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NEURAL NETWORK AND TRAINING STRATEGY DESIGN FOR TRAIN DRIVERS' VIBRATION DOSE SIMULATION

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Abstract
Vibration can cause professional illnesses in train drivers, giving also rise to lawsuits to the employer. A possible cause may be the lack of systematic vibration estimation processes, due to operational complexities, subjectivities involved and the cost of dedicated tests. Estimation quality may be improved by using a driver seat model along with cabin floor vibration data acquired during the train dynamic approval tests. However, due to the nonlinearities present, analytical models frequently show inaccurate results. This work deals with the design of an appropriate neural network for predicting the seat-driver interface vibration, based on selected and processed cabin floor acceleration data obtained during the dynamic approval tests. Network type, input signals set and signal conditioning have considerable impact on the simulation accuracy. Results show good correlation between simulated and experimental data, even better between simulated and measured standard vibration dose indicators, being *RMS* errors between 3.9 % and 9.4 % and peak factor errors between 0.8 % and 9.6 %.
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Key Words: Vibration Dose, Artificial Neural Network, Nonlinear Model, Train Engineer, Train Driver

1. INTRODUCTION

Given its harmful health effects, vibrations in the workplace become an increasingly more relevant issue. In Europe, directives have been issued since long time (e.g. [1]), aiming to establish a methodology for its assessment and control. Although regulations for proper vibratory design of the workplace exist [2-4], there is evidence that vibration may have caused illnesses, especially back pain and sciatica in drivers [5, 6] particularly in those driving old or poorly maintained material, with poor or wrong sized seats and circulating in low quality tracks. In the United States, lawsuits by employees subjected to excessive vibration [7-9], have meant payment of considerable sums by employers.

The measurement of vibrations received by the driver is simple. The standards are based on dose indicators which take into account the average square values of the vertical, transverse and longitudinal accelerations or its quadratic sum, measured on the driver-seat interface by means of an instrumented pad equipped with a triaxial accelerometer. The indicators take into account peak factors for overweighting acceleration peaks.

The ISO 2631-1 standard suggests the indicator $A(8)$ defined in Eq. (1) as the *RMS* value of the weighted acceleration $a_w(t)$ measured during the T = 8 shift hours, or the *VDVn* (Vibration Dose Value) as defined in Eq. (2), as the quadratic root of the sum of the fourth power of the accelerations measured, used when shocks are present in the measured vibration, assessed in terms of crest factors. If $n = 8$, $VDV_8 = A(8)$:

$$a_w = \left[\frac{1}{T}\int_0^T a_w^2\,(t)dt\right]^{\frac{1}{2}} \qquad A(8) = \sqrt{\frac{1}{8}\sum_{n=1}^{n=N} a_{wn}^2\, t_n} \tag{1}$$

$$VDV = \left\{\int_0^t [a_w(t)]^4 dt\right\}^{\frac{1}{4}} \qquad VDV_n = \sqrt[4]{\frac{t_n}{t_{n\,measured}} VDV_{n\,measured}^4} \tag{2}$$