver's body. This study focuses on the seat-to-head transmission response function, which encapsulates the relationship between vibrations at the seat/head interface and the resultant motion responses of the driver's head. To address this, an artificial neural network model was developed based on experimental measurements involving ten healthy female subjects who were exposed specifically to horizontal fore-and-aft vibrations. Training of the artificial neural network was conducted using values from the transfer functions derived from these experiments. The findings indicate that the devised model can accurately forecast transfer function values within the range of the experimental data upon varying the input parameters, thereby offering insights into managing oscillatory comfort for automobile drivers.

Key words: artificial neural network, experimental measurements, vertical body vibration

1. Introduction

While on the road, vibrations originating from the surface are transmitted to a vehicle, affecting both the driver and passengers by potentially leading to discomfort [1], [2]. The primary focus of this paper lies in the development of a recurrent neural network model, utilizing frequency response functions derived from experimental measurements. Recurrent neural networks, a subtype of artificial neural networks, are characterized by their ability to form connections between nodes in a directed graph over a temporal sequence. Developed model in this paper is able to predict the frequency response functions of the seat-to-head transmission response function in a different seating angles (90° and 100°) under different fore-and-aft excitation (0.45 and 0.8 m/s² r.m.s) and different anthropometric characteristics of the subjects.

2. Dataset and Methods

To test the models' robustness, the dataset was divided into training, validation, and testing sets [3]. In the first hidden layer of the Long Short-Term Memory (LSTM) recurrent neural network, 30 neurons were set, with one neuron in the output layer for predicting seat-to-head transmission response function for the selected subject. The input shape was one time step with 10 features, including categorical encoding and personal subject data. Mean Absolute Error was used as the loss function, optimized using the efficient Adam version of stochastic gradient descent. The model was trained for 50 epochs with a batch size of 20.

3. Results

Time-series forecasts on test set, in this case it was the frequency response function seat-to-head, for each frequency and angle separately, were shown in Figure 1. Actually, the original and predicted values of STHT for one female user were shown.

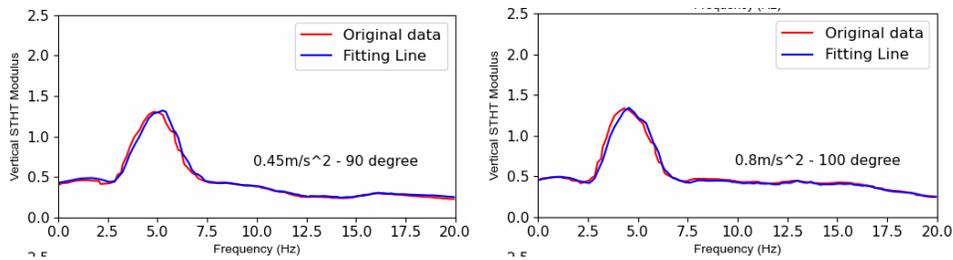


Fig. 1. Original and predicted values for one female subject

The regression in training, validation and test are over 92% accuracy 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 for these four combinations for the LSTM model was 0.06, which show 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 analyze the data, apply a forecasting algorithm, and derive an accurate forecast.

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