# GDMS: A Spatial Semantic to Evaluate Soundmarks Effects on an Urban Pedestrian Pathway

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## ABSTRACT

Through interactions with environmental phenomenon such as light or sound, urban and architectural spaces produces atmospheres, so called ambiences. This notion of ambiences is related to the human being position through its perception of environmental physical phenomenon during its pedestrian walk. The aim of our work, within AMBIOFLUX's interdisciplinary research project, is to evaluate, so as to characterize, the impact of sound ambiences (soundscape) onto an urban pedestrian pathway using and extending the spatial semantic we developed in the context of the GearScape project (a customization of the OrbisGIS project).

In this paper, we will first present the spatial formalism and the soundmark and soundscape concepts we use. The remainder of this paper is dedicated to the evaluation's methodology of the pedestrian pathway's acoustic fingerprint using the spatial formalism already described. First results obtained will be presented.

## INTRODUCTION

As mentioned in (Tomlin, 1994), “the first major component of [a geographic] information system is its data, the second component is a set of data-processing capabilities”. Data that need to be processed in a GIS depend on the nature of the spatial phenomenon involved. All data relative to a particular geographic area of interest are stored in a single map called a layer. It corresponds to a bounded plane surface, where all atomic data share the same scale, orientation and planimetric projection. To process such a layer (the digital cartographic variable), the need for a spatial query formalism has been clearly identified and thoroughly studied over the last years. As noticed by (Liu, 2004), “many studies focusing on the management of vector data in [Spatial DataBase] have progressed rapidly in the past”.

In the OrbisGIS project (Leduc, 2009 and 2007, Bocher, 2008), recently re-engineered in the GearScape project, we have already focused on the definition and the implementation of an abstraction layer called GDMS (Generic Datasource Management System) to handle and process spatial data. Main objectives with GDMS, are to provide the user not only a simple and powerful API but also a spatial SQL derived language. Moreover, as an intermediate layer between the user and the information source, GDMS intends to reduce the coupling between the processes and the specificities of each underlying format. As a consequence, former work may easily be reused in a much larger set of scenarii. The learning curve is consequently even simpler.

One of the objectives of this paper is to re-use, adapt and extend the GDMS formalism to the specificities of the AMBIOFLUX research project. The main idea is indeed to take benefit from GI well-known concepts and technique and apply them both to the spatial interactions between sound ambiences and an urban pedestrian walk.

With defining ambiences as an anthropocentric view of the global environmental production through physical, human and built constraints of architectural and urban design, we consider urban space as a field of data aimed to ambiences physical parameters description through multi-phenomenal characterization (Woloszyn, 2002, Sarradin, 2007, Zekri, 2007).

An application of this principle is actually proceeded through the interdisciplinary research project AMBIOFLUX, concerning spatial interaction between the notion of ambience and an urban pedestrian walk. The objective is to produce dynamical urban environmental indicators through « ambient pointers ».

This work will focus on informational indices production, in order to provide dynamical GIS-powered outdoor ambience representation tools, taking the sensory aspect of phenomenal perception, mainly auditive, into account (Woloszyn, 2000).

Dedicated methods to proceed to soundscape informational analysis are observation, coupled together with statistical treatments of source items, and global entropy calculation. This approach is therefore founded upon elementary sound sources description, organization and re-cognition with proceeding to its elementary constituents elementary hierarchic identification and systemic modeling (Gibson, 1986, Richardson, 1999).

Soundscape informational dimensioning will be considered through urban sound sources spatial psychophysical indicators formulation, soundmarks. Murray Schaffer introduces the word “soundmarks” as a derivation of the word “landmark,” to identify sounds which signs the outstanding role of sounds for characterizing a place (Schafer, 1977, 1992).

In this sense, soundmarks describe sound events which get a specific informational status, mainly denotative, that means they are strong identity revealers. The dedicated informational order scaling correspond to near-order indices, which can be evaluated through maximal information entropy, that means, a high degree of information.

Therefore, soundmarks are defined as maximum-entropy sources a sound walker can meet, defined as the most consciously emerging urban-situated events within his world line, for a done urban trajectory. They are computed from local entropy sources H calculation (Woloszyn, 2008).

The graphical representation of a soundmark has to define clearly what constitutes the mark is applied for, so that the precise sound source at the origin, its location and its psychophysical extends, mapped within a pedestrian soundwalk into the urban maze. Considering environmental interaction process as a sensation vector from subject to the ambience complex, involved ambient pointer inter dimensional data are sound source localization, together with two spatial extends: the spatial sound pressure integrated levels and the soundmark entropy values. Event low-entropy sources scales the soundscape perception geometry from soundmarks (maximum entropy sound event) to “Keynotes” (Schafer, 1992) (null-entropy background sound).

## MOTIVATIONS

### Spatial query formalism's related work

Numbers of approaches have been proposed to address the need for formalizing spatial queries. Some of them have implemented spatial extension to the well-known Structured Query Language (SQL), assuming that it was much more powerful and easy to retrieve and analyze spatial data using the familiar select - from - where statement instead of procedural commands like macro language (Egenhofer, 1994). Indeed, the SQL is a world famous declarative programming language dedicated to CRUD (CRUD stands for the ability to Create new entry, as well as Read, Update and Delete existing entry in a data set) operations in the context of Relational DataBases Management System (R-DBMS). In their reviews of proposed query languages, among many other spatial data manipulation languages, (Oliveira, 1996, Egenhofer, 1994) successively mention:

- (Goh, 1989), its graphic query language (GQL) structured in SQL fashion is "designed to conform with ISO standard 7942 (graphical kernel system) and ISO standard 9075 (database language SQL)";
- (Ooi, 1990), its Geoql is an extension of SQL which provides spatial operators,
- (Egenhofer, 1994), its Spatial SQL is defined as a query and presentation language designed to preserve SQL concepts but also to incorporate spatial operations and relationships.

The processing of vector-encoded data through a spatially enabled and extended SQL language has thus already been normalized by the Open Geospatial Consortium in the Open-GIS "Simple Features Specification for SQL" (Herring, 2006a, 2006b). There also exist several efficient and industrial implementations that spatially enable R-DBMS (such as the PostGIS, a spatial extension for PostgreSQL).

### Overall view of the GDMS spatial layer

GDMS (Leduc, 2009, Bocher, 2008) is related with a similar layer used in the gvSIG project to manage the alphanumeric data access. This layer is called GDBMS (Anguix, 2005) and one of its main limitation is that it can only be used for alphanumeric purposes. GDMS work is a general refactoring that mainly adds spatial functionalities and a more powerful SQL processor to GDBMS.

As noticed in (Leduc, 2009), the heterogeneity of source types makes difficult the reuse of algorithms that are tightly coupled with the specified file format, database vendor, etc. With an intermediate layer between the user and the information source, the work developed by the former will not be coupled with the specificities of each format but with the intermediate layer itself, letting the work to be reused in a much more wide set of scenarios and of course simplify the learning curve for new developers.

One of the problems that such a layer arises is that it has to be able to access any potential source type. As the current number of source types is huge and can grow indefinitely, the user has to be able to extend the access capabilities of the layer. By introducing the concept of driver, GDMS intends to potentially fit any situation, even if the types of sources are not well known or currently the layer does not have the driver to access it.

With GDMS, the idea was to postpone all problems of interoperability across data repositories, but also about the SQL semantics by developing a highly flexible, portable and standards compliant tool to build SQL queries. Currently, GDMS is dedicated for GIS clients but in the future it will also be a software component for SDI to process spatial data according to Web Processing Service.

GDMS provides an API that lets the user operate independently of source type. However, this API is not friendly enough for an end-user and reduces the acceptance of the solution by final users. With the purpose of simplifying both access and manipulation of data sources, GDMS provides a SQL processor that lets the execution of the common Data Manipulation Language statements against any source mapped by a driver. To avoid introducing a new grammar, GDMS fully preserves the SQL-92 grammar and adds to this standard geometric concepts and spatial functions as in OGC simple features SQL specification. As an analogy to spatial SQL for R-DBMS, GDMS provides an extended SQL query language on heterogeneous data types.

It is the main purpose of GDMS to improve data creation and sharing. As in an SDI the consumption of data is as important as the production and sharing of data, the SQL processor in GDMS allows data feedback as if they were new data sources (materialized views). This means that the result of SQL queries can easily be integrated into the SDI as a new data source. Those data will be ready to be used by further SQL statements as any other existing data source.

Finally, to improve further code reuse, GDMS introduces the concept of Geo-knowledge repository. GDMS allows an extension to the semantics of the SQL language in terms of functions and custom queries. Functions and custom queries are artifacts that contain the implementation of some operations on the data and can be reused just by referencing its name into an SQL statement. This way, some user can implement a buffer operation and other can reuse it just by calling buffer in a SQL query: SELECT buffer(the_geom, 20) FROM mydata. The collection of all these artifacts is the Geo-knowledge repository. The purpose of GDMS is to maintain such a repository and encourage the feedback of new artifacts from the user to make it a growing knowledge base.

The Geo-knowledge repository is more than a library of functions that can be extended by new user-defined add-ons; we aim to go a step further with this concept. Indeed, the goal is to provide a high level of spatial semantics:

- checking: a “just in time” validation process of input data type, range… made by a dedicated spatial SQL pre-processor,
- sharing: future releases will embed network-groupware capacity because users need also to share spatial process and not only geographic data,
- interoperability: the GDMS core is fully OGC compliant, so it is possible to copy and paste spatial SQL scripts from/into PostgreSQL/PostGIS.

At last, our Geo-knowledge repository provides not only spatial functionalities but also description and (sometimes) useful use-cases for each of them.

## IMPLEMENTATION DETAILS

As written before, one of our objectives is to re-use, adapt and extend the GDMS formalism to the specificities of the soundscape informational dimensioning. The main idea is indeed to take benefit from GI well-known concepts and techniques and apply them both to the spatial interactions between sound ambiences and an urban pedestrian walk.

Therefore, we have to map soundmarks effects onto the pedestrian pathways and compute some relevant indicators to characterize the environmental interaction process. Among all of them, we have decided to focus on the spatial sound pressure integrated levels and on the maximum entropy sound event. The remainder of this paper is dedicated to the presentation of the spatial methodology we develop and the result we obtain.

## Input spatial tables

As summed up in Table 1, maps that have to be processed are purely of vector type.

| Name | Geometry type | Description |
|---|---|---|
| soundmarks | point | The set of sound sources' spatial positions with corresponding physical parameters (mandatory). |
| pathways | (Multi)LineString | The set of linear pedestrian pathways (mandatory). |
| roads | (Multi)LineString | The set of surrounding linear roads (optional, more realistic background). |
| buildings | (Multi)Polygon | The set of surrounding polygonal building (optional, more realistic background). |
| wetland | (Multi)Polygon | The set of surrounding polygonal wetland (optional, more realistic background). |

***Table 1:*** Recap of all input maps that have to be processed.

## Sequence of spatial processing

As illustrated by Figure 1, the global spatial process we have designed is divided into 7 main steps. Let us describe them one by one:

- starting from the so called soundmarks input map (the set of sound sources' spatial position), a set of polygonal zones – discs - of influence is built, assuming the isotropy of the phenomenon. The resulting layer is called soundscape. As an example, in the particular case of noise energy, the zones are concentric discs (centered on the source's position itself) and corresponding values are decreased by 6 dB each time the distance to the center is doubled;

- nesting some well-known OGC predicates mentioned in table 2, a Region Of Interest (ROI) is determined,

- applying some well-known OGC predicates mentioned in table 2, an extended soundscape layer is produced (assuming that the background noise is the same everywhere in the ROI),

- re-using the CreateGrid operator developed in the context of the UrbSAT plugin (Long, 2008, Bocher, 2008), a regular orthogonal vector grid based layer is produced (fine grain). It is called grid;

- combining the input linear pathways layer with this grid, a sort of “discrete” pathways layer is produced using a classical spatial join query,

- the “discrete” pathways layer is merged with the extended soundscape one, in another SQL join query. The result is a sort of valuated “discrete” pathways, insofar as each unit cell (sort of pixel even if we do not process data of raster type) is valuated with a set of physical indicators inherited from the extended soundscape map;

- at last, some post-processing of the valuated “discrete” pathways are realized such as a global equivalent sound level.

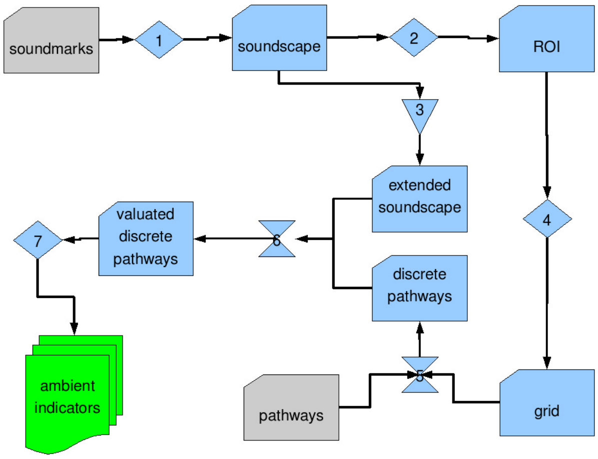


***Figure 1:*** Processing schema we have adopted. The sequence is composed of 7 main operations. Input maps are colored in gray, intermediate results are colored in blue and final output results are in green.

## Spatial knowledge sharing

As written before, GDMS layer's goal is to maximize user's access to spatial data but also to minimize the redundancy of efforts and investments. To avoid introducing a new grammar, GDMS fully preserves the SQL-92 grammar and adds to this standard geometric concepts and spatial functions as in OGC simple features SQL specification. In the recap of the Table 2, we clearly distinguish between classical GI procedure and specific developments dedicated to this project.

| Phase's number | OGC Spatial predicate or function (or classical SQL query) | Specific or external development |
|---|---|---|
| 1 | Buffer, Difference | Noise decreasing |
| 2 | GeomUnion, Envelope, Buffer | |
| 3 | GeomUnion, Difference, SQL Union | |
| 4 | | CreateGrid (re-use from the UrbSAT plugin) |
| 5 | SQL join query | |
| 6 | Intersects, SQL join query | |
| 7 | | Aggregated Equivalent Sound Level (Leq)… |

***Table 2:*** Recap of the global sequence of spatial processes distinguishing between classical GI procedure and GDMS specific developments dedicated to the project.

## EXAMPLE CASE STUDY

To avoid introducing a new grammar, GDMS fully preserves the SQL-92 one and adds to this standard some geometric concepts and spatial functions defined in the OGC simple features SQL specification. In this section we will successively detail all the 7 processes presented before. First step consists in producing the soundscape layer. Thus we have to load all input data before, using as an example the GDMS register instruction. The following two instructions make it possible to script the whole process (assuming that the soundscape table contains at least a geometric field called the_geom and two alphanumeric fields: gid and db).

```
select register('/home/data/soundmarks.shp', 'soundmarks');
create table soundscape as
  select SoundSignalArea(gid, the_geom, db) from soundmarks;
```

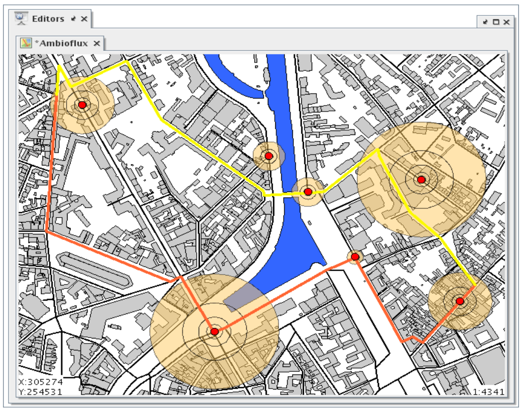

***Figure 2:*** As showed in this figure, several layers of vector type are loaded as input data, such as the soundmarks (red points), the pedestrian pathways (yellow and orange polylines) but also buildings, roads and rivers as background maps. The 1st main operation is then applied to the soundmarks layer so as to produce the soundscape layer (pale orange discs).

Second and third steps consist in producing the Region of Interest (RoI) and the extended soundscape layers (with a background noise equals to 40 dB as an example). It can be scripted in (GDMS) spatial SQL so:

```
create table roi as
  select Buffer(Envelope(GeomUnion(the_geom)), 100) as the_geom
    from zones;
create table t1 as
  select GeomUnion(the_geom) as the_geom from soundscape;
create table t2 as
  select 0 as gid,
    Difference(roi.the_geom, t1.the_geom) as the_geom, 40 as db
      from roi, t1;
create table ext_soundscape as soundscape union t2;

-- at last, we can delete the two useless tables:
drop table t1;
drop table t2;
```


***Figure 3:*** With the 2nd and 3rd processes a Region of Interest (yellow polygon) and an extended soundscape are built.

The grid is then produced really simply just by re-using an already developed query called CreateGrid:

```
create table grid as select CreateGrid(2,2) from roi;
```

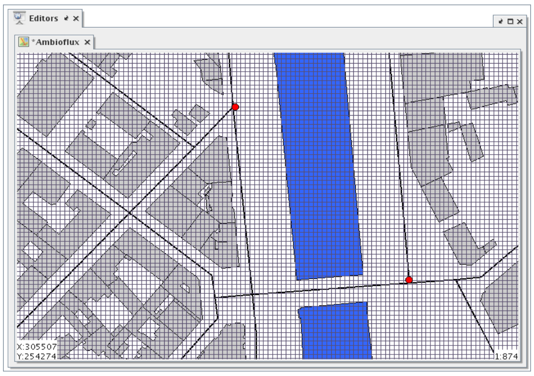


***Figure 4:*** In the 4th step, a regular grid layer is produced with a resolution of 2m x 2m.

In the 5th step, the "discrete" pedestrian pathways are produced using a SQL join query and the OGC spatial predicate Intersects:

```
create table discrete_pathway as
  select g.* from pathway p, grid g
    where Intersects(p.the_geom, g.the_geom);
```

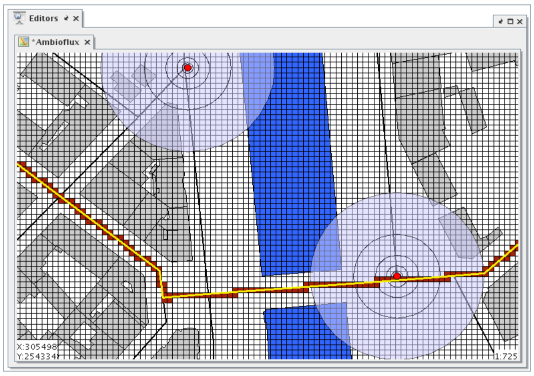


***Figure 5:*** In the 5th step, joining the grid map with the linear pedestrian pathways, a set of sort of "discrete" pathways is produced.

In the 6th step, the valuated "discrete" pedestrian pathway layer is, once again, produced using a SQL join query. The where condition is a combination of OGC spatial functions:

```
create table valuated_discrete_pathway as
  select p.*,db from discrete_pathway p, ext_soundscape e
    where area(intersection(p.the_geom, e.the_geom)) > 2;
```

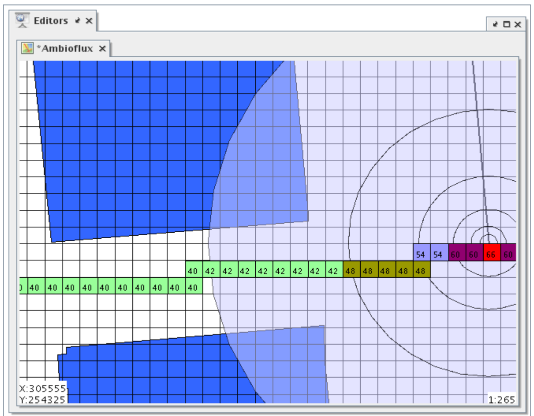


***Figure 6:*** In the 6th step, the "discrete" pedestrian pathways are merged with the extended soundscape layer so as to produce (multidimensional) valuated "discrete" pathways. The ambient indicators are built from the resulting layer.

In the whole previous sequence, for easiness motivation, we just presented the noise energy parameter and did not take the sound entropy into account. It is obvious that similar sort of processes could be applied to entropy (except some differences in the 3rd and 7th steps).

At last, to distinguish the two studied pedestrian pathways, two different indicators are produced. The first one has to do with noise energy: Equivalent Sound Level is formulated in terms of the equivalent steady noise level which in a stated period of time would contain the same noise energy as the time-varying noise during the same time period (EPA, 1974). Following discrete domain equation is applied to the both paths and returns 44.3 dB for the 1st one and 57.6 dB for the 2nd one.

$$L_{eq} = 10 \times \log\left(\frac{1}{T}\sum_i 10^{\frac{L_{eqi}}{10}} \times \Delta T_i\right)$$

The second indicator corresponds to the Maximum Entropy Principle (Woloszyn, 2009). Following spatial SQL instructions set gives us the possibility to obtain it:

```
create table t3 as
  select gid, GeomUnion(the_geom) as the_geom
    from ext_soundscape group by gid;
create table entropy as
  select t3.*, entropy from t3, soundmarks s
    where tmp.gid = s.gid;
create table entropy_discrete_pathway as
  select p.*,db from discrete_pathway p, entropy e
    where area(intersection(p.the_geom, e.the_geom)) > 2;
select count(*) as count,entropy,count(*) * entropy as mult
  from entropy_discrete_pathway
    group by entropy
    order by mult;
```

Indeed, with the numerical values presented in the so-called "soundmarks" table in Figure 7, for the 1st path, according to the Maximum Entropy Principle the 2nd source is the most important one (even if it is not in term of slice time). The same way, for the 2nd path, the outstanding source is the 3rd one.

In the "soundmarks" table from Figure 7, all entropy values (last column) are input data of the GI part of our model. Those values are determined using both quantitative (sound signal emergence area, sound pressure integrated level…) and qualitative parameters (mainly opinion survey).

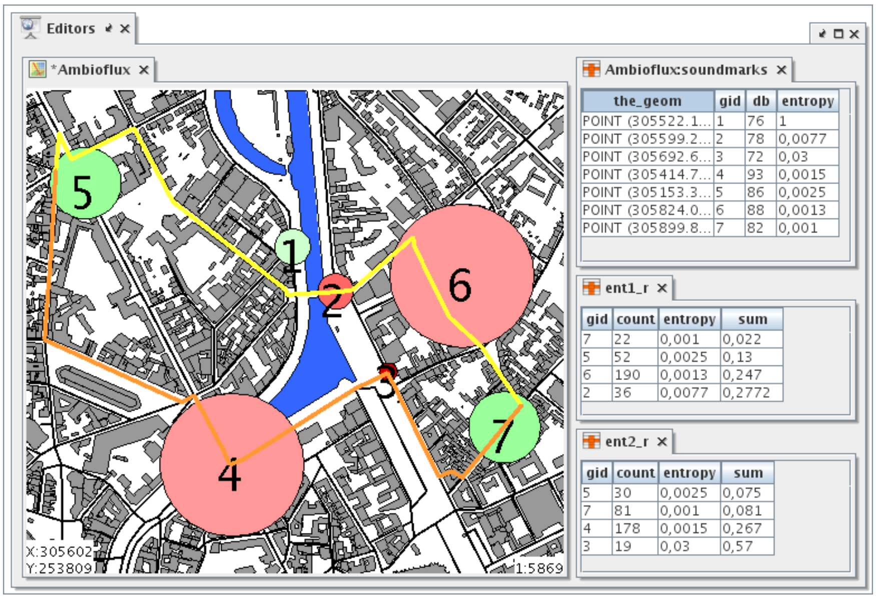


***Figure 7:*** Post-processing relative to the Maximum Entropy Principle. 1st path (in yellow) is under the influence of the 2nd source, while the 2nd path (in orange) is under the influence of the 3rd source. Discs represented in this figure correspond to the sound signal emergence area where the entropy value is constant.

## CONCLUSION AND FUTURE WORKS

Mainly for sound characterization, classical GIS phenomenon visualization provided with parameters related to physical factors can not afford a satisfying representation without integrating the sensitive aspect of the phenomenal perception. Thus, taking sensory interaction through the physical simulation process into account leads us to an hybrid GIS-powered ambiences representation model based on the GDMS layer.

This strong dependency drastically reduces the amount of development needed to produce the soundscape indicators and is another proof of concept for the relevance of this layer in term of spatial knowledge sharing.

Concerning future evolutions, it seems essential to improve the model, taking surrounding buildings (with their 3D components) into account, but also to identify and produce some other soundscape indicators (indeed a sort of standard deviation for the Equivalent Sound Level could be useful, such as a spectrum of the sound walk…). At last, what could be of great worth, would be to merge the soundscape ambience we present with the visual perception phenomenon.

The study presented in this paper has clearly shown that a sound walk in an urban soundscape can be characterized extending GI methods. A potential application of the present work could be to produce a soundscape map of relevant preprocessed urban sound walk (relevant means here crossing interesting places from a sound point of view). Indeed, next step of our research is, for a given origin and destination couple, to produce a set of pedestrian pathways, compute some acoustic indicators and characterize each pathway using a clustering method.

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## AVAIBILITY

A GDMS implementation included in the GearScape front-end and developed under GPL license will be soon available for public download at http://gearscape.forge.osor.eu/. This layer is also available in the original OrbisGIS project.

## BIBLIOGRAPHY

Anguix, A. and Carrión, G., 2005. gvSIG: OpenSource Solutions in spatial technologies. In GIS Planet, Estoril, Portugal.

Bocher, E., Leduc, T., Moreau, G., and González Cortés, F., 2008. GDMS: an abstraction layer to enhance Spatial Data Infrastructures usability. In 11th AGILE International Conference on Geographic Information Science — AGILE'2008, Girona, Spain.

Bocher, E., Leduc, T., and González Cortés, F., 2008. UrbSAT: from spatial SQL to urban indicator definition and production. In Free and Open Source Software for Geospatial Conference, FOSS4G'2008, Cape Town, South Africa.

Egenhofer, M. J., 1994. Spatial SQL: A Query and Presentation Language. IEEE Transactions on Knowledge and Data Engineering, 6(1):86–95.

EPA (U.S. Environmental Protection Agency), 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74-004, 1974. Washington, D.C.

Gaisbauer, C. and Frank, A. U., 2008. Wayfinding model for pedestrian navigation. In Bernard, L., Friis-Christensen, A., Pundt, H., and Compte, I., editors, AGILE 2008 Conference - Taking Geo-information Science One Step Further, University of Girona, Spain.

Gibson, J.J., 1986. The Ecological Approach to Visual Perception. Hillsdale, New Jersey.

Goh, P.-C., 1989. A graphic query language for cartographic and land information systems. International Journal of Geographical Information Systems, 3(3):245–255.

Herring, J. R., 2006. OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 1: Common architecture. http://www.opengeospatial.org/standards/sfs.

Herring, J. R., 2006. OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 2: SQL option. http://www.opengeospatial.org/standards/sfs.

Leduc, T., González Cortés, F., and Bocher, E., 2007. OrbisGIS: a GIS for scientific simulation. In RMLL'2007, Amiens, France. http://2007.rmll.info/article348.html.

Leduc, T., Bocher, E., González Cortés, F., and Moreau, G., 2009. GDMS-R: A mixed SQL to manage raster and vector data. In GIS Ostrava 2009 — Symposium on Seamless Geoinformation Technologies, Ostrava, Czech Republic.

Long, N., Bocher, E., Leduc, T., and Moreau, G., 2008. Sensitivity of spatial indicators for urban terrain characterization. In IEEE International Geoscience & Remote Sensing Symposium, IGARSS-2008, Boston, Massachusetts, U.S.A.

Ooi, B. C., 1990. Efficient Query Processing in Geographic Information Systems, volume 471 of Lecture Notes in Computer Science. Springer.

Richardson, K., 1999. Hyper-structure in Brain and Cognition. psyc.99.10.031.

Sarradin, F., Siret, D., Couprie, M., and Teller, J., 2007. Comparing sky shape skeletons for the analysis of visual dynamics along routes. Planning and design: Environment and planning B, 34(5):840–857.

Schafer, R. M., 1977. The Tuning of the World, Knopf, New York (republished in 1994 as The Soundscape: Our Sonic Environment and the Tuning of the World. Rochester, Vermont: Destiny Books).

Schafer, R. M., 1992. Music, non-music and the soundscape in Companion to Contemporary Musical Thought, Vol. 1, Paynter, J., Howell, T., Orton, R., & Seymour, P. (ed.'s) (Routledge)

Tomlin, C. D., 1994. Map algebra: one perspective. Landscape and Urban Planning, Elsevier Science, 30:3–12.

Woloszyn, P., Follut, D., 2000. The visualization of the urban "ambients" parameters. In 14$^{th}$ International symposium, in: Computer Science for environmental protection, Gesellschaft für Informatik (GI), Bonn. Marburg (DE) : Metropolis Verlag, pp. 173-186.

Woloszyn, P., 2002. From Fractal techniques to subjective quantification. In Landscape and Architectural Modeling Symposium, Sousse, Tunisia, pp. 1-6.

Woloszyn, P., Bourdin, G., 2008. A territorial ambience co-creation game. In international colloquium « Faire une ambiance - Making an athmosphere », Cresson UMR AAU, Grenoble, France.

Woloszyn, P., Leduc, T., 2009. Ambient Pointers Geocomputation in Urban Maze: Soundmark Fluxes Psychophysical Dimensioning. In 39$^{th}$ International Conference on Computers & Industrial Engineering (CIE39), Troyes, France.

Zekri, E., Hégron, G., and Legendre, A., 2007. Characterization of pedestrian paths by the physical factors of ambiences. In Le piéton et son environnement : Quelles interactions ? Quelles adaptations ? 1$^{ier}$ colloque francophone de la plate-forme intégratrice COPIE (COmportement du PIéton dans son Environnement), Paris, France. INRETS.