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SONORUS Project: Classification of historic urban areas through multisensory perception and expectation

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ABSTRACT

The present research project was aimed to show new approaches to the assessment of the environmental quality in general and the soundscape quality in particular of the urban areas. Within this framework, the research deepens in the complete multisensory process of perception, focusing on the influence of context and expectations on the reaction of the individuals towards sensorial stimuli. The research study explores several methods with which to evaluate the soundscape of urban open spaces, making different contributions to the identification of the patterns that define its identity. The evaluation of the potentiality of these methods was carried out applying them to case studies in Naples and Brighton. The applications of these methods on the cases study consider the spatial variability of the sonic environment and its characteristics. Consequently the outcomes obtained were used to refine the proposed assessment methods and to evaluate their feasibility. Variables selection methods, traditional regression methods, or artificial neural networks, were used to assess objective as well as subjective measures in the perception and interpretation of the soundscape of the urban environments.

Keywords: Soundscape, Expectations, Neural network, Waterfront I-INCE Classification of Subjects Numbers: 56.3, 76.9

1. INTRODUCTION

Noise is one of the consequences of the activities and displacements performed daily in our cities. Nowadays different measures can be undertaken in order to improve the quality of the environmental sound and protect citizens from the harmful effects of noise, ranging from applications of noise control engineering to the soundscape management. The authorities in charge of the environmental issues typically use noise maps as an available tool to evaluate the noise exposition. These maps do not take into account how sound is perceived but long term sound levels of traffic or industrial noise, without considering other sources rather than the named ones, or the positive effects of certain visual environments. The current research offers a new approach for the evaluation of the soundscape of historic urban areas based on the subjective perception, the expectations and the emotional dimensions linked to environmental factors, in order to give policy makers alternative information to the tradition noise maps to identify and diagnose noise problems. This approach was developed through the analysis of the information collected in relation with the environment, and the representation of the analysed information through coloured maps.

Different working lines were followed from the beginning of the project, such as the investigation and use of community based measurement techniques for the data acquisition, the study of the environmental stimuli that influence the emotional reactions of people in an urban context, or the elaboration of maps for the features' definition of the soundscape in urban areas. As a consequence, a combination of different methods was applied to collect and analyze objective and subjective acoustic data. The waterfronts of the cities of Naples and Brighton were used as test sites.

2. PROJECT DEVELOPMENT

2.1 Data collection

The assessment of the social and psychological factors that influence the perception and emotional

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reaction of people in an urban context was conducted with the participation of the citizens through face to face surveys and online surveys. The data collection methodology was designed in order to obtain objective precise acoustic data simultaneously with the subjective data (in relation with the perception of the participants of the environment) and to be sent to a server for its post processing (see Fig.). The questionnaire used for the subjective data collection was divided into two parts, one to be compiled in situ through a tablet, composed by questions in relation with the perception of the place, and another one to be compiled anywhere via internet, in relation with personal aspects of the interviewees' life, such as the neighbourhood amenity, personality traits or noise sensitivity.

An application was built in Visual Basic for Excel to be used in tactile devices on Windows Operating System. This application allowed presenting the first part of the questionnaire to the interviewees and sending the compiled questionnaires for further analysis (see Fig.). The sonic environment in each of the identified sites was recorded binaurally (16 bits/44.1 kHz) in fixed positions through binaural headphones ("Sennheiser HDC 451") worn by the operator connected to a portable digital audio recorder (M-Audio Microtrack 24/96). Photos were taken with a Nikon D80 digital camera equipped with an objective AF-S Nikkor 18-105mm 1:3.5-5.6G ED, set on a tripod 1.5m above the ground (1–3).

2.2 Soundscape classification

The influence of the sensorial stimuli on the complex process of perception of an open space demands a holistic approach to evaluate the effects that the sound, vision, or odors have on the degree of satisfaction of their occasional and daily users. The interpretation of these factors may open up new paths to evaluate the relationship between the human perception and the context. Some steps were given in this research work in order to classify outdoor areas using subjective factors related with the sense stimuli, in particular a methodology for the characterization of the urban waterfronts was developed (1). This methodology classified the areas through the best performed clustering method and characterized them through the outcomes of the multivariate linear regression method. The clustering methods were applied to the responses given on the quality of the overall environment (ENV), of the soundscape (SD), of smelling (SM) and of landscape (LD) (see Fig. 1). As a result, two clusters were obtained, consistent with the pedestrian areas and the road traffic areas (1). Eight acoustic parameters (namely the overall equivalent level L_{Aeq}, 5th percentile of loudness N_5, sharpness S, fluctuation strength F, roughness R, L_{A10}-L_{A90}, L_{A50} and log G) together with the soundscape quality appraisal (LD) were selected to perform the multivariate linear regression (MLR) with the soundscape quality as target variable (SD). The outcomes highlighted the importance of the visual factors on the soundscape perception, confirming the results of previous research studies (4,5).

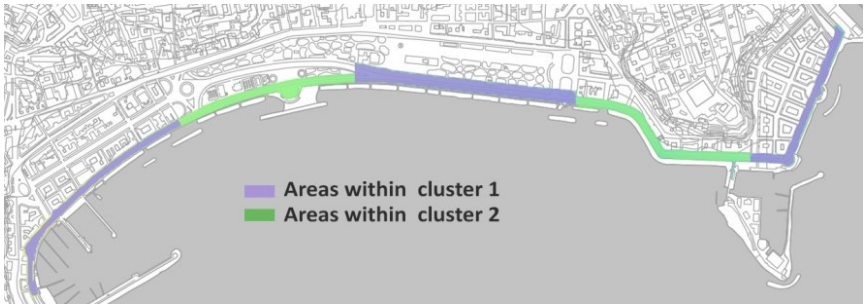

Fig. 1. Cluster 1 and 2 calculated with the variables environmental quality, landscape quality, smellscapes quality and soundscape quality.

2.3 Soundscape modelling

The reinterpretation of the local specificity and identity of the urban open spaces, especially in the historic city centres, may be a valuable tool for the design of the existing city. Finding this new local specificity is the starting point for enhancing the quality of abandoned or underused open spaces in pursuit of a continuous improvement. This improvement may be driven through the creation of new atmospheres in which the soundscape plays such an important role as the landscape (3,6,7). Considering the soundscape as an identifier mark that offers congruence to the overall environment, the identification of the patterns that configure the soundscape identity of a place may be powerful information for future urban interventions (2,3).

Modelling techniques have shown their adequacy to establish the relationship between different

objective and subjective parameters and the soundscape quality (8,9).

A modelling approach to evaluate the influence of objective acoustic and visual parameters on the perception of the sonic environment (in order to define the elements that identify it) was performed through artificial neural networks. Objective acoustic, visual and spatial parameters were used as input variables of the model (3).

The objective acoustic data used were the L_{eq}, L_{Aeq}, and the percentiles L_{A5}, L_{A10}, L_{A50}, L_{A90}, L_{A95}, as well as psychoacoustic descriptors, namely loudness (N) and the fifth percentile of loudness (N_5), sharpness (S), roughness (R), and fluctuation strength (F).

Different research studies have lately used spatial metrics as an objective measure of the visual and spatial features of an environment (10–12). For the collection of objective visual data, spatial metrics were calculated on the bases of the aerial photographs. Three groups of spatial metrics were used in this study: 1) Area and edge, 2) Shape and 3) Aggregation (13).

The minimum redundancy maximum relevance feature selection method was applied to reduce the number of input variables. The database was divided into train (70%), test (15%) and validation sets (15%). A resilient backpropagation algorithm with backtracking was used in the calculation of the artificial neural networks. The best performed model among the 500 was selected (with better results in comparison with linear regression methods), concluding that the percentage of the sea that can be seen or the aggrupation of the green areas had a positive effect on the soundscape perception. The outcomes on the acoustic variables ratified the importance of N_5 on the soundscape perception highlighted by some research studies (14,15).

2.4 Soundscape representation

Further analysis was conducted to identify the visual and acoustic parameters that define the soundscape perception and to evaluate the relative importance of each factor (3,16). The relative importance of each factor explains the contribution of the variables under study on the quality of the soundscape and gives a clue on how the environment can be improved in order to obtain optimal results in the soundscape interventions (3,16). The outcomes of this analysis were represented in maps through the kriging interpolation method using the software QGis (see Fig. 2).

These coloured maps offer an understandable visualization of different factors that affect the soundscape perception, such as the visual environment or the expectations, and may help the stakeholders in the decision making processes of renewal interventions.

3. CONCLUSIONS

Different theoretical and practical approaches were been undertaken in order to look into the knowledge of the soundscape of the urban open spaces. These approaches offer an alternative perspective in the understanding of the multisensorial phenomenon of perception. In order to test the applicability of this research work, procedures of modelling, classification and representation were used for the analysis of outdoor environments. The utility of the combination of these procedures was demonstrated through the analysis of real cases study in Brighton and Naples.

Fig. 2. Scheme of the process used in the data acquisition and analysis.

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REFERENCES

1. Maffei L, Puyana Romero V, Brambilla G, di Gabriele M, Gallo V. Characterization of the soundscape of urban waterfronts. Forum acusticum. Kraków (Poland); 2014.
2. Puyana Romero V, di Gabriele M, Fernández Álvarez D, Maffei L. Overview of the waterfronts features: a perceptual approach. XII international Forum Le Vie dei Mercanti Best practice in Heritage Conservation Management. Aversa-Capri (Italy); 2014.
3. Puyana Romero V, Maffei L, Brambilla G, Ciaburro G. Modelling the soundscape quality of urban waterfronts by artificial neural networks. Appl Acoust [Internet]. Elsevier Ltd; 2016;111:121–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0003682X16301037
4. Viollon S, Lavandier C, Drake C. Influence of visual setting on sound ratings in an urban environment. Appl Acoust. 2002;63(5):493–511.
5. Liu J, Kang J, Behm H, Luo T. Effects of landscape on soundscape perception: Soundwalks in city parks. Landsc Urban Plan [Internet]. Elsevier B.V.; 2014;123:30–40. Available from: http://dx.doi.org/10.1016/j.landurbplan.2013.12.003
6. Forte F. Inspiration from land-sea connection. Landscape visions, addresses to the project. Territ della Ric su insediamenti e Ambient Riv internazionale di Cult Urban. 2014;7(il):67–82.
7. Laidley J. The ecosystem approach and the global imperative on Toronto's Central Waterfront. Cities. 2007;24(4):259–72.
8. Rey Gozalo G, Trujillo Carmona J, Barrigón Morillas JM, Vílchez-Gómez R, Gómez Escobar V. Relationship between objective acoustic indices and subjective assessments for the quality of soundscapes. Appl Acoust [Internet]. Elsevier Ltd; 2015;97:1–10. Available from: http://dx.doi.org/10.1016/j.apacoust.2015.03.020
9. Yu L, Kang J. Modeling subjective evaluation of soundscape quality in urban open spaces: An artificial neural network approach. J Acoust Soc Am. 2009;126(3):1163–74.
10. Mazaris AD, Kallimanis AS, Chatzigianidis G, Papadimitriou K, Pantis JD. Spatiotemporal analysis of an acoustic environment: Interactions between landscape features and sounds. Landsc Ecol. 2009;24(6):817–31.
11. Liu J, Kang J, Luo T, Behm H, Coppack T. Spatiotemporal variability of soundscapes in a multiple functional urban area. Landsc Urban Plan [Internet]. Elsevier B.V.; 2013;115:1–9. Available from: http://dx.doi.org/10.1016/j.landurbplan.2013.03.008
12. Liu J, Kang J, Luo T, Behm H. Landscape effects on soundscape experience in city parks. Sci Total Environ [Internet]. Elsevier B.V.; 2013;454-455:474–81. Available from: http://dx.doi.org/10.1016/j.scitotenv.2013.03.038
13. McGarigal K, Marks B. Fragstats – Spatial analysis program for quantifying landscape structure. USDA For Serv. 1994;General Te.
14. Genuit K, Fiebig A. The acoustic description of patterns in soundscape. INTER-NOISE 2007. Istanbul; 2007.
15. Fastl H, Zwicker E. Psycho-acoustics: Facts and models. Third Edit. Huang TS, Kohonen T, Schroeder MR, editors. Springer Series in Information Sciences. Springer Series in Informatin Science; 2006.
16. Olden JD, Jackson DA. Illuminating the "black box": a ramdomization approach for understanding variable contributions in artificial neuronal networks. Ecol Modell. 2002;154:135–50.