Geometric Post-Processing of GIS Data for Noise Mapping

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Introduction - What Data will be Provided In A GIS System?

The only economic approach to large-scale environmental noise modelling using complex models in dedicated noise calculation software is often by using existing data from Geographic Information Systems (GIS). However, such data is often collected over a long period, is not optimised for acoustic calculations, and often only has 2-D information. Now, 3-D GIS data is collected in a well-structured manner, either from aerial photography or from laser scanning. In addition to pure geometry data, more sophisticated data with attribute information can be delivered. But, for traffic planning, important acoustical details such as road surface are missing. As GIS was originally aimed at drawing functional maps, data may be too detailed for acoustic analysis. In addition, the demands on data accuracy will vary depending on the kind of acoustic analysis done. With this in mind, it is not surprising that GIS data cannot always be used immediately. Either the GIS or the noise calculation software must process the input data for optimal use.

Terrain

Digital terrain models (DTMs) define the terrain heights at objects and at source or receptor positions. They should also be used as diffraction edges and should prevent the potential reflection of reflectors beneath their base. An efficient noise calculation software relies on an in-built DTM with "relative" height definition. To ease use, additional height definitions might also be defined:

- absolute, i.e. height above mean sea level (M.S.L.)
- relative to buildings or edges of neighbouring objects (e.g. embankments)
- based on a known gradient to a neighbouring terrain object

Simple DTMs work with a regular grid of tiles, which can easily cause jumps in diffraction effects at neighbouring receptors. More complex (interpolation or extrapolation) algorithms exist. However, GIS and noise calculation software do not use the same DTM algorithms. Thus, the quality of the DTM should be checked by producing contour lines from the input data, showing areas needing further model input. In addition, GIS terrain information can easily create multi-Gigabyte models, greatly slowing handling. So it is important to reduce it to that data that is significant for acoustic analysis. GIS may provide point heights, contour lines, ridges, slope and escarpment edges.

Point information needs to be converted into a 3-D terrain surface.

Contour lines may consist of many vertexes that are far too detailed for our purposes. Sometimes they are single segments. This demands concatenation (merging) in order to create suitably simplifed polyline objects. Simplification might be done by just skipping certain height intervals, unless they describe the bottom or top level of the local terrain. More sophisticated smoothing techniques with user-defined accuracy that can be automatically adopted when contour lines are placed close to each other.

In theory, ridge-edge models describe relevant diffraction edges more directly than contour edges and the model would need less definition. However, ridge edges are usually generated as triangles from pre-calculated grids, and 50% of the information may be redundant.

For planning, or when updating data, an existing terrain model might have to be modified. Clipping of existing geometry is needed. Take care with objects whose height information is defined relative to clipped objects.

Handling Buildings and other Polygons

Closed polygons are split up into single edge elements for hierarchical drawing. In acoustic modelling, buildings must be closed polygons in order to recognise any indoor receptor position, thus requiring concatenation. This may be hampered by missing line segments e.g. a line being beneath a more important line (e.g. building edge beneath border of property) or contours not clearly recognised in aerial photography (e.g. edges underneath trees).

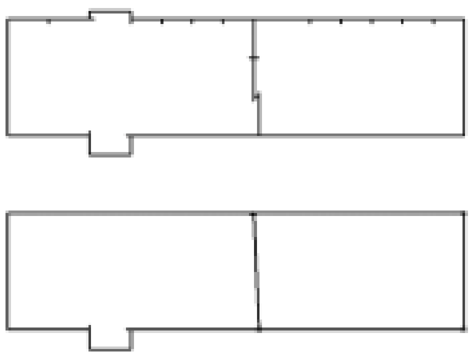

Figure 1: Segmented and smoothed facades

If GIS organises buildings as multi-patch polygon parts consisting of several outer and inner rings, the noise calculation software needs to convert this into barrier objects. If facades are digitised in GIS as small segments, façade elements may not fulfil minimum reflector size criteria. Façades should therefore be smoothed to create simplified structures (see Figure 1) and walls between buildings must be treated identically.

Several kinds of area objects are needed in the calculation (e.g. topography areas, attenuation areas or planning zones). Sophisticated noise calculation software can handle changed properties along the path of propagation in a nested structure (e.g. patches of hard ground within larger soft ground area), reducing the information needed to define hierarchies.

Topography areas help describe acoustically hard and soft surfaces. To simplify modelling, some regulations assume hard surfaces on and next to the road in the propagation formula. So only more general areas need to be defined. However this will not cover the effect of noise propagation from a neighbouring road or other source types. The noise calculation software should automatically generate road surface objects around road centre lines and correctly handle how these areas interact with the primary source.

Often, the edges of **planning zones** (used to define noise limits) run along the front façades of buildings. If they cover the road space, undesired maximum values in conflict maps will occur. If placed on the façade itself, receptor points in front of the façade and related to it will be outside the planning zone, again creating errors. Thus, GIS data may either be revised or the noise calculation software should use some criteria to find the proper receptor noise limits.

3-D Modelling with 2-D GIS Data

In general, buildings are made flat-roofed with one height. When attribute information is used to assign heights, height is typically assigned to the first node element of the building geometry. Thus the starting position of polygons needs to be easily recognised and modified. Textual information, e.g. number of floors, placed inside the polygon may be useful.

Today, 2-D GIS data can be transformed into high quality 3-D data using airborne laser scanners to produce very dense topographic height information (e.g. every 3 m). This data can be merged with the GIS 2-D position of buildings. Filters are needed to eliminate misleading z-information caused by e.g. cars, advertising pillars or even street lights. A terrain model and building heights can be created in a automatic process.

Road representation in GIS may vary (e.g. centre line representing traffic of both directions, 2 centre lines in same position with opposite direction, centre line with information about position of far lanes and central reservation, centre line of each lane in their correct positions, sealed surface area of the road space). This can either be helpful or result in extra work, depending on the regulations used for the acoustic calculation. Post-processing includes splitting line elements as its properties change (e.g. on either side of a road junction) and creating parallel objects at a given offset (e.g. creating multiple lanes). Heights will often just be defined as 0.0 m relative to terrain. Automatic adjustment of line or area sources is needed to align the road geometry with the terrain. Simplifying road geometry leads to fewer barrier and road segments and significantly reduces calculation effort).

When 3-D road objects are smoothed, the vertical pitch (i.e. the minimum deviation allowable for non-segmentation) should be kept smaller then the horizontal one, to avoid a too large influence on diffraction. For 2-D road objects smoothing should be performed before any adjustment to terrain takes place.

Data are collected for the acoustic model from various sources, with varying attribute information details and geometric accuracy. For example, a rough geometry might be available in traffic models and high quality geometry supplied from ordnance survey (see Figure 2). Linking the traffic data to the detailed geometry can be automatic. Results need to be checked for ambiguous geometry.

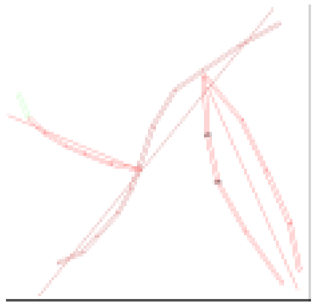

Figure 2: Collecting attribute data from simple geometry and applying to complex road object geometry

Geometric and attribute integrity of the model can be checked in various ways, e.g. visually by attribute-dependent graphics, in 3-D and in tables. Automated numerical analysis is also needed for hidden errors in the model (e.g. cross-digitising of buildings, unclosed area objects, duplicate objects including multiply-digitised line sources, reflecting screens or facades, and unintentional gaps between screens.

Checking the Influence on Result Quality

Geometric manipulation can drastically influence calculation speed and result accuracy. It is recommended to validate its influence on the final results by comparing results from a detailed model to those from the simplified model used. Software should provide random calculations of a user-defined percentage of grid points. The two sets of results may then be compared using statistical tools.

Conclusion

Due to the intended multi-use functionality of GIS data, it is often not set up according to the demands of the particular project. Thus, tools for automatic or semi-automatic post-processing of attribute and geometry data are needed for noise mapping. They have to be supplied by the GIS or by advanced noise calculation software. In other words, low to mid-range GIS products put higher demands on the post-processing capabilities of the acoustic software tool used. More information can be found in [1].

References

[1] Geometric Post-Processing of GIS Data. Manvell et al, Proceedings of Internoise 2003