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An objective method of street classification for noise studies

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ABSTRACT

An average daily traffic (ADT)-based street classification method to assess urban noise has been experimentally analysed. Different statistical tests were applied to the noise levels and traffic flows measured in a medium-sized city (Mérida, Spain). The ADT-based classification method was compared to a previously proposed categorization method. The results obtained showed that not all of the statistical tests provided similar results, and that the ADT-based classification method provided good results with less overlapping categories/levels. It also showed a better classification of sampling points than the one obtained when applying the categorization method. Advantages and drawbacks of each classification procedure are discussed.

1. Introduction

Noise can be considered as one of the major pollutants present in cities. Its evaluation, control and reduction are among the major environmental health concerns for public authorities of developed countries [1].

In order to assess noise levels in cities, two different strategies are usually considered. On the one hand, noise levels in streets are measured in situ, and on the other hand, the noise distribution is modelled with specific software. Although modelling noise levels has great potential and is usually proposed for evaluation of long-term indexes of noise [1,2], it must be complemented by in situ measurements in order to calibrate the different computer models [3]. Undoubtedly, an adequate sampling strategy for selection of these in situ measurement points would be desirable in order to benefit from them.

Different methods have been proposed for selecting sampling points in measurement-based noise assessment (e.g., Brown and Lam give an extensive review [4]). The grid method was the most commonly used during several years [5–8]. Moreover, this method was mentioned in the ISO 1996-2 standard [9]. Nevertheless, the grid method usually requires many measurements, so alternative methods have been proposed to overcome this problem. Some of them are based on previous classifications of streets into categories [10–13]. In these cases, noise measurements (or traffic to feed a noise mapping simulation) are carried out by choosing a representative sample of each category. Thus, the number of sampling points required for the whole noise assessment is manageable.

The necessary independency of the different categories is one of the key points in the selection of a classification criterion to separate the city streets. In previous studies, the categories proposed by the Acoustics Laboratory of the University of Extremadura were shown to be independent in the majority of cases when studying cities of different sizes [11,14]. This method becomes a powerful alternative to the grid method [15]. The potential of the categorization method is that the classification of the streets can be done before any measurement and is thus theoretically free of bias (in previous studies it was proved that the use of an arbitrary selection of sampling points may lead to the noisiest points being chosen, thereby introducing bias into the results [16]). The main drawback is that the proposed definitions have a degree of subjectivity to the extent that, for instance, two different technicians may assign the same street to different categories.

In mobility and transport planning studies, it is usual to classify the different streets into categories as a function of the average daily traffic (ADT) of the different streets. This is an objective method. Due to the known relationship between traffic flow and noise in most of the cities, the validity of this classification method for noise assessment is analysed in the present work.

Thus, the main objective of this study is to analyse an ADT-based street classification method to assess urban noise. ADT and the categorization method are compared, discussing the advantages and drawbacks of each classification procedure. The study was carried out by using a collection of different statistical tests.

The rest of the paper is organized as follows. In Section 2, the proposed methodology is presented as well as the city where the methods will be applied. Section 3 presents the experimental results and a discussion of them. Finally, the conclusions are drawn in Section 4.

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2. Methods

2.1. The studied city

Mérida (Spain) is a medium-sized city (nearly 7 km^2 and 60,000 inhabitants) located in the southwest of Spain. Its urban structure is conditioned by the presence of many remains of the original Roman town (it is a UNESCO World Heritage Site), as it was an important Roman administrative centre in the past. Currently, it is the administrative centre of Extremadura (one of the regions of Spain), which, together with the great number of visiting tourists, implies a major influx of people. The mean temperature and rainfall are 16.9 °C and 473.6 mm per year, respectively.

2.2. Street classification methods

In order to analyse different classification methods for the streets in the city that could be adequate for noise-assessment studies, three methods were considered: the ADT method with a previous classification (method M1); the ADT method extrapolating the traffic flow from the data obtained in the noise measurements (M2); and the categorization method (M3).

2.2.1. ADT method with previous classification

In 2009, Ruiz Labrador [17] measured the ADT of the streets in Mérida, which were divided into four levels depending on the ADT values obtained. The four levels are indicated in Table 1.

In this paper, we have used the same classification as in [17], except for one street whose use had clearly changed and which was moved from one level to another. In each level, a random selection of sampling points was made. None of the streets belonging to the first level were measured, since all of them were located outside the inhabited part of the city.

2.2.2. ADT method extrapolating from the traffic flow data obtained when measuring noise

When the previous ADT method was applied, unexpected results were found (as will be described after), indicating that the proposed assignation of streets to levels was not adequate for the sampling period of the present work (the years 2015–2016). For this reason, as an alternative, after carrying out the noise measurements, the ADT values of each street were extrapolated from the traffic flow data obtained during each 15-min sampling period. With these extrapolated ADT values, the assignation of streets to the different levels (the same as shown in Table 1) was done.

As the traffic flow was only measured during the 15 min of noise sampling, extrapolation of this flow to an ADT value was necessary. Unfortunately, no traffic data were available for the city of Mérida and thus we used continuous traffic data from Cáceres (a medium-sized city located 70 km to the north of Mérida with around 100,000 inhabitants that could be considered similar to the city of Mérida in several aspects). These data, corresponding to 19 sampling points, were provided by the local police of Cáceres. By using the whole year 2012, we obtained the average distribution of traffic, as shown in Fig. 1. This distribution was used to obtain the ADT values of the sampling points in Mérida.

Table 1
Levels for ADT.

Level	Average Daily Traffic (ADT)
1	> 15,000 vehicles/day
2	Between 10,000 and 15,000 vehicles/day
3	Between 5000 and 10,000 vehicles/day
4	< 5000 vehicles/day

Note that in method M1 (and also in method M3, which will be described later) a previous assignation of the streets to each level (or category, in method M3) is performed and, then, a random selection of sampling points is carried out in each level (or category). Nevertheless, in method M2, assignation of the streets to a level is done after measurements have been carried out. After calculating the ADT values, some of the measured streets presented ADT values belonging to the first level (Table 1) and were thus assigned to this level. So, while only three levels were measured in method M1, measurements were made at four levels in method M2.

2.2.3. The categorization method (M3)

In this method, categories are defined according to the role played by the streets in connecting the different zones of the town. Six categories had been previously considered [11,14]. In this case, one of them (Type 6) was not considered in the study since it includes pedestrian streets. The definitions of the categories used in this method are as follows:

- Type 1 includes those preferred streets whose function is to form connections with other Spanish towns and to interconnect those preferred streets. In general, these streets are indicated by a system of road signs.
- Type 2 contains those streets that provide access to the major distribution nodes of the town. For the purpose of this study, a distribution node is considered to exist when at least four major streets meet. This definition does not include any possible nodes of preferred streets as defined in Type 1, but includes streets normally used as alternatives to Type 1 streets in the case of traffic saturation.
- Type 3 includes streets that lead to regional roads, streets that provide access from streets of Types 1 and 2 to centres of interest in the town (hospitals, shopping malls…), and streets that clearly allow communication between streets of Types 1 and 2.
- Type 4 contains all other streets that clearly allow connections between the three previously defined types of streets as well as the main streets of the different districts of the town that were not included in the previously defined categories.
- Type 5 comprises the rest of the streets of the town except for pedestrian-only streets.
- Type 6 comprises all the pedestrian-only streets.

Once the definitions of the categories had been established, the different streets of the city were assigned to one of the defined categories.

2.3. Sampling method

A total of 62 sampling points were randomly selected in streets from the different levels defined by method M1 and, then, the selected streets were assigned to the different categories of method M3. The traffic flows were measured and the ADT values were extrapolated. Then, considering the intervals in Table 1, each sampling point was assigned to a different level for analysis by method M2.

At each sampling point, three 15-min measurements were carried out during three different time intervals, randomly selected from the following four periods: 7–10 a.m., 10 a.m.–1 p.m., 1–4 p.m., and 4–7 p.m. Measurements were done in the winter months of 2015 and 2016, on different working days.

Measurements were performed following the ISO 1996-2 guidelines [9] using Brüel & Kjaer 2238 Type-I sound-level meters with a tripod and windshield. Calibration was performed using a 4231 Brüel & Kjaer calibrator.

The sound-level meter was located one meter from the curb. The traffic flow was visually determined and classified (cars, heavy vehicles, and motorcycles) during sampling. Other relevant information (noise sources, meteorological conditions, street dimensions, road surface type, conservation of the road surface, etc.) was also collected.