[N234] Artificial Neural Networks in Sound Quality Design: An Application for Hair Dryers

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ABSTRACT

The product sound quality with its objective and subjective properties is an important design parameter that discriminates the similar products in the market today. In this study, using the attributes of sound determined from the objective sound measurements, the artificial neural networks are used to predict the human response to a specific sound. The product chosen for the analysis in the present study is the hair dryer. The sounds of several hair dryers are measured and for each sound, twenty-seven sound quality metrics and twenty-two 1/3-octave band values are calculated. At the same time the jury tests are performed to find out the subjective human response to hair dryer sounds. The results of the jury tests are analyzed by principle components analysis (PCA) and an annoyance factor is obtained. By taking this annoyance factor as the output an artificial neural network, composed of sub-networks, is trained. The results obtained are compared with the results of another study based on the PCA. To conclude, a relationship between objective parameters of sound and subjective ratings is constructed and by using the same network it is possible to estimate the perceptual human response to any hair dryer sound from the objective parameters of the sound without performing jury tests.

KEYWORDS: Artificial neural networks, sound quality, annoyance, principle components analysis.
INTRODUCTION

Sound is an important attribute for many products that affects the competition power of that product in the market. Sound quality of a product is defined as the adequacy of that sound for the product and the listener’s acceptability degree of that sound for the product. The acceptability criteria, which changes according to the product and the customers’ judgments on that product may be; the perceived power of the product, how well it is made or it works, or how loud it is, and so on. Sound quality affects the place of the product, among its competitors, in the market where the pleasure of the customer is in the first place.

The generally used method to measure the sound quality of a product is the jury tests. However this method is not only time-consuming but also costly. To get rid of these disadvantages one approach is to develop a model of the human judgments on the quality of the sound. In this context, the mathematical models of perception of sound referred to as sound quality metrics, such as loudness, sharpness, roughness, fluctuation strength, etc. are proposed. Today generally used metrics are the ones defined by Zwicker [1] and the research on the development of new metrics still continues.

The researchers in general discussed the most appropriate tools for the sound quality assessment either for specific products or for specific types of noise. Blauert described sound quality evaluation as a multi-layered problem and introduced a system-oriented approach [2]. Laux, taking Zwicker’s “unbiased annoyance” as a starting point created an artificial neural network model to be retrained to subjective response data and modeled human annoyance to noise, [3]. May, used the approach of correlating human subjective response with objective sound quality metrics for developing predictive models and showed that a linear combination of sound quality metrics could be used to predict the annoyance of refrigerator noise [4]. Beidl developed an annoyance index for engine noise quality that gives the opportunity to eliminate the need for subjective assessment sessions and gives information about the noise problem through the quantification of the objective parameters [5]. Prante, created a FIR neural network to model the subjects’ perception of daily sounds and used the approach of correlating physical features of sound directly with the sound quality without using psycho-acoustic metrics, [6].

SOUND QUALITY EVALUATION

Sound quality evaluation can be thought of as a cycle that could be updated according to the changing psychological judgments of the subjects and developing technology. Target sound which is determined by acoustic design experts, is the starting point of the cycle. Next stage to translate the target sound into engineering design is sound recording. Sounds of the existing