Noise pollution modeling for early stage design in urban environments

Background

Noise pollution management has for a long time been a challenge in urban development [1] and is considered an increasingly critical threat to mental- and physical health for urban populations worldwide [2]. In certain large cities, residents think that noise pollution is a bigger problem than air pollution [3] and the problem is growing as cities gets denser and traffic becomes heavier. The World Health Organization recommends that the sound level of living spaces should be below 45 dB, allowing residents to sleep with windows open [4]. In addition, many countries have their own regulations when it comes to managing the noise pollution levels in residential areas.

Today many developers use specialist acoustic consultants to authenticate that the allowed threshold values are not exceeded. This is a costly, yet necessary, way to verify that a proposal is viable from an acoustic perspective. Doing an acoustic analysis of a project proposal is an expensive and time-consuming task that in general requires model conversion and involvement from external personnel. It is therefore often done as an post-design verification rather than as an active part of the design process. This sometimes results in that unnecessary compromises and non-optimal solutions has to be incorporated in an already existing design, such as sound barriers or noise-shielding windows.

Thesis proposal

With this thesis we would like to investigate the possibilities of incorporating sound pollution analysis as a part of the early stage design process.

Noise mapping is one of the easiest ways of gaining an understanding of environmental noise prevalence in urban settings. The way that this type of analysis is commonly performed is by using GIS-based noise-maps to predict the noise situation by overlaying the main sources with superpositioning techniques [5].

GIS-based methods are in general most suitable for analysis in a large-scale setting where the goal e.g. is to find the areas in a city district with the largest noise exposure. However, when an acoustic analysis is done on a single-building scale, other techniques that can yield a more precise result and a higher output resolution is often preferred. One such method that has been been increasingly popular lately in architectural workflows is the use of parametric models in software such as Rhino3d and Grasshopper. Here, a 3-dimensional model of the building and the surrounding area can be used to preform more precise acoustics simulations compared to the 2-dimensional noise mapping techniques that is purely based on GIS-data.

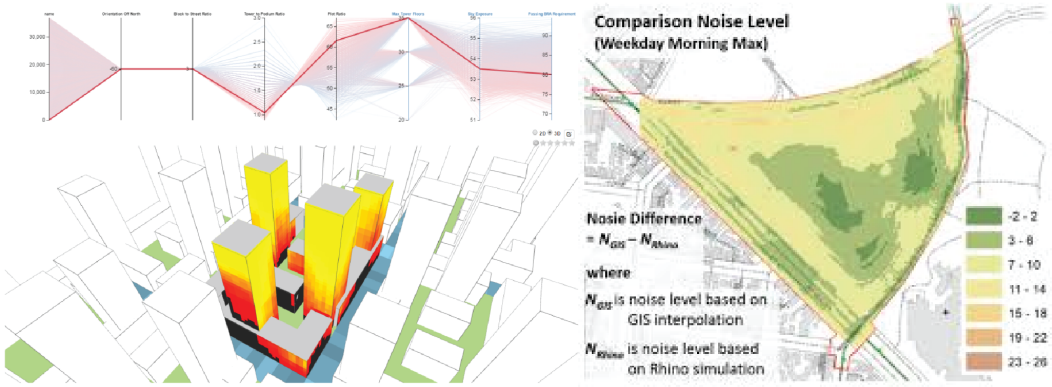

Figure 1: *Left hand side:* A parametric model for noise simulation. *Right hand side:* A GIS-based model for city-scale noise noise prediction. Images taken form [5], [6].

Both GIS-based spatial modeling and parametric approaches are widely use techniques. One of the main limitations with parametric modeling techniques is that the ray-tracing algorithms commonly used are computationally heavy and therefore require expensive hardware resources to run efficiently.

The goal for this thesis is development of a lightweight and easy-to-use toolbox for acoustic analysis in a parametric environment. The goal for the toolkit is that it could be tested and evaluated together with other parametric tools as part of Bonava's early stage design strategy for informed decision making. To simplify the integration with other tools and resources used today at Bonava, Revit or Rhino3d togeather with Grasshopper are the suggested implementation environments.

Bonava will provide useful information and real-world project environments for testing during the course of the thesis and will be able to provide feedback from an industry perspective. Some supervision for parametric modeling and the programming will be provided as well if necessary. If possible, an academic supervisor with knowledge in acoustical engineering is appropriate for the project.

Required skills

- Basic knowledge in acoustic engineering and noise control
- Ability to work independently and make decisions
- Experience of visual programming and parametric modeling
- Preferably comfortable in using one or more of the following languages: C, python, VB
- Preferably previous experience with working in the building industry

Practical information

Supervisor: Patrik Lindvall, Bonava, patrik.lindvall@bonava.com & Erik Forsberg, Parametric Solutions, erik.forsberg@parametric.se
Credits: 30 ECTS

Start date: January 2022

About Bonava

Bonava is a leading residential developer in Northern Europe which has been creating homes and neighbourhoods since the 1930s. Bonava offers apartments and single-family housing to consumers, and rental apartments to investors. With 2,100 co-workers, Bonava operates in Germany, Sweden, Finland, Denmark, Norway, St. Petersburg, Estonia, Latvia and Lithuania. Bonava is actively working with their Innovation and Digitization strategy by constantly have several ongoing RD initiatives. This is a part of their strategy where the aim is to always be at the forefront with new technology and ways of working, and by doing so keep their position as a leading developer of affordable housing units in northern Europe.

Further reading

https://medium.com/propertyfinder-engineering/modelling-noise-pollution-b914743b2963
https://gispoint.de/fileadmin/user$_u pload/paper_g is_o pen/DLA_2$020/537690013.*pdf*
http : *//core.thorntontomasetti.com/design – explorer – use – cases*

References

[1] C. R. BRAGDON, *Noise Pollution: The Unquiet Crisis*. University of Pennsylvania Press, 1971, ISBN: 9780812276381. [Online]. Available: http://www.jstor.org/stable/j.ctv4v31dk.

[2] B. C. Rosenberg, "Shhh! noisy cities, anti-noise groups and neoliberal citizenship," *Journal of Sociology*, vol. 52, no. 2, pp. 190–203, 2016. DOI: 10.1177/1440783313507493. eprint: https://doi.org/10.1177/1440783313507493. [Online]. Available: https://doi.org/10.1177/1440783313507493.

[3] P. Das, S. Talukdar, S. Ziaul, S. Das, and S. Pal, "Noise mapping and assessing vulnerability in meso level urban environment of eastern india," *Sustainable Cities and Society*, vol. 46, p. 101 416, 2019, ISSN: 2210-6707. DOI: https://doi.org/10.1016/j.scs.2019.01.001. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2210670718316019.

[4] (). "Guidelines for community noise.," [Online]. Available: https://www.who.int/docstore/peh/noise/Comnoise-1.pdf. (28.02.2020).

[5] K.-T. Tsai, M.-D. Lin, and Y.-H. Chen, "Noise mapping in urban environments: A taiwan study," *Applied Acoustics*, vol. 70, no. 7, pp. 964–972, 2009, ISSN: 0003-682X. DOI: https://doi.org/10.1016/j.apacoust.2008.11.001. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0003682X08002557.

[6] *Design explorer – use cases*, Dec. 2016. [Online]. Available: http://core.thorntontomasetti.com/design-explorer-use-cases/.