Visual-Acoustic Simulation for landscape impact assessment of Wind Farms: VisAsim

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Introduction

In Europe, renewable energies are strongly exploited for sustainable energy supply. Wind energy is an important energy source. However, in Switzerland, the development of wind energy proceeds very slowly due to objections of local inhabitants and landscape organizations.
As main difficulties, top-down planning approaches lacking the public's judgment about the acceptability of a wind farm in particular places have been identified. Most significant factors explaining support or rejection of wind farms are their impacts on the **visual** aesthetical landscape quality and the sense of place in a specific landscape context and **noise** made by rotating turbine blades. Current planning tools offer 2D maps, 3D visualizations and data for noise levels. However, they fail to provide true perceptional experience.

Goal and Methods

Within the project **VisAsim** we develop a visual-acoustic simulation tool, which integrates the realistic soundscape of wind turbine noise into GIS-based 3D landscape visualizations of alternative wind farm scenarios for valuing their impact on the landscape quality. In an interdisciplinary approach realistic acoustic soundscape modeling and GIS-based 3D landscape visualizations are integrated into a single simulation tool. In the first project phase, we will generate for a reference site of an existing wind farm at the Mont Crosin (Switzerland) a reference movie and sound recordings as well as a visual and an acoustic simulation. The latter will then be integrated into a prototype of an audio-visual reproduction system, which will be tested in experiments to proof the validity of the simulation in comparison to the reference movie/sound. In the second project phase, visual-acoustic simulation models for three focus areas with different landscape characteristics will be established and used in virtual reality choice experiments for valuation of alternative wind farm scenarios. Overall, the simulation tool allows for an improved impact assessment, which provides a better, more comprehensible decision basis for designating suitable locations for wind farms, e.g. in federal concepts on the potential areas for wind farms, in cantonal directive plans or in communal land use plans.

Screen shot of a visual simulation of a landscape with rotating wind turbines and moving grass due to wind.

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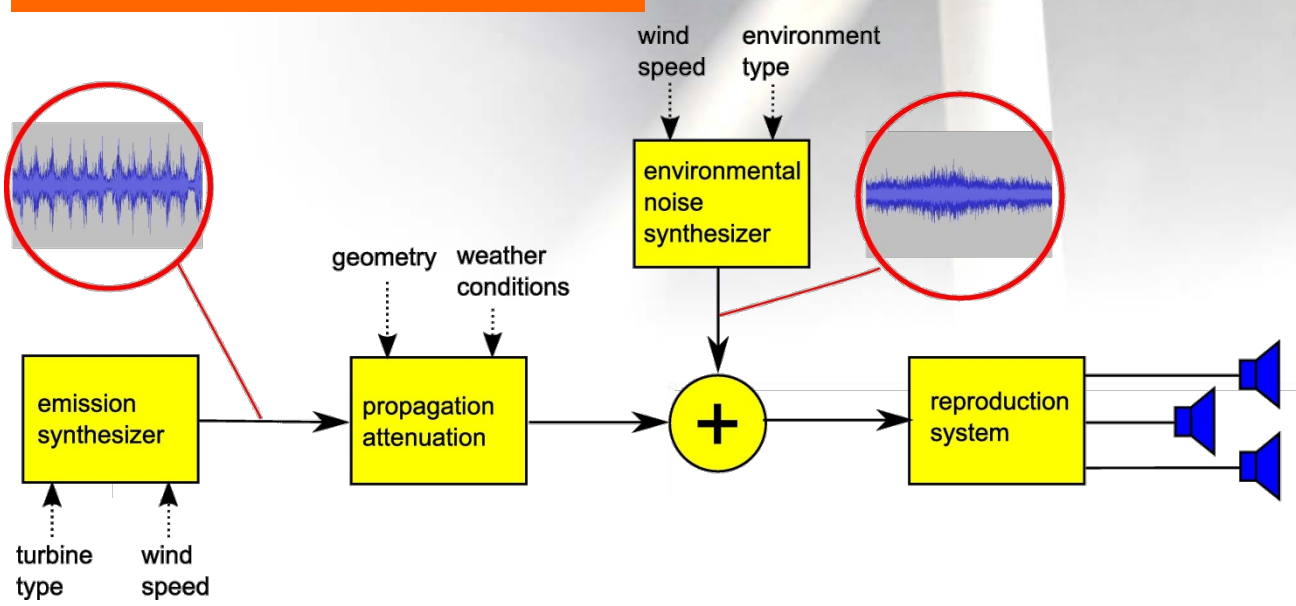
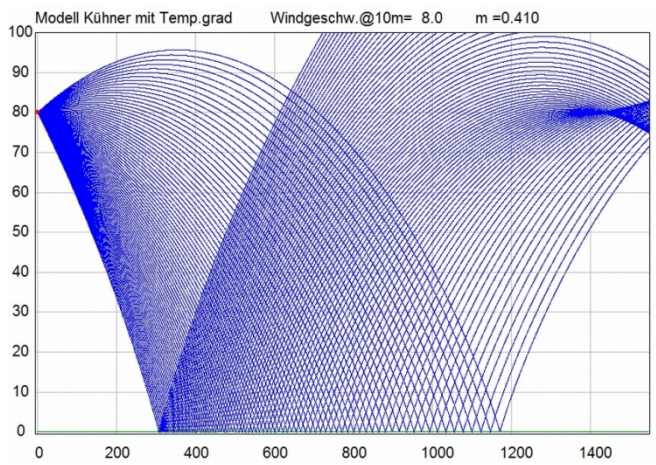
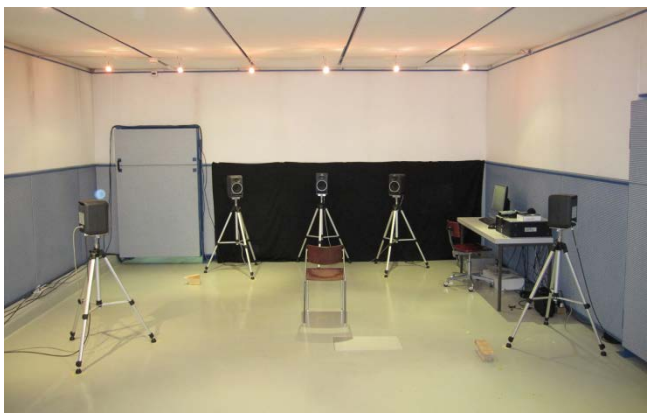
Acoustic Model



Block diagram for the generation of synthetic wind turbine and environmental noise.



Ray tracing simulation of wind turbine noise propagation under inhomogeneous atmospheric conditions. The curved lines show sound rays that are emitted by the turbine on the left. Note the different scaling of horizontal (1500 m) and vertical axis (100 m).



Preliminary loudspeaker set-up for the reproduction of wind turbine noise in the Empa laboratory.

The synthesizer module generates the emission audio signal by superposition of possible tonal components and a noise component that is independently modulated in amplitude for sufficiently small frequency bands. It will be investigated how the signal depends on turbine type, wind speed and temperature stratification. In a second step the frequency dependent sound propagation attenuation is calculated and expressed as a series of digital filters. A major challenge is the incorporation of meteorological effects and the resulting short term temporal variations of the propagation conditions. In a third step, a library of natural background sounds has to be established. The enormous variety of possible environments has to be classified in order to define a few prototype situations. Preliminary investigations have shown that vegetation noise can successfully be deduced from a random process with the application of appropriate filtering and modulation. The fourth step covers a suitable mapping of the synthesized signals to a system of loudspeakers in order to generate an appropriate listening impression regarding sound pressure levels and directional information.

Significance

The innovative aspects of acoustical auralization are the development of new algorithms and strategies for simulating spatially explicit sound of wind turbines taking into account the environmental context.
Regarding the field of 3D landscape visualization, the project will contribute to the research on providing sufficient realism for visual landscape quality assessment as well as the integration of spatially explicit sound into GIS-based visualization tools. Moreover, the application of combined visual and acoustic simulations in virtual reality choice experiments will further enhance state-of-the-art non-market valuation techniques. Within a broader context, the valuation results will allow deriving recommendations for planning wind farms and support exploiting the full potential of wind energy.

Project partners

- Empa, Laboratory of Acoustics / Noise Control: acoustic simulation
- ETH, PLUS: visual simulation

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Project website: www.visasim.ethz.ch