EEN GEÏNTEGREERD SYSTEEM VAN GELUIDMODELLEN EN GIS:

Een optimalisatie van de kwaliteit en de efficiëntie van geluideffectstudies

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SAMENVATTING

Het ontwerp en de aanleg van grote infrastructurele werken zoals snelwegen en spoorwegen vereisen grote aandacht voor het milieu. GIS speelt een steeds grotere rol bij onderzoeken naar de invloed van dergelijke projecten op het milieu.
Vooral het aspect geluid is gebaat bij het gebruik van GIS. Om de geluideffecten in beeld te krijgen is een uitgebreide ruimtelijke database en veel rekenkracht noodzakelijk. Het beïnvloedingsgebied van geluid is groot in vergelijking met de andere milieueffecten zoals bijvoorbeeld externe veiligheid, trillingen of sociale aspecten. Geluid heeft bovendien invloed op veel zaken zoals op mens en dier, op wonen, werken en recreëren.

GIS is de centrale database waarin alle (geografische) informatie die in geluideffect-studies een rol speelt samenkomt. In deze database kan de informatie worden opgeslagen, beheerd, gecombineerd, bewerkt, geraadpleegd en gepresenteerd. Daarnaast biedt GIS de tools om analyses uit te voeren zoals kwantificering van geluideffecten, interpolaties en cumulatie van geluid. Bovendien zou GIS inzicht kunnen geven in de foutmarges rond de resultaten. Iets wat momenteel nog veel te weinig gebeurt.
Momenteel wordt de geografische invoer voor de geluidmodellen gegenereerd door deze te digitaliseren op basis van bestaande kaarten en/of bestanden en aan te vullen met hoogte-informatie die is verzameld door veldonderzoek. Veelal is deze data echter al digitaal aanwezig. Een automatische koppeling tussen deze data en de geluidmodellen in een GIS zal de betrouwbaarheid en de nauwkeurigheid van geluidberekeningen verhogen en de efficiëntie ten goede komen. Deze integratie zal leiden tot een verdergaande standaardisatie en uitwisselbaarheid. Bovendien zal gebruik kunnen worden gemaakt van reeds bestaande ruimtelijke berekenings- en analysemethodes in GIS, wat de kwaliteit van geluidstudies zal verbeteren. Ook op het gebied van presentatie kan GIS voor geluideffect-studies nog veel betekenen, bijvoorbeeld door combinatie van 3D-GIS en de simulatie van geluid in een Virtual Reality-wereld.

Bij de sectie GIS technologie, afdeling Geodesie op de TU in Delft is een onderzoek gestart
waarin een verdergaande integratie van GIS en geluidmodellen wordt onderzocht om de kwaliteit en efficiëntie van geluidstudies te verbeteren. Dit onderzoek wordt uitgevoerd in samenwerking met de afdeling verkeerslawaai van NS Technisch Onderzoek. Er wordt gekeken naar een oplossing om de integratie te realiseren en naar toekomstige mogelijkheden, waarbij ook aandacht wordt besteed aan de problemen die bij dergelijke koppelingen naar voren komen.

INTRODUCTION

Noise pollution is a major factor of dissatisfaction with the environment, especially in the Netherlands where space is limited and population density is high. Infrastructure is the most important noise source. Therefor it is important to study the possible side effects on the environment when new infrastructure is planned and to monitor the effects of existing infrastructure. These effect studies support the decision-making process. Based on these studies, the design with minimal effects on the environment can be selected and measures can be schemed by which the influence on the environment is reduced.

Geographical Information Systems (GIS) are becoming more important in the study on the possible side effects of infrastructure. The possibilities of GIS to analyse and present geographical data improve these studies. This is particularly the case in the study on noise pollution, since noise transmission and the effect of noise on the environment have many spatial components. The quality and efficiency of noise mapping can be optimised using GIS-functions.

NOISE POLLUTION AND GIS

In the Netherlands noise levels are predicted with special noise computer models. A substantial part of the noise study is usually gathering and digitising the needed information in the suitable format for the computer models. The results of these computer models are input data for a GIS. Based on these input data noise effects can be quantified and visualised using functions available in GIS (see figure 1).

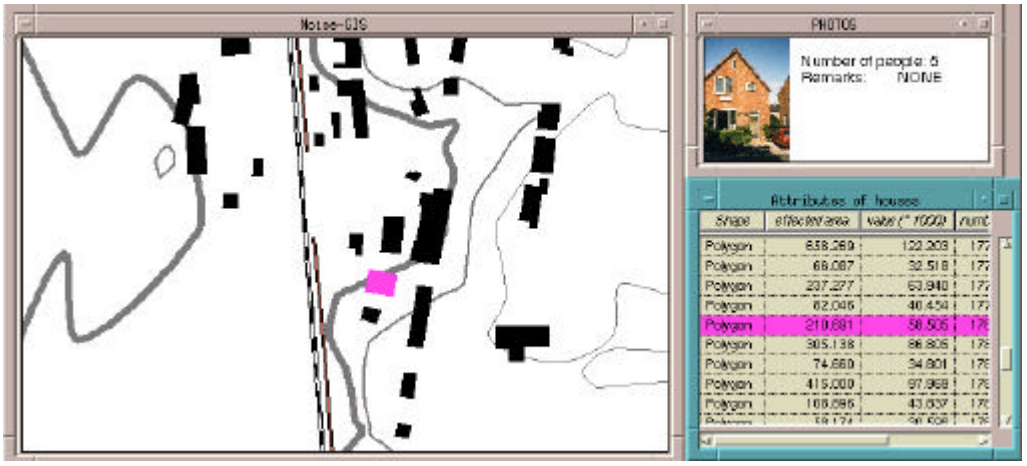

Figure 1 An example of combining data originating from different destinations in a GIS (spatial and additional data).

The analysing of noise effects includes:

- computing the area, which is effected by noise
- determining the number of dwellings, schools, hospitals etc. where a desired noise level is exceeded
- determining the area of nature parks where the noise-level will be higher than the desired value
- determining the number of citizens who are annoyed by noise

Besides quantifying noise effects GIS is used to store and manage the geographical data involved in noise effect studies.

Till now a widely used integrated system of GIS and noise prediction models is lacking. GIS is only used as a pre- and post-processor in the study on noise pollution. As a consequence GIS and the available digital data are not optimally used.

Since there is no far-reaching integration of GIS and noise prediction models, the following shortcomings and problems are met:

- Much data conversion is needed between noise prediction models and GIS. This process is not efficient and causes confusion about the actuality and validity of the data.
- The differences in scale, format and accuracy of the data endanger the quality of the results. A control system to deal with this problem is absent.
- The shortage of a standardised method for assessing noise effects on the environment gives ambiguous results.
- Little or no attention is paid to data uncertainties and inadequacies and the accuracy of used methods. A tool to give insight in these errors is missing.

Nowadays some systems make a link between noise and GIS. To a certain degree they give a solution to the problems mentioned but these are distinctive solutions and they demand specific data formats and offer only specific analysing possibilities.
As will be shown in the following paragraph the integration of GIS and noise prediction models will give a more general solution to the problems mentioned. Such a system forms an appropriate monitoring tool on noise effects and can assist to control the long-term effects.

THE RESEARCH PROJECT

At the Delft University of Technology, Department of Geodesy, we are working on a research project to integrate the Dutch noise prediction models and GIS. This project is done in collaboration with the section traffic noise of the Department of Technical Research of the Dutch Railways.
In this research it is studied how the integration of GIS and noise pollution models can improve the quality and efficiency of noise effect studies. It is examined how the integration can be realised best. Also future possibilities are considered.

The issue of noise pollution is country specific since the used noise models and the legislation on noise pollution is different for each country. This research project can contribute to face the problem of noise pollution more general and it can support standardisation of prediction models and legislation, which is desirable in the European Community. It is expected that in a few years noise mapping will be an important tool in supporting European Policies.

To realise the integration between GIS and noise prediction models, interoperability and OpenGIS are basic principles. A core system consisting of a spatial database management system, (spatial) tools and noise prediction software allows the interaction between noise software and GIS functions and gives the facility to use the same data in both systems (see figure 2).

The central spatial database management system serves as a collector, supervisor and provider for the input data for the noise models and for data needed to compute noise effects. In addition a tool built upon this DBMS is able to generate and supply the input data for the acoustic models automatically. This is discussed in the paragraph ‘future developments’.

Additional conditions that should be realised in the integrated noise-GIS system are the following:
In the spatial DBMS all relevant data can be collected, stored, controlled, standardised and managed.

- The quality and accuracy of the data is guarded by the system.
- The (spatial) data is stored in a kernel and can be retrieved independent of the software that is used. The system acts like an interpreter between different software and models.
- The use of the central spatial DBMS supplies the tools to make it possible that everyone who works with the data uses the same and most actual data, without the need to copy and convert data.
- The output data of the noise models can also be stored in the central DBMS. In this way other applications and users can access these data as well, so the data becomes available for different authorities. This will ensure legal security for all parties (owners of the infrastructure and the people living in the surroundings).

Since exhaustive studies have been done to build the existing noise models, it is not availing to replace these noise models totally in a GIS. Instead the integration of GIS utilities and noise prediction models mainly takes place by being able to access and process the same data. GIS utilities are in this way expansions and enhancements on noise studies.
Additional tools that are essential in the integrated noise-GIS system are the following:

- A tool that implements the communication between GIS utilities and noise prediction models. The tool is used to access and use the output and input data from noise prediction models in GIS and vice versa.
- A control tool which supervises the use of the correct data (version, accuracy, scale etc.).
- A tool for visualising the data during the modelling process. With this visualisation tool it is possible to perform a visual analysis on the information in any phase of the study giving an extra control on the used data and computed values.
- A GIS-application for monitoring and quantifying the noise effects on the environment for different scenarios, giving an unambiguous instrument to support the decision-making process in infrastructure planning.

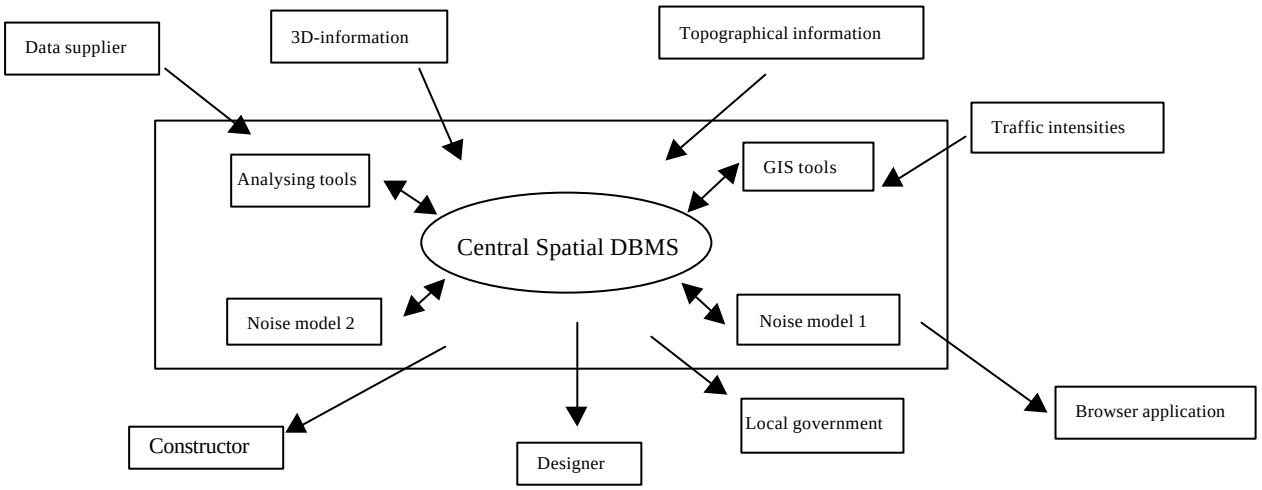

Figure 2 Interoperability between GIS, databases and Noise Prediction Models.

FACING QUALITY AND ACCURACY

Since important decisions are based on the results of noise effect studies, it is not only important to obtain results, but also to have information on the quality and the reliability of the results. This gives more meaning to the results. Reliable decisions can only be made if the level of the errors is sufficiently low and if the significance of the results is abundantly transparent. This problem is often discarded.
The quality of the results of noise studies depends on the quality of the data and methods used. GIS can control, supervise and reveal the quality of the results by regarding the quality of the input data and the used methods. Techniques of dealing with uncertainties and data inadequacies and techniques of quantifying the quality of the results will therefor be focused on in this research.

CONCLUSIONS

The integration of noise computer models and GIS makes it possible to calculate the impact of noise on the environment with information based on noise levels computed in noise computer models combined with information of the sensitivity of the surroundings to noise. The needed information can be supplied by different data sources.

A central spatial database management system where all needed data is stored and managed, increases the efficiency and quality of the study on noise effects.

Integration of GIS and noise computer models has shown to have the following advantages:

- GIS can form a link between geographical and geometrical information of the surroundings and the noise prediction models.
- A central spatial DBMS supports the use of the correct and proper data in noise effect studies and it increases the efficiency of noise effect studies.
- A noise-GIS application for monitoring and quantifying noise effects for different scenarios provides an unambiguous instrument to support the decision-making process in planning infrastructure. Such an instrument can assist to control and preserve the noise emission and immission of existing infrastructure.
- A noise-GIS application can contribute to face the problem of noise pollution more general. An internationally standardised monitoring tool will give insight in the noise problem in Europe and can be an important tool in supporting European Policies on noise pollution.
- The quality of the results of noise studies should be a major factor in the decision-making process. GIS can improve noise effect studies by detecting and dealing with uncertainties in the modelling process and data inadequacies and by quantifying and visualising these uncertainties in the results. Based on this information more founded decisions can be made.

FUTURE DEVELOPMENTS

A new development in GIS is the storage of geo-objects as 'world-alike' 3D-objects. The location and geometry of these 3D-geo-objects is determined by x, y and z-co-ordinates. The transmission of noise is influenced by the height of the surroundings (for example obstruction by surrounding terrain, buildings and objects). 3D-information is therefor necessary in order to calculate noise levels in noise computer models. A link with a 3D-GIS system makes it possible to generate noise models automatically and is therefor a subject that has to be studied further.
It can be evaluated if existing noise computer models can be improved with 2.5D and 3D functions available in GIS (advanced interpolation techniques, spreading functions etc).

With a link to a 3D-GIS Virtual Reality system it is possible to make a real time presentation of the planned infrastructure. In addition to the 3D visual presentation the simulation of noise caused by passing trains or road traffic will make Virtual Reality models more realistic. A Virtual Reality world with 'real' sound can help the designers and can play an important role in the communication process with the community (see figure 3).

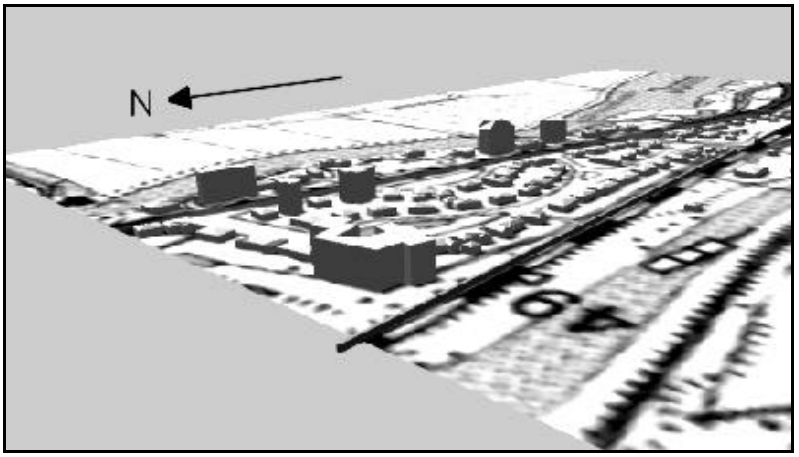

Figure3 An example of a 3D-visualisation based on a GIS-database.

Further research has to be done on implementing parts of the noise calculation method in GIS. With simplified noise calculation tools available in GIS, it is possible to indicate possible solutions to noise problems without the need to use the complete noise calculation method for obtaining precise results.

CRITICAL REMARKS

To make the integration successful not only the technical part of the system should be considered. Since different disciplines have to work together to make the integration tool functional, effort should be made to prepare the organisation where the system will be incorporated.
Another point that should be considered in the integration process is that users frequently expect digitally obtained, computed and managed data to be of a high quality, especially if fabulously presented. In general advanced digital systems are capable of processing data precisely, but their overall accuracy still depends on the accuracy of the source data and in noise studies on the models used. Therefor users working with the integration system of GIS and noise computer models should be aware of this. The integrated system can assist in this process by taking data inadequacies and uncertainties into account and by revealing the quality of the results.