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ANALYSIS AND SYNTHESIS OF URBAN NOISE ENVIRONMENTS

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ABSTRACT

For the analysis of acoustic impact in the urban plans and the evaluation of improvement strategies in urban noise environments, it is of prime importance the use of a tool capable of simulating results both in numeric terms and sense perception. To introduce a methodology to evaluate noise in our towns, not only upon noise quantity criteria but also upon quality criteria of urban noise scenery, we have developed a system for analysis and synthesis of urban noise environments based on source analysis. Sources are separately identified, quantified and characterized in order to establish a set of rules and laws that allow synthesis from pure sources. In addition, we have designed two software tools for the analysis and synthesis. The first one is based on a GIS system to access data (urban, social, economics, energy, etc...) in Barcelona city. The second one consists of a GIS-connected software module, which makes calculations of noise level and indicators. Synthesis is realized by mixing up the corresponding sources according to the model chosen. Results are displayed, and synthesized noise is played by the system's multimedia tools. This analysis is being developed within the "Life" project, in Barcelona and other towns in Catalonia such as Mataró, Vilassar de Mar, Calella de la Costa, etc., by making simultaneous sound recordings and noise measurements that enable us to set up the model and gather the pure sources that constitute sound environment.

This paper presents a system for the analysis and synthesis of urban noise environments developed for the SIMU project (Urban Information and Modelling System)

The tool SIMU has been designed for decision support in that it enables us to have a global overview of the region and the variables affecting any real or simulated planning measures.

The aim of the project is to develop global planning tools capable of accounting for the city as it is: an urban ecosystem. In order to do this, it is necessary to deal with urban reality, or a part of it in a truly global sense, using sufficiently powerful tools capable of integrating partial perspectives, whether in the area of urban planning, mobility, environmental, economic or social considerations.

The main characteristic of SIMU is that it brings together the bulk of significant information at municipal level (in addition to much supra-municipal information), along with tools for its analysis; another is its definition of a series of integrated models arising from urban ecology, which permit us to outline the urban scenarios of the future and thus have a considerable impact in terms of reducing the disfunctions inherent to present-day models.

Despite the enormous variety of sounds existing in a city, if we consider them upon the viewpoint of "Noise" and we take "noise" as those sounds transmitting very little information due to their monotonous and repetitive character, noise sources are basically reduced to four:

- Traffic sound
- People sound
- Animal sounds
- Background noise

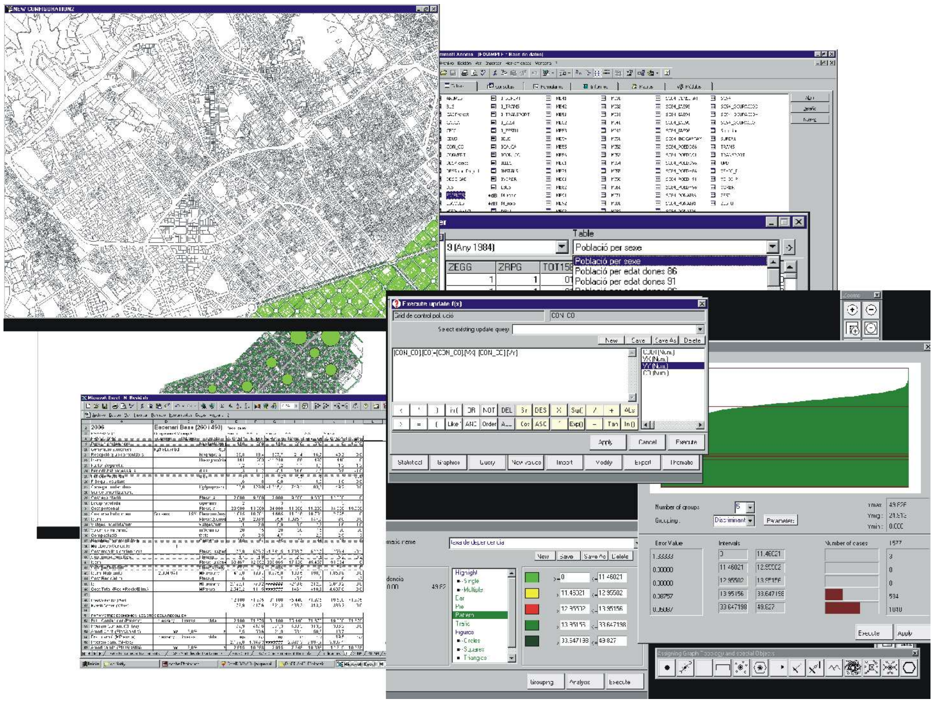


Figure 1.

Each sound has a number of variants which are to be taken into account for the synthesis to become appreciably authentic.
In traffic sound it is necessary to distinguish between day traffic and night traffic since they have different dynamics, as well as three kinds of traffic sound: low traffic (less than 500 vehicles/hour), moderate (between 500 and 1500 vehicles/hour) and heavy traffic (more than 1500 vehicles/hour).
As it refers to people sound, we consider that it is only produced during the day. Thus, there are two varieties: Sound of people who are walking or shopping in the street and sound of children who are playing or who are leaving the school. There are three varieties in the sound of walking people according to the amount of people: high, moderate or low.
The animal sounds considered in the model are those that can be geographically situated and their populations evaluated. These are birds: sparrows, pigeons, seagulls and cockatoos, whose presence is directly related to well-defined habitats. Other sounds such as dog barking, will be analysed according to a probability model.
For Background noise we may consider a single source whose intensity will be determined by traffic density in the surrounding areas.
The intensity of the aforementioned sources will be determined by a set of formulae that relate it to parameters existing in the GIS database.
The level of traffic sound is established according to the traffic density in each street.
The function that gives the Leq with traffic density is shown in figure 2.
This function is the result of the extrapolation of a wide number of real measures corrected by means of coefficients that adjust the geometric characteristics of the street, as well as the rate of light and heavy vehicles and bikes that conform traffic.
The background level (which is independently analysed with in the model) is substracted from the resulting function in the extrapolation such that for zero vehicles/hour the equivalent level is zero. Obviously, the background effect is of prime importance for low traffic density whereas it is unimportant for high traffic density.
As the background value is considered independently, the equation meets both day and night conditions.
To obtain the intensity of people sound, a relationship has been established between eradication taxes payed by shops and the density of pedestrians walking on the pavement. This relationship is satisfactory since this tax is calculated according to the pavement characteristics and the street commercial use. Thus, the density of pedestrians walking on the pavement is indirectly parameterized.
The intensity of sound coming from children's play is given by the area of playgrounds on the one hand, and by populations and leaving timetable at schools on the other.

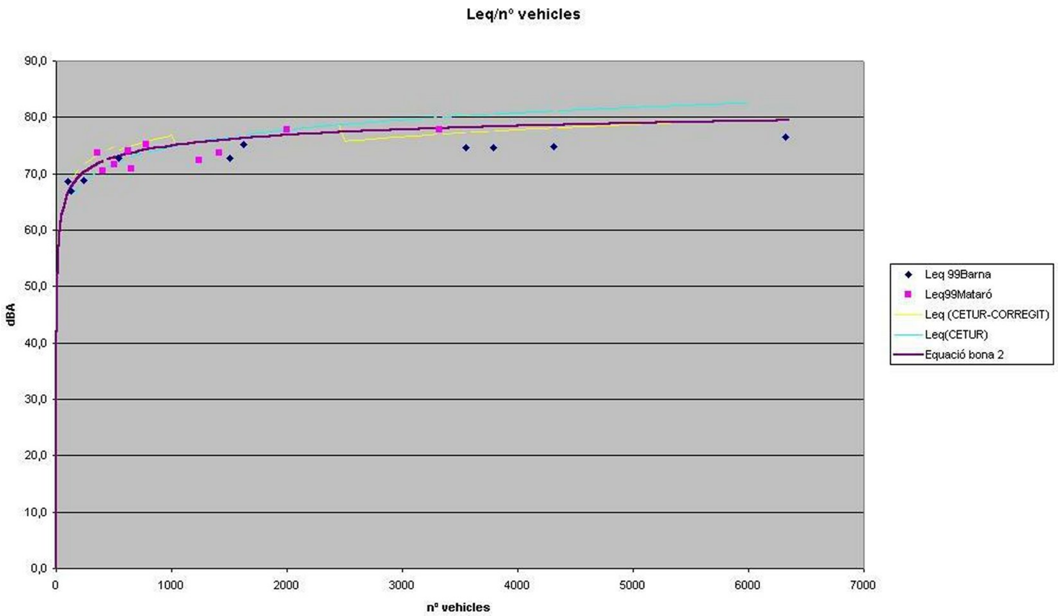


Figure 2.

The intensity of bird sound is given by trees for sparrows, the colonies in the city and along the coastline for seagulls, the amount of palm trees for cockatooes and known populations for pigeons. These data are sufficient if we take into account that, for this model, we only need to consider low, moderate and high populations, and distance attenuation does offer a wide range of values.

Once the sources and their intensity have been determined, we need to establish attenuations according to the distance from each source to the listening point. We have used, in the horizontal plane, the propagation laws of punctual sources, line sources and surface sources with some coefficient modifications. This is done to adjust simulation results to those obtained in a wide number of real measures taken at different cities and towns on the Catalan coast.

Vertical-plane attenuations have been obtained experimentally by a number of simultaneous measurement pairs taken on different floors in the same building and by averaging out the results of different buildings situated in different kinds of street.

To choose the sources that are to be mixed, we consider those that are within a circle of 90 m. diameter, which eliminates the sources that are intercepted by buildings. The sources within this 90 m. diameter circle and another circle of 300 m. diameter, (see figure 3), are independently quantified in order to fix background level. Finally, we add a fixed value to the background level depending on urban and mobility features of the suburb where the simulation is performed.

The application software carries out calculations from a text file that GIS creates with the descriptions of detected sources, their intensity and the distances to the point chosen for observation. Such calculations are made by using an external database where the model formulae are kept. This process allows the modification of the formulae and their coefficients without changing the program code by simply using an expert-restricted access password.

Depending on the calculations made, we display, on the one hand, the overall numerical results and, on the other hand, the mixing of the different sounds described in the input file by adjusting their particular level according to propagation laws of each source and the established distance.

The output file is a *.wav which re-creates the sound of the stage chosen by dosing the sources described and adding random noise (sirens, dog barks, shouting, building noise, etc.) In the database with the model formulae there is a probability table which gathers the probability that a specific sound is produced according to the time (day or night) and the area where the observation point is.

Any modification in the GIS supporting the application instantaneously creates the corresponding change in the output parameters. Consequently, the tool permits not only to evaluate the present situation but also any future change. This is developed within the context of the other models in the SIMU, allowing an evaluation of the suggested modification upon the perspective of atmospheric contamination, waste, hydrologic cycle, diversity, mobility, economy, price of soil, health, etc., and, above all, noise.

Further work will comprise the following issues:

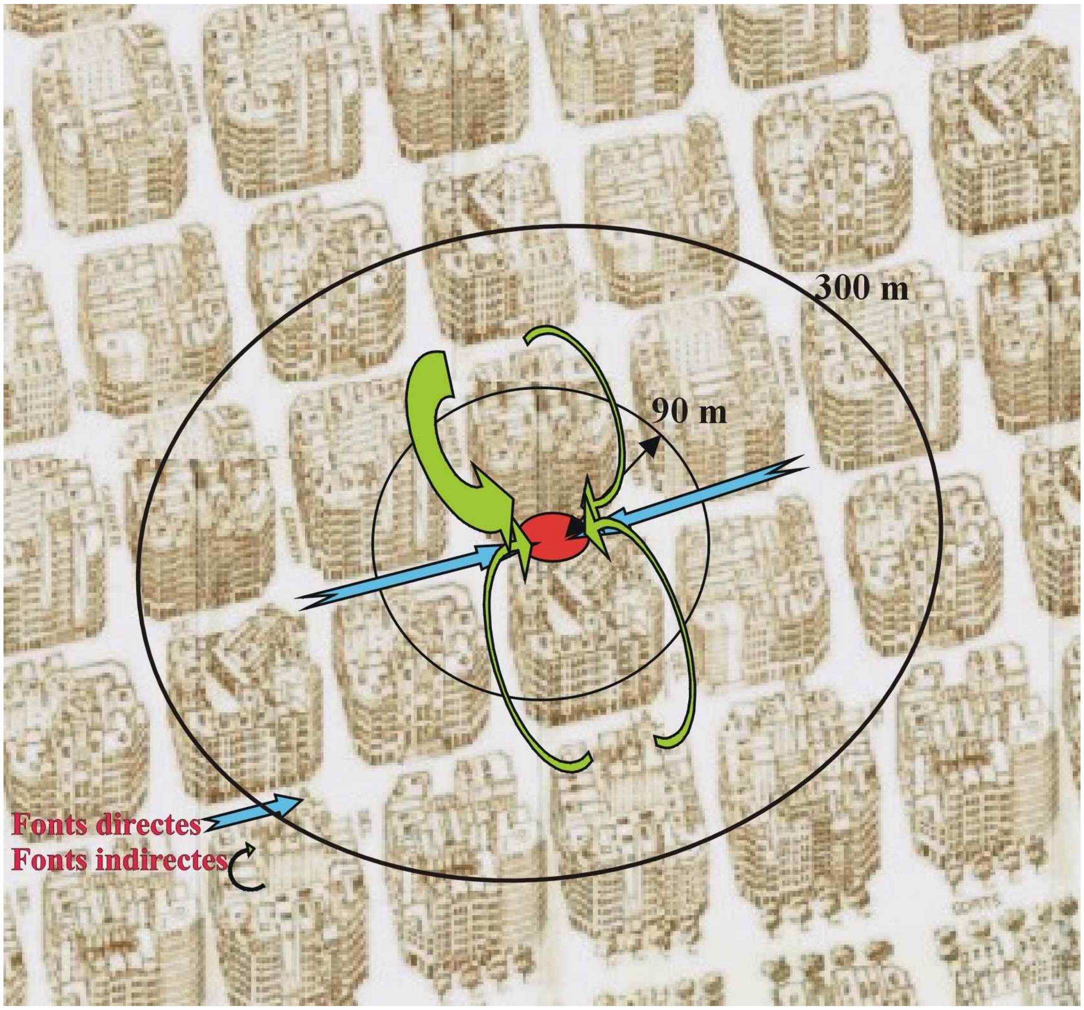
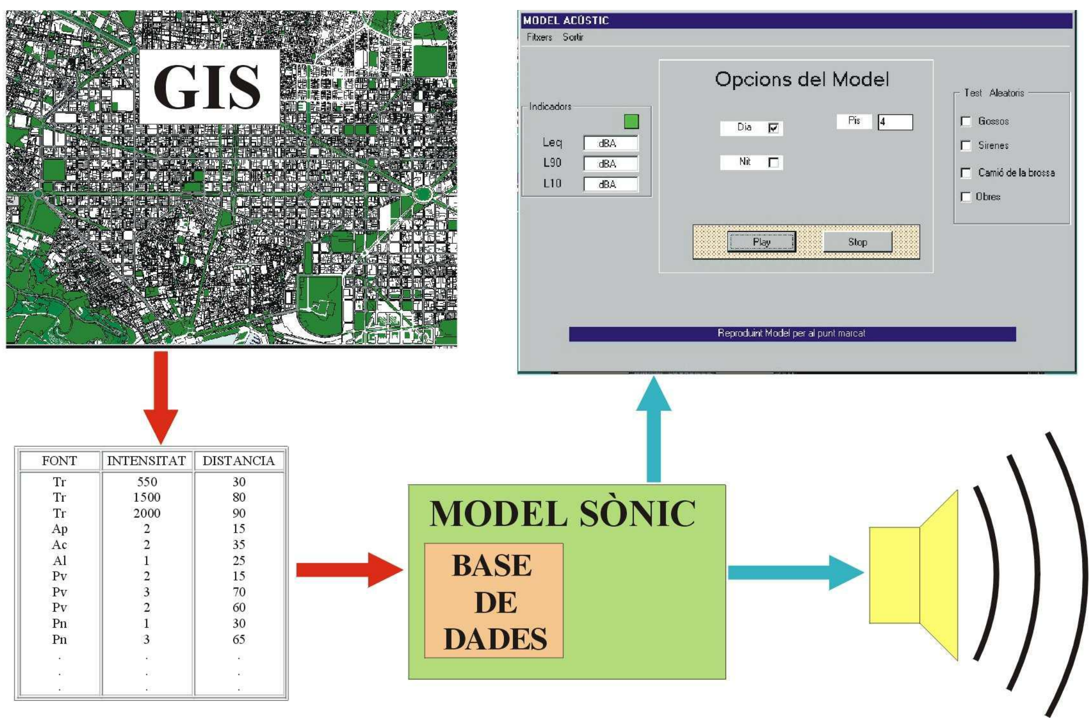


Figure 3.

1. Introduction of indicators for numerical qualification of sound scenery quality.
2. Registration of pure sources by means of an artificial head upon a binaural approach.
3. Use of formats of audio compression, such as MP3, for pure-source files in order to reduce file size and increase their number.
4. Improvement of propagation laws of each type of source according to the particular geometry of each scenery and the absorption coefficients of the buildings' façades.
5. Improvement of the probability model incorporating new random sources.



FONT	INTENSITAT	DISTANCIA
Tr	550	30
Tr	1500	80
Tr	2000	90
Ap	2	15
Ac	2	35
Al	1	25
Pv	2	15
Pv	3	70
Pv	2	60
Pn	1	30
Pn	3	65
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Figure 4.