Chapter 3

GeOxygene: An Interoperable Platform for Geographical Application Development

3.1. Introduction

Geographical application development generates costs for research laboratories [BAD 03, BUC 11]. In spite of standardization efforts made by consortia such as ISO[1] and OGC[2], the different geographical models implemented in common geographical information system (GIS) software do not allow for interoperable use of these models. The applications developed for one of these non-standard models are thus not necessarily reusable for applications based on a different model. Moreover, the programming languages used to develop applications relying on market GIS software are often legacy languages. Thus, the code sharing is made

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1 International Organization for Standardization: http://www.iso.org.
2 Open Geospatial Consortium: http://www.opengeospatial.org.

difficult and methods developed for one application must be reimplemented for another relying on a different piece of software, requiring an increase in cost not only for development but also for the training of researchers. These reasons were behind the decision of many laboratories to choose solutions that used free software. More specifically, the COGIT Laboratory of the IGN (French Mapping Agency) began in 2000 to develop the *open source* GEOXYGENE platform.

3.2. Background history

Originally designed between 2000 and 2004 by Thierry Badard and Arnaud Braun, then enriched by many researchers at the COGIT Laboratory, the GEOXYGENE platform's first release (1.0) was registered[3] in 2005 under an LGPL (GNU *Lesser General Public License*)[4]. Its main goal is to respond to and meet the laboratory's development needs. These needs are many and varied, and concern geographical data interoperability as much as the reuse of the data, the maintenance and sharing of code between researchers (laboratory researchers and external researchers), as well as the manipulation of the used data model. Indeed, the question was both to improve the development of research applications and to better understand data and the models used to manipulate it.

The different GEOXYGENE releases are:

– Release 1.0: registering the GEOXYGENE core (May 2005);

– Release 1.1: correcting minor bugs (June 2006);

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3 http://oxygene-project.sourceforge.net/
4 http://www.gnu.org/copyleft/lesser.html

– Release 1.2: registering "basic" applications (August 2007);

– Release 1.3: registering the data matching tools (January 2008) [MUS 08];

– Release 1.4: registering (June 2009):

   - data persistence with Hibernate[5] (as well as OJB[6]);

   - new graphical interface;

   - management of complex styles for map display;

– GPL registering for the interface between GEOXYGENE and OpenJUMP (June 2009);

– Release 2.0 (throughout 2012):

   - GPL registering of the three-dimensional (3D) model [BRA 09];

   - legend design support and improvement [BUA 09, CHR 09];

   - data matching based on the belief function theory [OLT 09].

3.3. Major functionalities and examples of use

GEOXYGENE's major functionalities concern the loading and manipulation of geographical data compatible with ISO norms and OGC standards. GEOXYGENE was designed as a research application platform. The targeted audience is thus essentially made up of the geomatics researcher community and, more generally, of GIS application developers. GEOXYGENE also allows us to develop more collaboration

5 http://www.hibernate.org/
6 http://db.apache.org/ojb/

possibility between former doctoral candidates and laboratory researchers.

3.3.1. *Generic functionalities*

GEOXYGENE provides the user with tools that enable the loading and save of data from/in an *ESRI Shapefile* format, as well as storing spatial data in a POSTGRESQL/POSTGIS database[7]. Moreover, GEOXYGENE offers algorithms allowing the user to create and manipulate topological maps, to match databases, to create and improve legends, etc., and allows the user, if the existing algorithms do not correspond to his needs, to develop new ones. Finally, it is possible to visualize and edit data and their schemas due to a dedicated graphical interface or an *ad hoc plugin* for OpenJUMP[8], another *open source* GIS software.

3.3.2. *Use case: building data manipulation*

The use case is described due to two fictional characters, called Justine and Robert: "Justine, an experience developer, has data in the *ESRI Shapefile* format which describes the buildings in a given geographical zone (in this case, Orléans) and wishes to load and manipulate it, run her algorithms, and add the results of these algorithms to her data schema to then send it to Robert, who does not do much developing".

3.3.2.1. *Data*

In this example, our starting hypothesis is that the user (Justine) has the data in *ESRI Shapefile* format files. The data illustrated in Figures 3.1 and 3.2 correspond to the BDTOPO® database that contains the description of buildings respecting

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7 http://www.postgis.fr

8 http://www.openjump.org

precise specifications; they must, for example, have a surface superior to 20 m^2. In our example, we have used Release 1.3 of these database specifications.

Figure 3.1. *Attribute data on the* BDTOPO® *buildings*
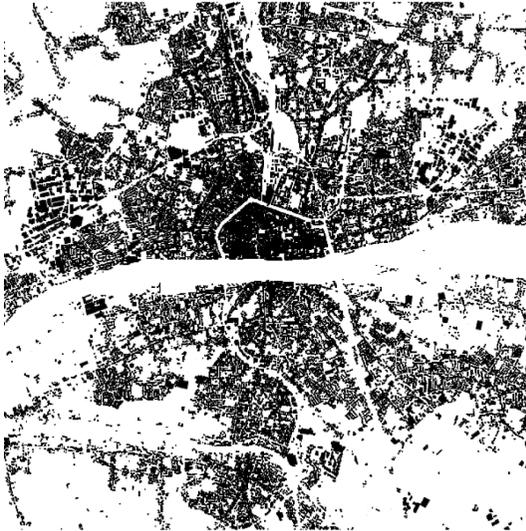
Figure 3.2. *Geometrical data on the* BDTOPO® *buildings*

First of all, the user must load his/her data into a database management system. For example, Justine uses a POSTGRESQL/POSTGIS database called geoxygene. This

load can, for example, be carried out in a command line with the `shp2pgsql` function. The complete command will look like this:

```
shp2pgsql -g geom -D -I building.shp buildings
                | psql geoxygene
```

It is a double command. The part before "|" corresponds to the creation of an SQL loading command file from the file in the *ESRI Shapefile* format. The parameters mean that the geometry is called `geom`, that the loading format to be used is `dump`, and that an index on the geometry column must be created, and that the new table will be called `buildings`. The part after "|" corresponds to the execution of the SQL commands written in the generated file to create a table in the `geoxygene` base.

Moreover, GEOXYGENE is the user to directly load data in an *ESRI Shapefile* format on volatile memory, without having to go through intermediate storing in a database (as mass storage). However, in this example, the user would rather use a database to take advantage of its functionalities (concurrent access, transaction security, "random access" to avoid an "out of memory" error when loading an amount of data exceeding the workstation's volatile random access memory capacity, etc.).

3.3.2.2. *The data schema: the* `Building` *class*

Using GEOXYGENE tools, Justine generates a fitting JAVA class from the loaded database, illustrated in Figure 3.3, as well as a *mapping* file that will match the JAVA class attributes with the columns of the POSTGRESQL/POSTGIS database tables (see Figure 3.4). The data schema created fits with the initial data. Justine can then modify this schema to add relative attributes to the processing results.

id [PK] serial	source character varying(254)	category character varying(254)	nature character varying(254)	integer	geom geometry
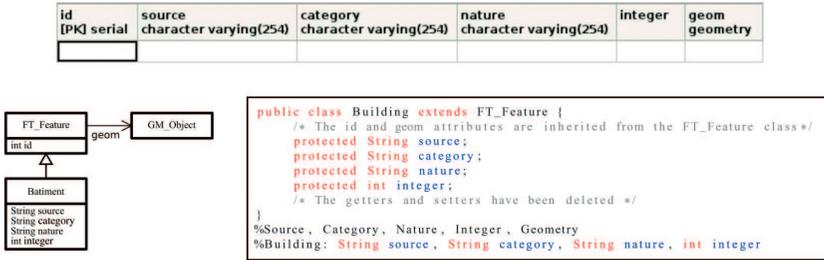
Figure 3.3. *Automatic generation of the* JAVA *structure fitting with the building objects originally stored in a* POSTGRESQL/POSTGIS *database*

```
<class-descriptor class="data.Building" table="building" >
  <field-descriptor name="id" column="ID" jdbc-type="INTEGER" primarykey="true" autoincrement="true"/>
  <field-descriptor name="source" column="source" jdbc-type="VARCHAR" />
  <field-descriptor name="category" column="category" jdbc-type="VARCHAR" />
  <field-descriptor name="nature" column="nature" jdbc-type="VARCHAR" />
  <field-descriptor name="integer" column="integer" jdbc-type="INTEGER" />
  <field-descriptor name="geom" column="geom" jdbc-type="STRUCT"
          conversion="fr.ign.cogit.geoxygene.datatools.ojb.GeomGeOxygene2Dbms" />
</class-descriptor>
```

Figure 3.4. *Example of object-relational mapping file with* OJB

3.3.2.3. *Object-relational mapping with OJB*

Justine can then implement her processing algorithms inside the `Building` class using its attributes (and thus the data model) while using the persistence, i.e. saving the results coming from the processing in the *geoxygene* database. And to provide the manipulated data to Robert, Justine can, for example, choose to save the data in an *ESRI Shapefile* format, or provide him with access to her POSTGRESQL/POSTGIS database through the Internet network (using *web* services, for example).

3.3.2.4. *A processing example: building urban areas*

A simple and common process (illustrated in Chapter 2 on ORBISGIS software) is to create urban areas from buildings. Such a process means merging the buffer zones of a certain size (in our example, 50 m), created from the geometry of buildings. Once these zones are merged, they are called

urban areas and can be subject to more processes (Douglas–
Peucker filtering to simplify geometry, for example), linked to
the buildings they belong to, and finally qualified (by area,
number of buildings they contain, etc.) [BOF 01]. The created
data layer is illustrated in Figure 3.5. GEOXYGENE allows for
the storing of this new layer in a database table or in a file
under the *ESRI Shapefile* format.

Figure 3.5. *Urban areas created from the* BDTOPO® *buildings (see Figures 3.1 and 3.2)*

One of the most common tools used in GEOXYGENE is the
topological map. Mainly developed by Sébastien Mustière and
Olivier Bonin, it offers an alternative to the topological model
defined by the ISO 19107 norm, considered too cumbersome.
The topological map actually refers to a topological structure,
allowing us to import objects (point, line, or surface) and to
treat them as topological objects (vertices, edges, or faces).
Its main advantage is that it enables us to use a set of
methods to create missing vertices, merge the duplicate
vertices, delete the simple nodes (vertices with degree 2), and
compute the associated planar graph (cutting up the edges,
correcting the geometry of the objects, etc.). A processing

example, illustrated in Figure 3.6, is to import the roads, paths, railways, and waterways of the BDTOPO®, and to create a planar graph used here to divide the urban areas into urban blocks.

Figure 3.6. *Urban areas divided into urban blocks due to the linear objects of* BDTOPO® *and the topological map*

3.4. Architecture

In GEOXYGENE, the geographical data manipulation is carried out through an application schema adapted to user's needs. The link between this application schema and the original data schema (coming from a data producer or another user) is made possible due to an object-relational mapping. To carry out this match within GEOXYGENE, common tools such as OJB[9] and Hibernate[10] are used. This mapping is explained in section 3.3.2.3.

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9 http://db.apache.org/ojb
10 http://www.hibernate.org

The three applicative layers for the development of applications in GEOXYGENE, illustrated in Figure 3.7, are the following:

– the GEOXYGENE core, containing main data structures;

– the basic data manipulation applications;

– the expert applications resulting from research work.
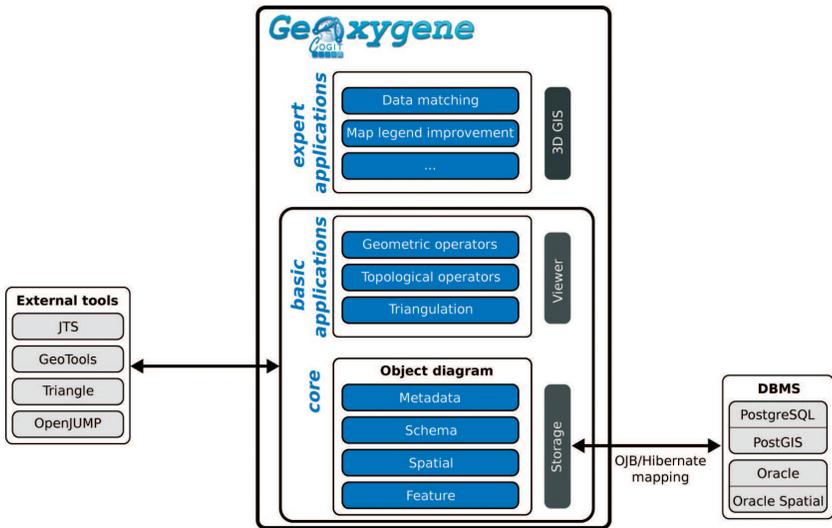
Figure 3.7. GEOXYGENE *platform's general structure*

3.4.1. *The core*

The main functionalities of GEOXYGENE's core concern the modeling of the applicative object schema. This layer enables the representation of data, the elements related to it, such as its geometry, its topology, its attributes, and its metadata, as well as operations directly applicable to data modeled by spatial objects (*features*). The core also contains tools enabling the import or export of these data toward databases as well as

a certain number of external tools (including GEOTOOLS and OpenJUMP).

Moreover, to guarantee the interoperability with norms and standards related to geographical information, the core implements them partially:

ISO 19107: geometry and topology representation. This is a set of *packages* (groups of classes) gathered in the "Spatial" module. The norm has been slightly modified to allow for greater ease of use [ISO 03a].

ISO 19109: metamodel allowing to build a geographical schema, also known as metamodel for geographical classes. This is a set of metaclasses gathered in the "Dico" *package*. These classes are the data dictionary (the types of attributes, all the possible values, etc.) [ISO 05].

ISO 19115: metadata. These classes are gathered in the "Metadata" *package* [ISO 03b]. Only the most relevant classes have been implemented, those that match what can generally be found at the IGN or outside the Institute. The evolution of this implementation will depend on the research carried out at the COGIT Laboratory on consulting and unifying geographical databases.

3.4.2. *First applicative layer: the basic applications*

This applicative layer contains many data manipulation tools:

– geometric operators (angles, vectors, algorithmic geometry) due to the *JTS Topology Suite* library [11];

– topological operators (graph algorithms);

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11 http://sourceforge.net/projects/jts-topo-suite/

– Delaunay triangulation due to the TRIANGLE library [SHE 96][12].

This applicative layer also offers a simple graphical interface (see Figure 3.8), which completes the series of tools enabling users to visualize and explore their data.
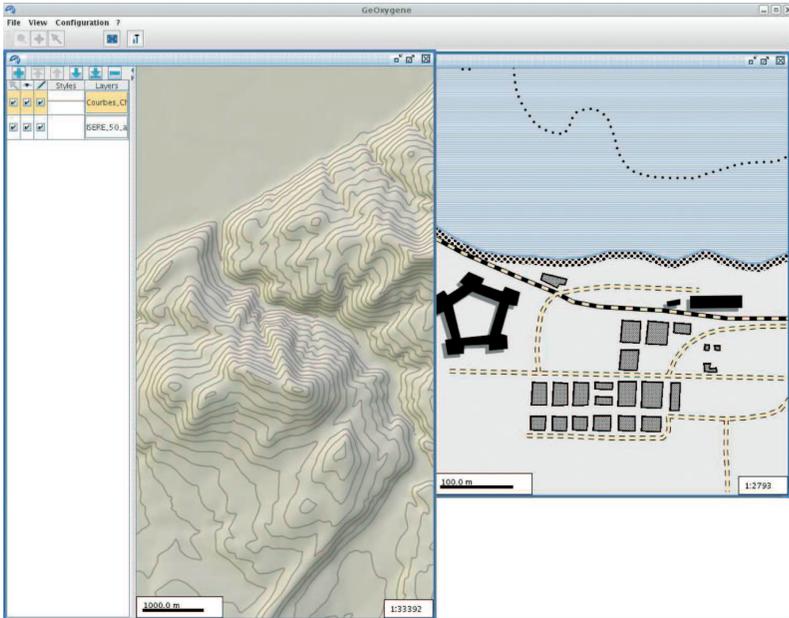
Figure 3.8. *Graphical interface of the* GEOXYGENE *platform*

3.4.3. *Second applicative layer: the expert applications*

This layer contains the research applications licensed under *open source*. It notably contains the data matching

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[12] Let us note that this library is not registered under an *open source* license. GEOXYGENE offers the possibility of using TRIANGLE due to a dynamic link, but the user has to obtain it himself: http://www.cs.cmu.edu/quake/triangle.html.

algorithms for multilevel data such as networks [DEV 97, MUS 08] and surfaces [BEL 01]. Tools are also provided to allow storing, management, and visualization of the data matching links that are created.

Figure 3.9. *3D visualization example of geographical data*

Among the applications currently being developed, and which will be licensed soon, there are tools that

– visualize and manipulate 3D data [BRA 09] (see Figure 3.9);

– manipulate geographical and ontological schemas [ABA 09];

– edit metadata: create a set and its metadata;

– analyze hydrographic graphs to characterize the landscape [PAG 08];

– improve the colors used to represent data [BUA 09, CHE 06];

– use a system of map specifications and legend improvement [CHR 09].

3.4.3.1. *Semiology modules*

The last two examples illustrated in Figure 3.10 are particularly important because they allow us to both question the design process for map legend, provide simple and intuitive tools rendering this process accessible to general public, and also question the content of a legend.

Figure 3.10. *Map created from a Van Gogh painting, according to [CHR 09]*

Moreover, due to the implementation, manipulation, and extension of different standards linked to map symbology (in this case OCG Filter [FIL 05] and Symbology Encoding [SYM 05]), the laboratory is developing expertise in these standards and has become source of proposals.

3.4.3.2. GEOXYGENE *3D module*

To carry out research on 3D, the laboratory decided to expand GEOXYGENE in order to integrate the third

dimension. This expansion was developed to respect the choices made at the core level, and actually enabled the completion of geometrical classes to be in line with the ISO 19107 norm (taking the Z coordinates into account, as well as classes allowing us to model solids, etc.).

This geometrical model can be instantiated due to different loaders integrated by the module. Different formats are also available, either from the 2D data or from 3D data that are transformed (for example, by extrusion): CityGML[13], digital terrain models – or DTM – (file in a ARC/INFO ASCII GRID format), *ESRI Shapefile* that has been extruded or mapped on a DTM (see Figure 3.11), POSTGRESQL/POSTGIS data, or data coming from 3D modeling software (3DS, OBJ).

Beyond visualization and 3D data loading, the module also offers a series of 3D geometrical analysis functions, such as Boolean operators (addition, subtraction, intersection, union, etc.), intervisibility calculation (see Figure 3.12), computation of 3D buffers, volumes, and surface areas, or even the breaking down of volumes into triangles and tetrahedra.

The 3D module can be used as an API or as an independent application. Indeed, it has a graphical interface allowing to carry out the operations we have listed as well as the standard GIS operations of moving, representing, and consulting. The JAVA 3D[14] graphical library enables us to manage the 3D display. The module was already used for various research works concerning the simplification of buildings, the suggestion of a management tool for urban planning rules [BRA 11], and the proposal for a visual variable enabling us to synthesize information carried by points of interest [BRA 10].

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13 http://www.citygml.org
14 http://java3d.dev.java.net
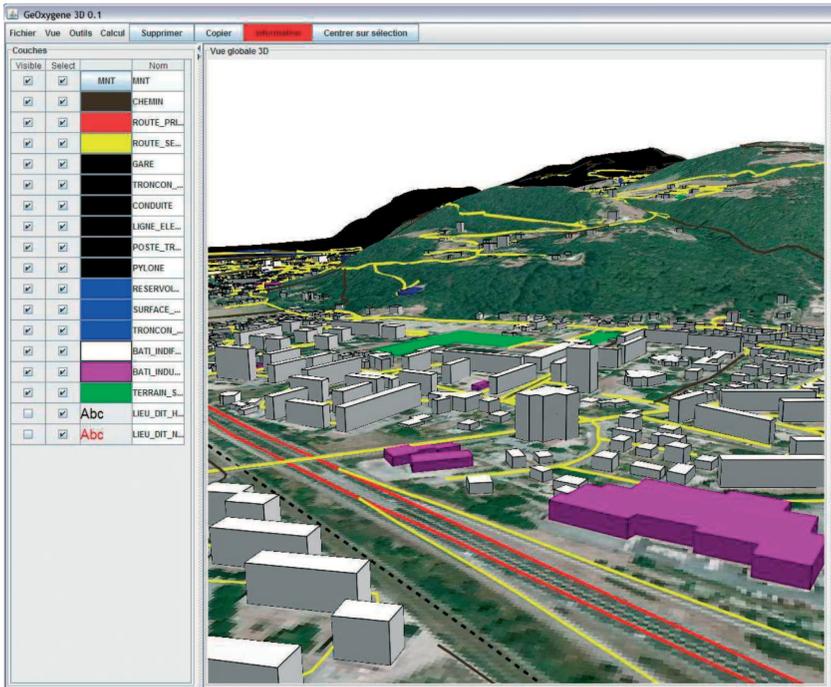
Figure 3.11. *Example of a 3D representation of the French "Large Scale Repository" (RGE)*

In the future, this module should welcome new 3D research, and specifically those linked to spatial analysis, as well as 3D semiology including, for example, geographical name placing, as well as new 3D-specific non-photorealistic (or expressive) styles proposals (see Figure 3.13).

3.4.3.3. GEOXYGENE *spatiotemporal module*

Another expert application developed on GEOXYGENE is the GEOPENSIM[15] platform. It has been developed within the framework of the eponymous project funded by the

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15 http://geopensim.ign.fr

French National Research Agency (ANR), and aims to offer an analysis and simulation tool for the evolution of urban fabric. Within this framework, many new functionalities were developed, especially in the area of creation and representation of historical databases [PER 09], their analysis, and their simulation [PER 10] (see Figure 3.14).
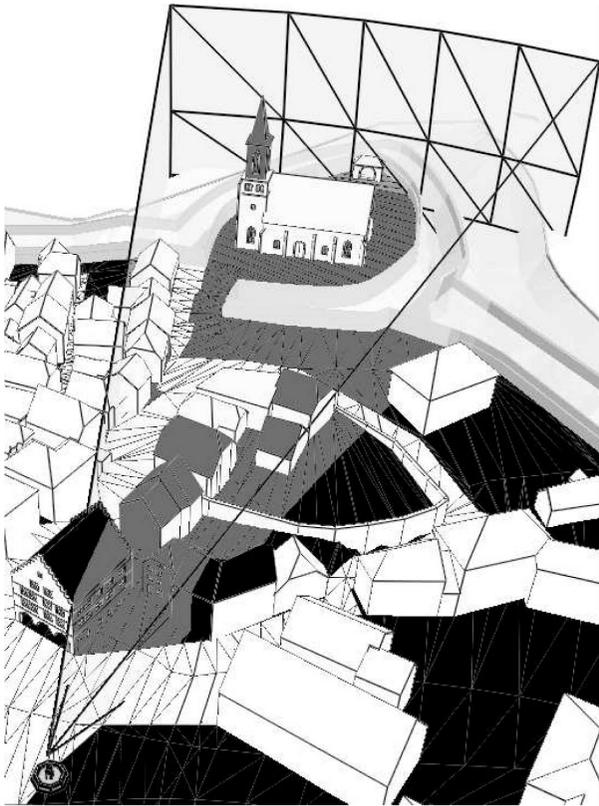
Figure 3.12. *3D intervisibility calculation: the gray buildings are visible from the fountain in the middle of the square, depending on the view angle represented here by a prism*
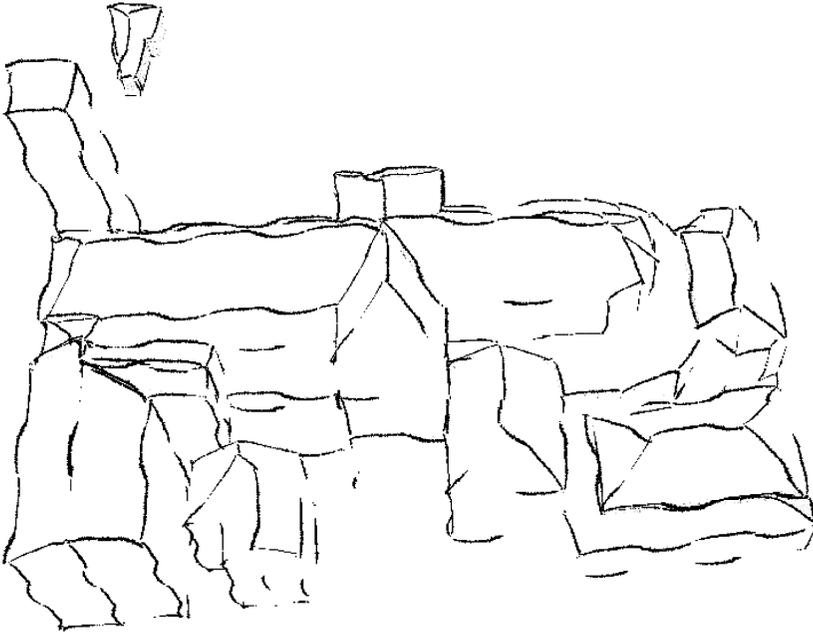
Figure 3.13. *Representation of a building with stylized edges*

3.5. Communities

Since GEOXYGENE is used as a research platform in most of the work carried out at the COGIT, the main GEOXYGENE user and developer community is made of the researchers from this laboratory. This community originally developed the core and basic applications for GEOXYGENE (see sections 3.4.1 and 3.4.2), and designed and implemented expert applications such as a generic multicriteria matching process [OLT 08], a tool to understand and interpret representation differences between pieces of geographical data [SHE 09], as well as the expert applications mentioned in the previous section (see section 3.4.3).

This community has thus opened itself up when doctoral candidates left for other laboratories, since they were able to

continue using the applications they had developed. Indeed, the first and foremost goal of GEOXYGENE as a community is to create relationship between former doctoral candidates and laboratory researchers.
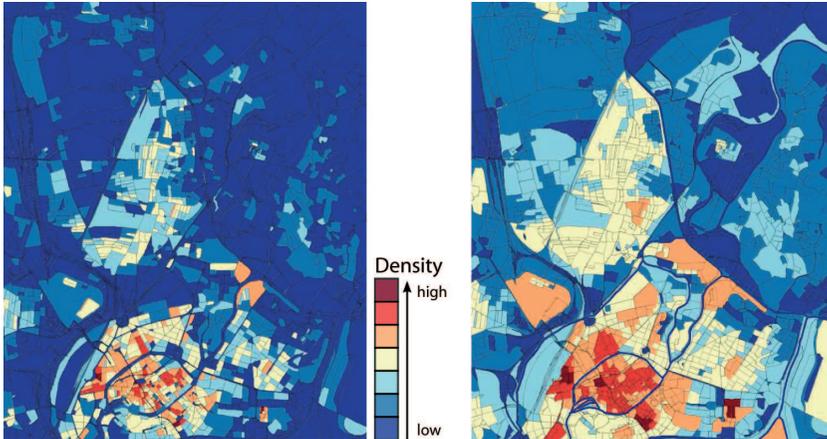
AQ4   **Figure 3.14.** *Evolution rule application in the* GEOPENSIM *city blocks between 2002 and a simulated date in 2010. Let us point out that the densification is exaggerated here to make the process easier to read*

The GEOXYGENE user community then got noticeably richer, due to the expert applications being available (such as the network matching tool). This tool first of all was integrated internally within the IGN through the "New Topographic Map" project whose main goal is to implement a new production chain for the Basic Map (scale 1:25000) from existing IGN databases. The data matching tool is used to ensure geometrical consistency between different databases. The Belgian IGN then integrated the matching tool in its own production lines, to match its data at the scale of 1:10000 and 1:50000 to ease their update. Finally, the English Ordnance Survey and Belgian Wallonia are currently testing the tool in

order to use it in the future [REV 09]. These first uses involve tasks such as advising, supporting, and even bug correcting. They allow us to highlight the limits of the proposed tools in terms of ergonomics or strength, and to improve them. These are actually excellent opportunities to create relationship between laboratories which might lead to fruitful scientific collaborations.

Beyond the specific use of GEOXYGENE as it has been previously mentioned, the platform is used in its whole in many projects, such as the GIS laboratory of the Ecole Polytechnique Fédérale de Lausanne, which uses GEOXYGENE for its urban fabric simulations, and the Laval University in Canada, which uses it for teaching purposes.

The developer community has lately grown under the impetus of ANR GEOPENSIM project which has an aim to develop spatial and simulation analysis tools on GEOXYGENE.

Finally, the user community grows through GEOXYGENE training sessions carried out within the framework of the MAGIS (formerly SIGMA)[16] research group.

3.6. Conclusion

There are many advantages in having a GIS development platform in a research laboratory. The GEOXYGENE platform enables COGIT to spread its research results. The first level of dissemination obviously concerns the laboratory researchers. This dissemination is important because it allows researchers to capitalize and to share developed tools on an internal level, and avoid multiple implementations of the same process. This dissemination also allows for the value of the tools developed during doctoral studies to increase, and for these tools to

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16 http://magis.ecole-navale.fr

be reused. A second level of dissemination concerns all the laboratory partners, within research projects, for example, as well as other IGN departments, especially production, for which the transfer of tools developed in GEOXYGENE (such as data matching) is planned out.

One of the strongest feedbacks about GEOXYGENE concerns the importance of the graphical interface for users, at all levels of development expertise. Indeed, until recently, GEOXYGENE only had a basic interface to visualize geographical data. For example, this interface didn't offer users any simple solution to run their algorithms. To overcome this deficiency, we developed an interface between GEOXYGENE and OpenJUMP; however, the use of different data structures, although it enabled us to demonstrate the interoperability of both tools, has not allowed for an optimal use of the resources. As such, the laboratory is currently developing a graphical interface for GEOXYGENE. This interface, due to the implementation of OGC Filter Encoding and Symbology Encoding standards, allows us to describe complex styles for map display. It also allows users to run simple processes and has the particularity of being easily modular and extensible, as the GEOPENSIM simulator development proves it.

Future developments in GEOXYGENE will focus on users, especially due to the new interface and the release of urban fabric analysis tools developed in the laboratory. Moreover, the tools to help design and improve map legends should allow users to create better maps without having any prior cartography knowledge, and still allow them to express themselves creatively. Finally, the GEOPENSIM module, released in 2011, offers an *open source* tool to create historical databases, analyze the evolution of such databases, and simulate urban evolutions.

3.7. Bibliography

[ABA 09] ABADIE N., "Schema matching based on attribute values and background ontology", *12th AGILE International Conference on Geographic Information Science*, Hannover, Germany, 2009.

[BAD 03] BADARD T., BRAUN A., "Oxygene: une plate-forme inter-opérable pour le déploiement de services Web géographiques", *Bulletin d'Information Scientifique et Technique de l'IGN*, no. 74, pp. 113–122, 2003.

[BEL 01] BEL HADJ ALI A., Qualité géométrique des entités géographiques surfaciques. Application à l'appariement et définition d'une typologie des écarts géométriques, thèse de doctorat, Université de Marne-la-Vallée, 2001.

[BOF 01] BOFFET A., Méthode de création d'informations multi-niveaux pour la généralisation de l'urbain, thèse de doctorat, Université de Marne-la-Vallée, 2001.

[BRA 09] BRASEBIN M., "GeOxygene: an open 3d framework for the development of geographic applications", *12th AGILE International Conference on Geographic Information Science*, Hannover, Germany, 2009.

[BRA 10] BRASEBIN M., BUCHER B., HOARAU C., "Enriching a 3D world with synthetic and visible information about the distribution of points of interest", *3D GeoInfo Conference*, Berlin, Germany, 2010.

[BRA 11] BRASEBIN M., PERRET J., HAËCK C., "Towards a 3D geographic information system for the exploration of urban rules: application to the French local urban planning schemes", *28th Urban Data Management Symposium (UDMS 2011)*, September 2011.

[BUA 09] BUARD E., RUAS A., "Processes for improving the colours of topographic maps in the context of map-on-demand", *International Cartography Conference, ICC 2009*, Santiago, Chili, 2009.

[BUC 11] Bucher B., Brasebin M., Buard E., Grosso E., Mustière S., Perret J., "GeOxygene: built on top of the expertness of the French NMA to host and share advanced GI Science research results", *Geospatial Free and Open Source Software in the 21st Century*, LNG&C, Springer-Verlag, 2011.

[CHE 06] Chesneau E., Méthodologie d'amélioration des cartes de risque par analyse locale des contrastes cartographiques, thèse de doctorat, Université de Marne-la-Vallée, 2006.

[CHR 09] Christophe S., "Making legends by means of painters' palettes", *Cartography and Art*, LNG&C, Springer, Berlin, Heidelberg, pp. 1–11, 2009.

[DEV 97] Devogele T., Processus d'intégration et d'appariement de Bases de Données Géographiques; Application à une base de données routières multi-échelles, thèse de doctorat, Université de Versailles – Saint Quentin en Yvelines, 1997.

[FIL 05] "OpenGIS filter encoding implementation specification", OpenGIS Specifications, 2005.

[ISO 03a] International Organization for Standardization (TC 211), ISO 19107:2003 Geographic information – Spatial schema, 2003.

[ISO 03b] International Organization for Standardization (TC 211), ISO 19115:2003 Geographic information – Metadata, 2003.

[ISO 05] International Organization for Standardization (TC 211), ISO 19109:2005(E) Geographic information – Rules for application schema, 2005.

[MUS 08] Mustière S., Devogele T., "Matching networks with different levels of detail", *GeoInformatica*, vol. 12, no. 4, pp. 435–453, 2008.

[OLT 08] Olteanu A.-M., Mustière S., "Data matching – a metter of belief", *The International Symposium on Spatial Data Handling – SDH'2008*, Montpellier, France, 2008.

[OLT 09] Olteanu A.-M., Mustière S., Ruas A., "Fusion des connaissances pour apparier des données géographiques", *Revue Internationale de Géomatique*, vol. 19, no. 3, pp. 321–349, 2009.

[PAG 08] PAGET A., PERRET J., GLEYZE J.-F., "La géomatique au service de la caractérisation automatique des réseaux hydrographiques", *Physio-géo, Géographie Physique et Environnement*, vol. 2, pp. 147–160, 2008.

[PER 09] PERRET J., BOFFET MAS A., RUAS A., "Understanding urban dynamics: the use of vector topographic databases and the creation of spatio-temporal databases", *24th International Cartography Conference (ICC'09)*, 2009.

[PER 10] PERRET J., CURIE F., GAFFURI J., RUAS A., "Un système multi-agents pour la simulation des dynamiques urbaines", *Les 18e Journées Francophones sur les Systèmes Multi-Agents (JFSMA'10)*, 2010.

[REV 09] REVELL P., ANTOINE B., "Automated matching of building features of differing levels of details: a case study", *24th International Cartography Conference (ICC'09)*, 2009.

[SHE 96] SHEWCHUK J.R., "Triangle: engineering a 2D quality mesh generator and delaunay triangulator", in LIN M.C., MANOCHA D., (eds), *Applied Computational Geometry: Towards Geometric Engineering*, LNCS 1148, Springer-Verlag, Berlin, Germany, pp. 203–222, 1996.

[SHE 09] SHEEREN D., MUSTIÈRE S., ZUCKER J.-D., "A data-mining approach for assessing consistency between multiple representations in spatial databases", *International Journal of Geographical Information Science*, vol. 23, no. 8, pp. 961–992, 2009.

[SYM 05] "OpenGIS symbology encoding implementation specification", OpenGIS Specifications, 2005.

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Author Query

[AQ1]   The acronym [GIS] has been defined at first mention
         in the chapter. Please check and confirm.
[AQ2]   Please check the edited sentence [Thus, the code. . .]
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[AQ3]   Please supply the English version for Figure 3.1 and
         3.11.
[AQ4]   Please suggest if the text [Let us point out. . .] can
         be set as part of body text. If so, please provide the
         appropriate location.
[AQ5]   Please provide the venue of conference in references
         [PER 09], [PER 10], [REV 09].
[AQ6]   Please provide the author name in references
         [FIL 05] and [SYM 05].