Politecnico di Torino

Honors Thesis

Master of Science in Architecture Construction City

Validation of predictive algorithm control of gatherings in enclosed places: simulation in the environment Mensa Circoop Polytechnic University of Turin

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During the first and second wave of the Covid-19 pandemic, it was hypothesized that the transmissibility of the virus increased significantly indoors where it is not possible to guarantee a correct and frequent ventilation, natural or forced, or in cases where it is not possible to maintain an interpersonal distance of at least 1-1.5 meters. Starting from these considerations, in Italy the government has proceeded to contain the Covid-19 pandemic by implementing numerous decrees including the D.P.C.M. of 26 October 2020 n. 265 called "urgent measures to contain contagion throughout the national territory" which establish the main restrictions and guidelines to follow in environments considered with higher contagious risk, among which the most interesting for the present thesis are catering environments such as school /university canteens. In the acoustic field, most of the academic literature has been based on investigating how to improve anthropogenic noise levels $L_{N,A}$ produced in rooms with different intended use, schools, canteens, auditoriums, etc., adopting instruments for noise control, as in the case of the SEM (speech and sound SEMaphore) designed by the DENERG of Polytechnic of Turin and used in school environments where it was possible to limit the noise levels L_{90} through visual feedback, or even proposing prediction models to calculate levels of $L_{N,A}$ expected starting from known physical characteristics of the analyzed environments, such as Volume, reverberation time t_0 of empty environment, maximum occupancy N_{max} to ensure good SNR signal to noise ratio, and so on. The aim of this master's thesis is to present a prediction algorithm, which, starting from the anthropic noise levels $L_{N,A}$ measured by sound level meters, is able to return a reliable value of N=number of people present in the analyzed closed environment. To validate the prediction algorithm, it was necessary to monitor in 4 days, 25-26 November 2020 (figure 1) and 14-16 April 2021 (figure 2), real levels of anthropic noise $L_{N,A}$ generated inside the CIRCOOP Canteen of Polytechnic of Turin and simulate the environment through acoustic software Odeon version 16 Combined and Grasshopper application of Rhinoceros 7, to obtain some parameters required for a correct application of prediction algorithm.

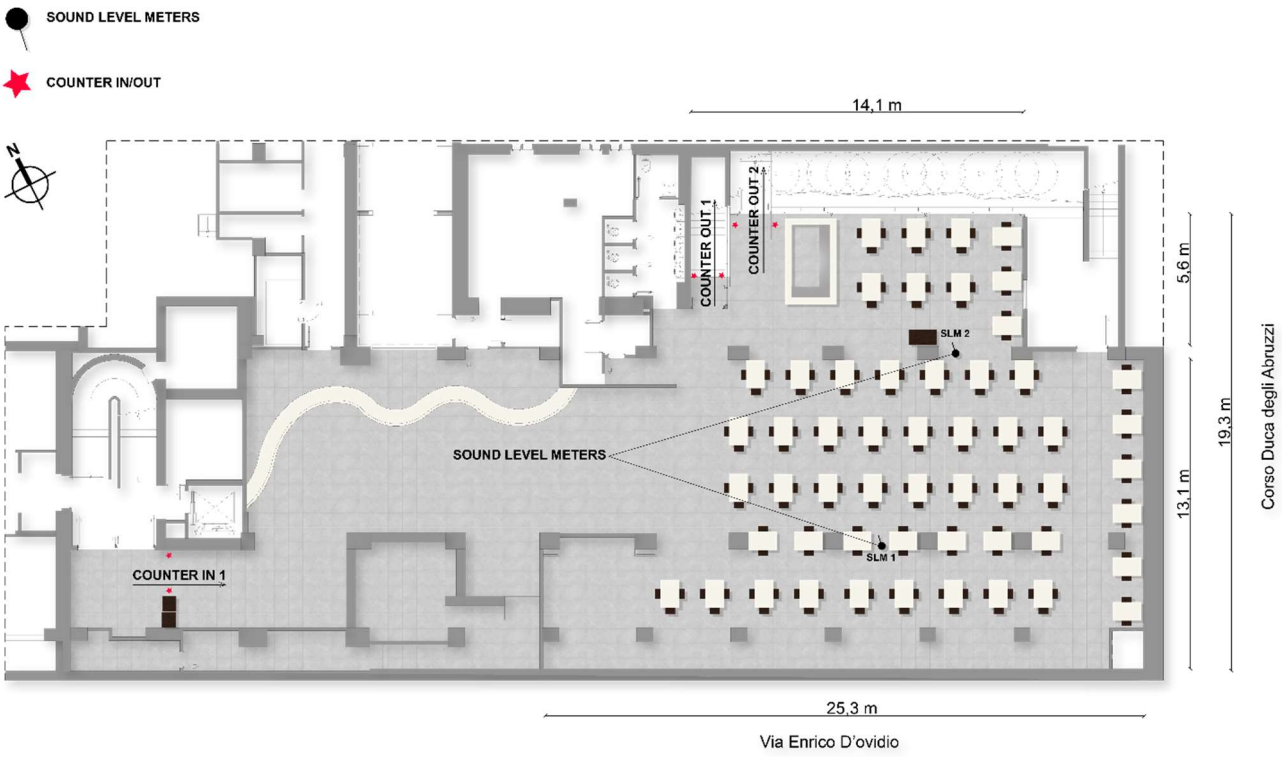

FIGURE 1 - Layout Canteen CIRCOOP Polytechnic of Turin during the measurement campaign of days 25-26 November 2020.

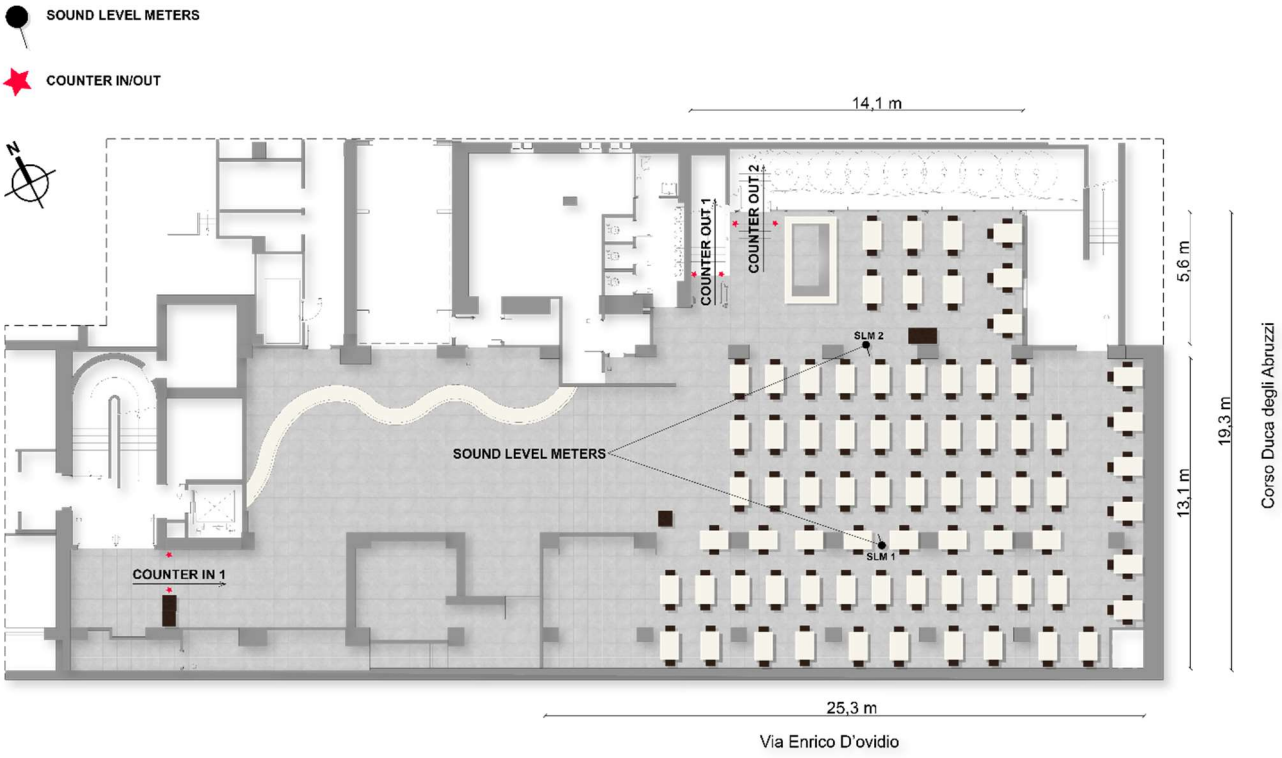

FIGURE 2 Layout Canteen CIRCOOP Polytechnic of Turin during the measurement campaign of days 14-16 April 2021.

The forecasting algorithm is based on 2 models developed by J. H. Rindel and D. D'Orazio in which it is necessary to insert known values such as the reverberation time of the environment, Volume, absorption per capita; values not known a priori are g = group size and c = Lombard slope which strongly depend on type of environment in which the forecast model is to be applied. In the case of the CIRCOOP Canteen where the levels of L_{N,A,dt_eq} and the corresponding N(t) were monitored during the 4 days of the monitoring campaign, it was verified that the values that are closest to the generalized Poisson distribution model are:

- **c=0. 50 falls within the range of values found by J. H. Rindel for the application of the forecasting model in school cafeterias, in which a c=0.4-0.5 dB/dB has been adopted;**
- **g= 8 is a value higher than the range of values found by J. H. Rindel, in fact in his studies conducted in school cafeterias there is usually a g = 2-4.**

Applying these values of g=group size and c=Lombard slope to the forecast models for the control of gatherings it is possible to note that the model of J. H. Rindel is better approximated to the data actually measured, while the model of D. D'Orazio has a good approximation for data up to 60 dB(A) corresponding to about 45 people speaking simultaneously within the closed environment, while beyond this value the data returned by the forecast model thus set tend to deviate from the data actually measured (figure 3).

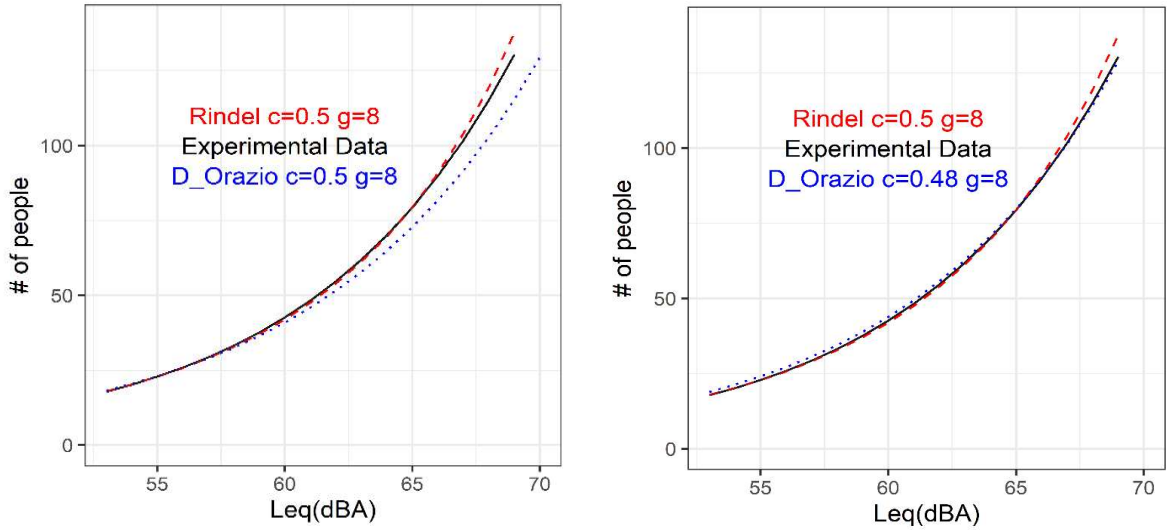

FIGURE 3 - Comparison between the forecasting models of J. H. Rindel and D. D'Orazio with data collected during the measurement campaigns.

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