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Abstract

Optimization of the acoustic characteristics of diffusive surfaces:

an objective evaluation method at the preliminary design phase

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by
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In architectural design, generally, the acoustic characteristics are considered in the last phases of the project: this is due to the requirements, in time and scientific expertise, of the simulations and acoustic evaluations. The purpose of this research is to enable architects and designers, so not acoustically specialized users, to design complex surfaces that are able to diffuse the sound energy, using a simple and quick method of preliminary evaluation, based on geometric optimization and simulation.

The first step of the research is the analysis of the specialist literature: the focus is determined by the preliminary study of the geometries that are able to maximizing the diffusing properties and by surface evaluation methodology, both through simulation and measurement. After studying the principles that control the acoustics of the surfaces and the reference standards, the process continues with the experimentation. This step can be considered the characterizing one of the thesis, in which is developed a new process of design and evaluation of the diffusion properties, using a geometric and parametric software that it is acoustically implemented; thus, a method that can be used for complex surfaces, unlike the simulation tools currently existing, from every type of user.

The data, collected during the research, allows defining the methodology for the optimization and the validation of diffusing surfaces. The method is constituted of four procedural steps for the design and the analysis of the surfaces:

- Introduction of the geometric dimensions that maximize the diffusing properties, in relation to sound frequencies, at the modeling step;
- Validation through qualitative tool;
- Validation through quantitative tool;
- Final test of measurement in reverberant chamber for a real modeled shape.

The design criteria, introduced in the panel, are related to its macro and micro scale size dimensions: in both cases, the general principle that is required to be respected is the irregularity, meant both as difference between planimetric sizes, as height and as layout. In addition, using a parametric software is possible to optimize the shape of the surface compared with the geometric inputs.
After the modeling phase, the user proceeds to the simulation in order to check the actual functionality of the designed surface. The first proposed analysis is a qualitative validation, which consists in testing the surface with a geometric tool based on Ray Tracing (RTM – Ray Tracing Method), a method useful to understand hoe the reflections can change, according to the different geometries of the surfaces. The second process of evaluation is defined by an energetic simulation, thus a quantitative evaluation, also aimed to direct comparison between surfaces.
After completing the analysis, the last procedural step, not explicitly required to the designer, is the measurement. This part is important because thanks to it is possible to demonstrate the simulation results, this validating the whole process.

In conclusion, it is possible to summarize the results:

- Optimization of the surface using the first geometric dimensional parameters;

- Optimization in progress during the modeling phase using continuous qualitative validations;
- Good results for accuracy and speed;
- Quick tool that consists of a few simple steps;
- Positive measurement results because the values of the measured coefficients are close to the optimal ones, but not for medium frequencies due to the inherent characteristics of the material used for the specimen.

The method, although it presents some gaps in terms of textural variables, suits the expectations and initial claims, because it proposes itself as a set of useful tools for the preliminary phase of surface design.

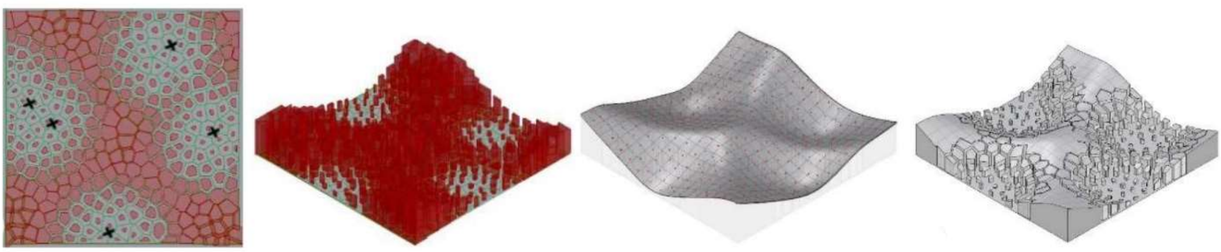

Figure 1. Geometric optimization process of the surface: a) to view of the configuration 1_PRISM, b) configuration 1_PRISM, c) configuration 1_CURVED, d) configuration 1_MIXED.

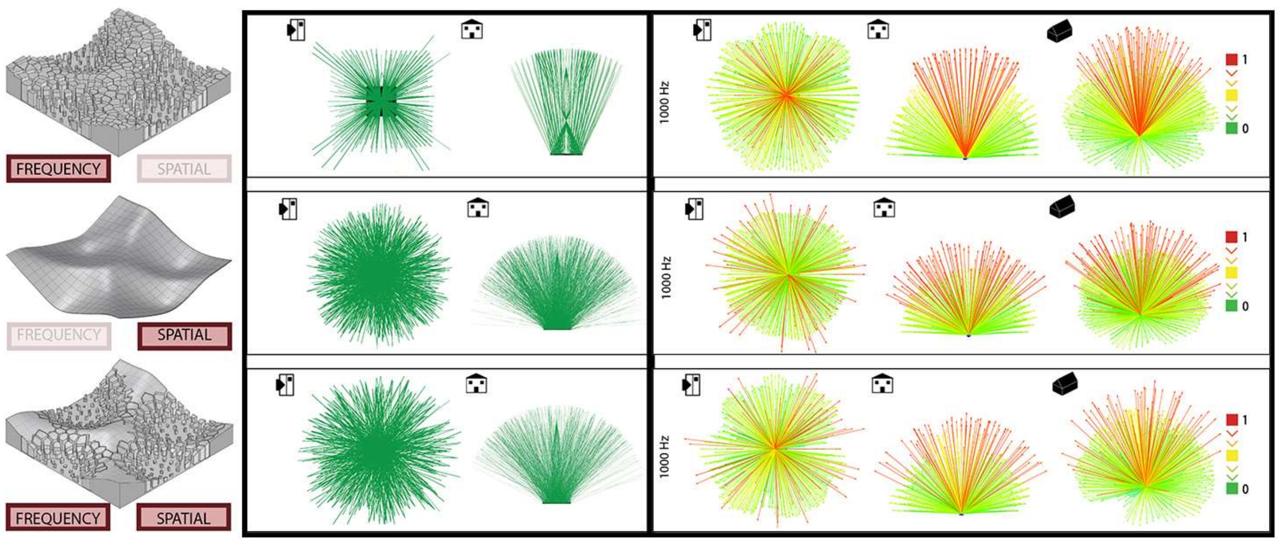

Figure 2. Results for the evaluation phase for the configurations 1_PRISM, 1_CURVED e 1_MIXED: qualitative analysis (left), quantitative analysis (right).

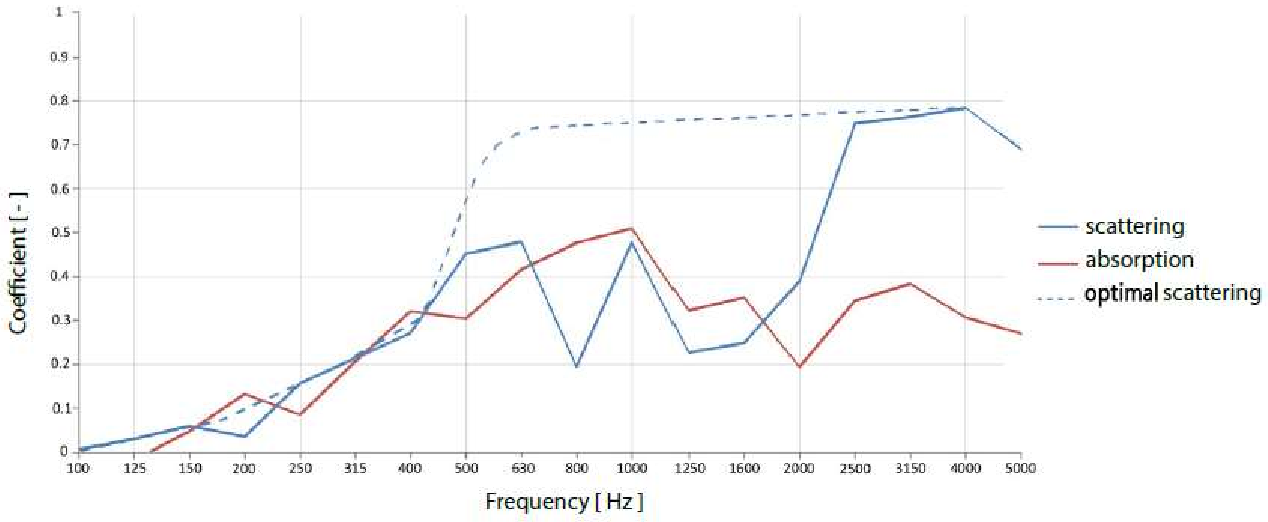

Figure 3. Measured scattering coefficient and absorption coefficient.

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