Insights on cadastral information uses for a diachronic space & time analysis

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Insights on cadastral information uses for a diachronic space & time analysis : The case of urban spread in La Rochelle (France)

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1. Introduction

La Rochelle, France knew during the second half of the twentieth century an important increase of its permanent and seasonal population. Since 1999, the city is grouped together with 17 others municipalities (communes) into an intercommunality (cooperation group between communes) : La Rochelle's community of Agglomeration (CDA-LR) (fig 1). Because of an attractive coastal position, the CDA-LR is subjected to a strong growing of population. It showed itself by a massive urban spread. This urban spread is constrained by a coastal position (physical constraints and planning regulations). This urban spread is today particularly visible in the peripheral municipalities (Communes) of the CDA-LR. These municipalities absorb the inhabitants because they cannot find a housing in the city of La Rochelle. The CDA-LR is under a strong land pressure because of its attractive coastal position. The land is very regulated and the built is already very dense. Inhabitants are thrown back towards the peripheral by the price of the housing. The mastery of the urban spreading of the CDA-LR is one of stakes of the future land development plan (schema de coherence territorial : SCOT). The SCOT is at present in progress. The aim of this paper is to propose space and time analysis tools in order to study the urban spread phenomenon. These tools are implemented in a geographical information system. Cadastral dataset is used as an input.
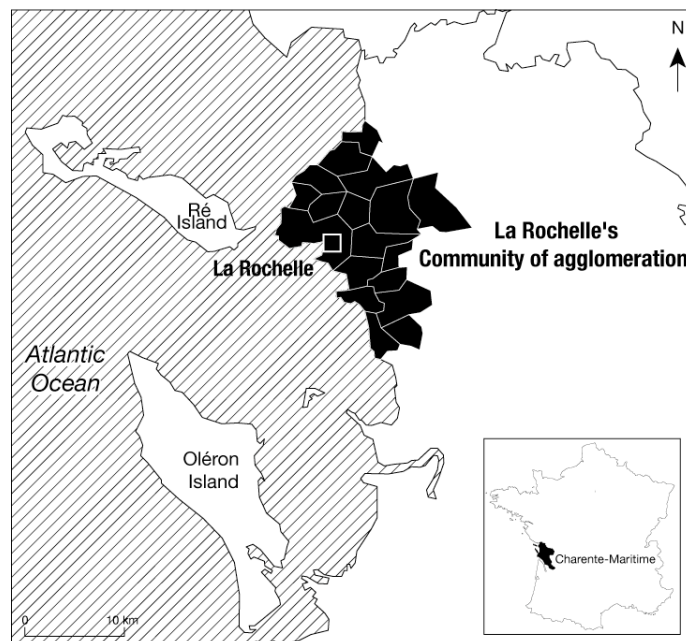

Figure 1. La Rochelle's community of agglomeration

Geographical information systems are first built around spatial data management. Only few software can manage both spatial and temporal data. Time dimension is often rather basically modelled than spatial dimension (Bordin, 2006). Most GIS deal with time information only with a single attribute. For example, there is usually an attribute for a birth date or two attributes (start/end) for a period time. None of them can easily manage semantic or geometric changes on geographical objects. Some geographical phenomenon such as urban processes need a space and time approach in order to carry out a valid analysis. Existing tools that have been developed around time dataset management are focused on visualization. Timemap (Johnson, 2004) is a very good example of time dataset visualization software. Recently, Google Earth offers the possibility to associate time information to its KML format. It allows visualizing data set. Time data set is displayed with a time slider in Google Earth user interface. Visualization is necessary but is not sufficient to understand and to quantify geographical process. On the contrary of spatial analysis tools, some few space and time generic analysis tools are available. Some space and time thematic tools exist for specific applications such as hydrology (Goodall *et al*, 2004).

From cadastral documents and a geographical database (BDTOPO from French mapping national agency), a method to analyse and to quantify urban spread is proposed. This method is based on space and time analysis of the urban spread. The question is focused on « the making » and the near evolution of the city (Dubos-Paillard, 2003). Studied area is the La Rochelle's Community of Agglomeration (CDA-LR). It is an interesting area because of an important urban spread from 1950 to today. Moreover, the important extend of the area helps to show the specific evolution phenomenon, constrained by its coastal situation. Urban spread is a urbanization process.

Urban spread is usually developed on attractive spaces (network or services proximity). For the implementation of the SCOT, urban engineers and elected representatives need knowledge regarding the impacts of urban spread on intercommunality. The first part of this paper presents institutional and scientific context of this research. The second part focuses on methodology and describes cadastral dataset as well as space and time tools implemented in a geographical information system. These tools are important to quantify and understand urban spread : How fast the city has been extended ? How fast has the building space consumed the free space ? Then first results are shown and discussed. The prime aim is *in fine* to better understand urban spread process on a coastal area.

2. Research background

This research is in keeping with two programs with different aims. This research is also in touch with a rich scientific context : time management (dataset, methods and tools) in geographical information systems.

2.1. Institutional context

This project is led in partnership with the La Rochelle's community of agglomeration. La Rochelle's community of agglomeration puts cadastral data at University disposal. These data are managed in France by the Ministry of finance (Direction générale des impots : DGI) and owned by CDA-LR. This research is included in a coastal and environment observatory (ECOP). This observatory is constituted by several departments, included the urban spread observatory. It provides a thematic approach and facilitates multidisciplinary approaches. This study joins also an IT research program (ESTE program) granted by Poitou-Charente region.

This one is more focused on space and time tools implementation, time data management and analysis.

2.2. Scientific context

Most of space and time analysis are based on non-continuous data. Satellite images are often used at different periods, and comparisons are made cells to cells. Sometimes, comparisons are made with multi-sources data such as aerial photography or rasterised old maps. Many sources of dataset are available but they only propose a non-continuous display of a time evolution (ANTONI, 2007). Data, scales and thematic between these documents are often heterogeneous and return hardly interpretable results. This research proposes an analysis with the same dataset (same source, same scale, same specifications). Cadastral dataset from 1950 to today is used for this study. It also provides continuous time information.

3. Dataset & methodology

This part focuses on the description of dataset and methods used for the urban spread analysis. A first part describes cadastral dataset. Cadastral dataset contains information regarding building dates, which are stored in a cadastral matrix. From this information, the urban spread will be studied. Methodology is described in a second part and focuses on the implementation of two time analysis tools.

3.1. Cadastral dataset :

The paper deals with urban spread at a large scale (intercommunity). Dataset consists of digital map files, which contain parcel-level cadastral information (between 1/2000 and 1/5000). In France, cadastral dataset are firstly in paper format but a numeric version has been made available for a dozen years (numeric cadastral plan) in raster or vector. Vector data are used for this research. Cadastral dataset contains two types of graphic information: parcels and buildings. All semantic information is linked to cadastral parcel. Building is linked to cadastral parcel thanks to its geographical position : « a building is inside a parcel ». Cadastral dataset also contain semantic information. They provide a lot of additional information such as « name of the owner », « number of floor», « area ». Concerning time information, it is important to note that only « building date» is available. If building is modified or destroyed, there is no information concerning these changes. Because of these restrictions, this study does not deal with urban changes or destructions of building. At the scale of the intercommunity, changes and destructions are in unimportant quantity and have no influence on global urban spread phenomenon.

Figure 2. An example of a French cadastral map

Cadastral dataset scale provides a sharper analysis of the urban spread phenomenon. To study this, space and time tools are implemented in a Geographical information system. These tools analyse the information stored in the cadastral dataset semantic. First, tools will help as visualising the urban evolution. Then, quantitative analysis are carried out on cadastral dataset to measure the urban evolution. Tools are described in the following part.

3.2. Methodology

The Method presents two tools adapted for space and time analysis. The first one is a visualization tool. It provides an easy way to navigate between space and time information. The second tool, which is described, is based on propagation principle. It provides information on building speed on a defined area.

The first tool that has been developed concerns time visualization. This is an old research thematic, but it has grown up much during these five last years with appearance of visualization softwares (TimeMap, Google Earth with time information stored in KML). We notice that the visualization development has not grown up in geographical information system. There are a few space and time visualization tools implemented in GIS. A visualization module available into a GIS would offer many links with GIS analysing tools. Tools are implemented in ArcGis, with the ArcObject library. This prototype was developed in two modules.

The first tool is a time slider (see Figure 3). It is a user-friendly interface used to navigate into time dimension. Users have to specify the attribute that contains the time data. Once the information is validated, the "Window time animation" appears. It allows the visualization of the evolution of the geographical object on the map. Time animation with different speeds can be chosen.

Figure 3. The time dataset visualization slider

The development of this application does not only aims at visualizing geographical Information System but also at providing analysis. The proposed tools for space and time analysis are based on speed of urbanization : How fast has the building space consumed the free space ? To create this information, a reference analysis scale is required. Speed of urbanization will be computed from this scale (cell, commune ? User can choose to make analysis from a grid or a vector polygon layer (eg communes, see figure 4).
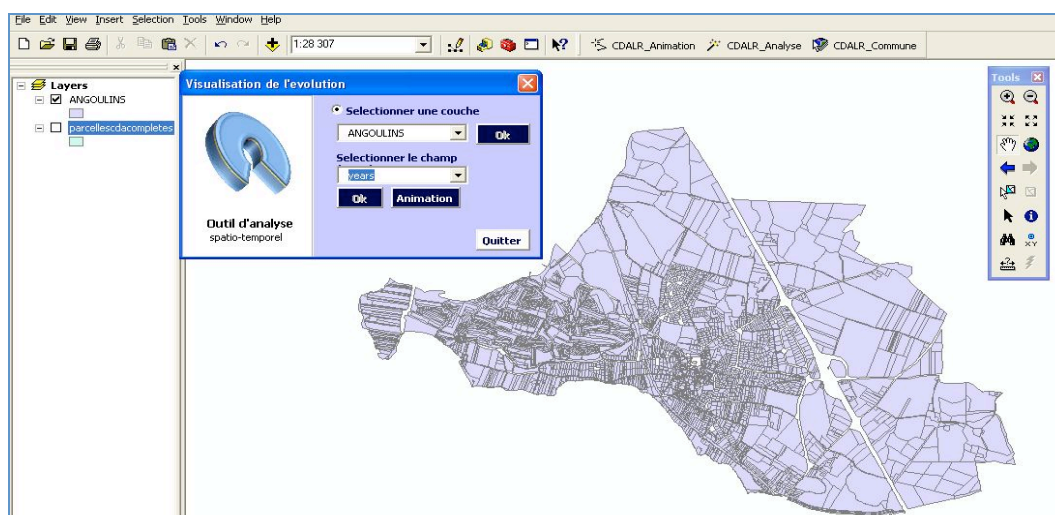

Figure 4. Analysis on a single commune

A vector polygon layer can also be automatically generated from cadastral dataset : all contiguous parcels are merged and grouped as « ilot ». « Ilot » unit is used in France by the national statistic institute (INSEE). User can overlay statistic information and generate ilots with time information.

The second module gives the possibility to the user, after having prepared the data, to carry out the analysis. The first analysis quantifies the speed of urbanization. It is based on analysis of cumulated densities of building (per communes) from 1950 to today. Different types of speed urbanization can be created depending on the profiles of the area (see figure 5). Profiles are compared to curve of tendency (linear, exponential, custom, etc.) and classified. The first profile shows an area without any significant evolution. The second profile shows a typical recent suburban construction in a peripheral commune of the CDA. The third profile illustrates a constrained suburbanized area. A different colour is associated to each profile on the map.
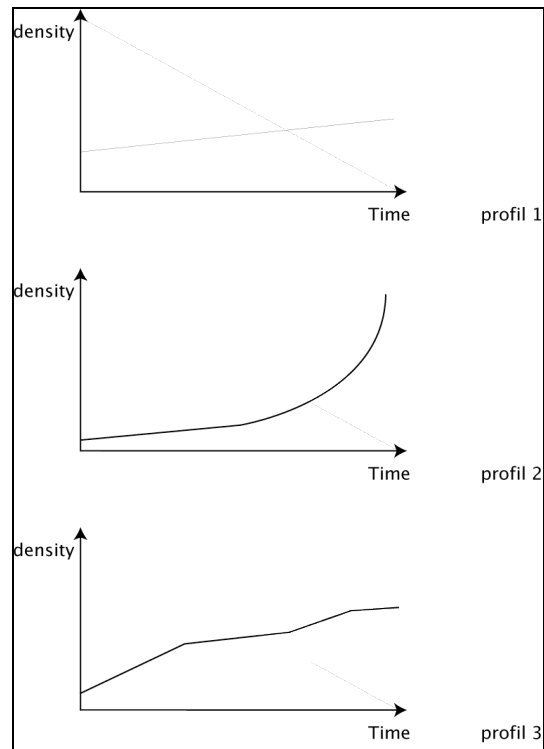
Figure 5. Profiles of speed of urbanization

4. First results and further work

First results are the followings : From the information related to the date of parcels building, a dynamic display of the urban evolution is available. A speed of urbanization map is also available (see Figure 6 for commune scale and figure 7 for cell scale). This map completes the visualization. It provides a measure of the speed of urbanization. This information is useful for future urban plans. Other space and time tools are in progress. It seems important to quantify correlation between important elements such as road network and urbanization speed of a nearer area.

Some works exist concerning time dataset modelling (Bedard, 1999, Wang *et al* 2005), but a few space and time tools are available in geographical information systems. For the CDA-LR, space and time analysis are interesting especially for urban engineers, elected representatives and planning managers. For the elected representatives, time visualization is a new way to see their territories. The development of new and efficient solutions for visualization will show the potential of the temporal data and will create new needs and new ideas in terms of space and time data and analysis.
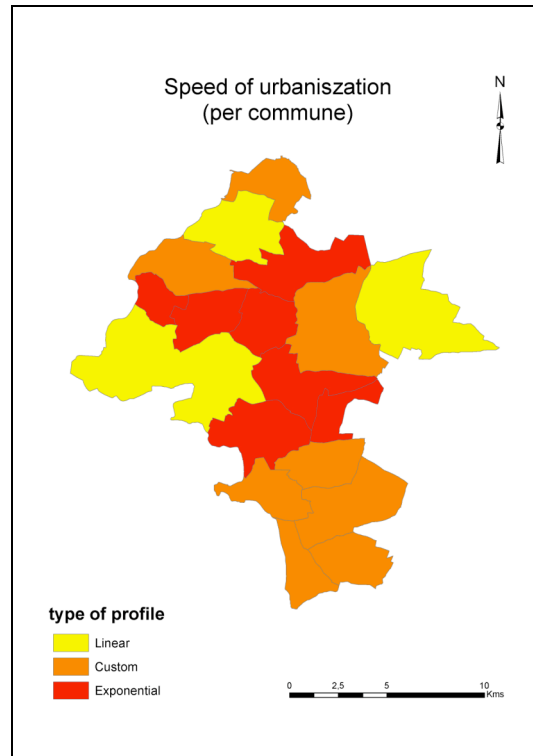
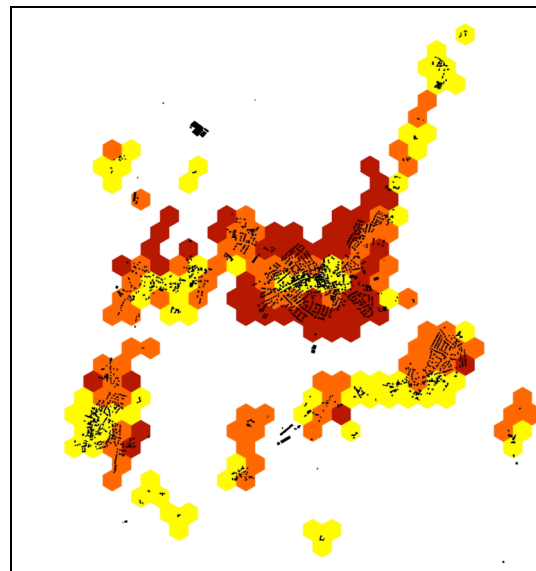*Figure 6. Speed of urbanization on La Rochelle's community of agglomeration*

Figure 7. Speed of urbanization per cells on Dompierre-Sur-Mer

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Biography :

Dr Frederic Rousseaux is lecturer in GIS and spatial analysis at La Rochelle University, France. His main research interests are the space and time analysis and the geographical data modelling.