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A spatial mixture model to account for risk discontinuities: Analyzing attempted suicide in Waterloo Region, Ontario

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Dynamic Optimization of Phenomena Mapping in GIS

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Abstract

Pollutions and urban climate are becoming a global issue. However the cartographic quality of related maps is not as expected. The visualization of phenomenon without its context or with inappropriate density might be incomprehensible for non-experts. The purpose of our research is to propose methods for phenomena mapping to facilitate map interpretation. In this paper, we generate adapted data for each level of detail (LoD) from raw data to visualize phenomena at different visual scales, add expert's knowledge into the visualization and readjust phenomenon data according to view conditions for a better visual perception.

1. Introduction

Pollutions and urban climate are becoming a global issue. However pollution and temperature are fields of values that are complex to estimate and to represent. In most cases, phenomena mapping has two deficiencies: 1- the phenomenon is not contextualized or overlaps its context 2- the information density is never adapted to user requirement. The aim of our research is to propose a better visualization of these phenomena, firstly by mapping phenomena with contextual (urban) data to estimate their impact or dangerousness. As phenomena are per-se complex, they should be viewed at different LoDs, from different angles. The understanding of phenomena requires exploration capacities. This research thus completes research in visual analytics (Andrienko *et al*. 2013).

We propose two ways to represent a phenomenon (Pham *et al*. 2015):

- With grids where a grid is composed by a set of punctual or area symbols. Grids allow seeing the phenomenon with its context because the symbols do not cover all the space.

- With plan, composed by a set of cells, each cell being a polygon represented by a color. Plan is used for small scale to give an overview of the phenomenon.

We propose to change the data density according to the zoom and to readjust the symbolization to the contextual information such as buildings. In order to do that, we create data for mapping by adjusting grid step, type of portrayal (grid or plan), grid orientation and we optimize symbolization. In the following section we propose a data model for phenomena mapping. Then we detail our optimization process in section 3 and conclude in section 4.

2. Model to facilitate the representation of data fields

Figure 1 presents a data model to facilitate the phenomenon visualization. In this model we distinguish *raw data* from *data for mapping* which are computed from raw data.
A *phenomenon* is represented by a series of *phenomenon episodes*. An *Episode* is described by a set of *value fields* from an initial time to a final time. For example we describe a Pollution Episode in London from 1.1.2016 to 1.3.2016, with one value field every hour. A *value field* is described by a set of values. Each *value* is associated to a *node* that belongs to a *grid*. In order to improve the visualization, we propose to generate a set of ***value fields for mapping*** because raw data is not suitable for all LoD. Each *value field for mapping* (vfm) is characterized by an area, a LoD, a color family, a cell size, - generated by generalization or

interpolation and - mapped in a resolution range. A vfm is represented on an ***adapted geometric structure*** which can be a plan (LoD1) or a grid according to requirements and zooming. In our research the LoD depends on the area extend and the thematic data granularity (the raw data cell size) on one side and, on the other side, the smallest reasonable cell size to explore the data. For air pollution, the smallest LoD would allow seeing Paris and the largest would allow navigating in a street (see figures 3 to 5)

To readjust the visualization to a view condition, we create a *temporary adapted value field* (t-avf) extracted from a vfm. This t-avf is automatically modified every time we zoom in/out or change observer's position.

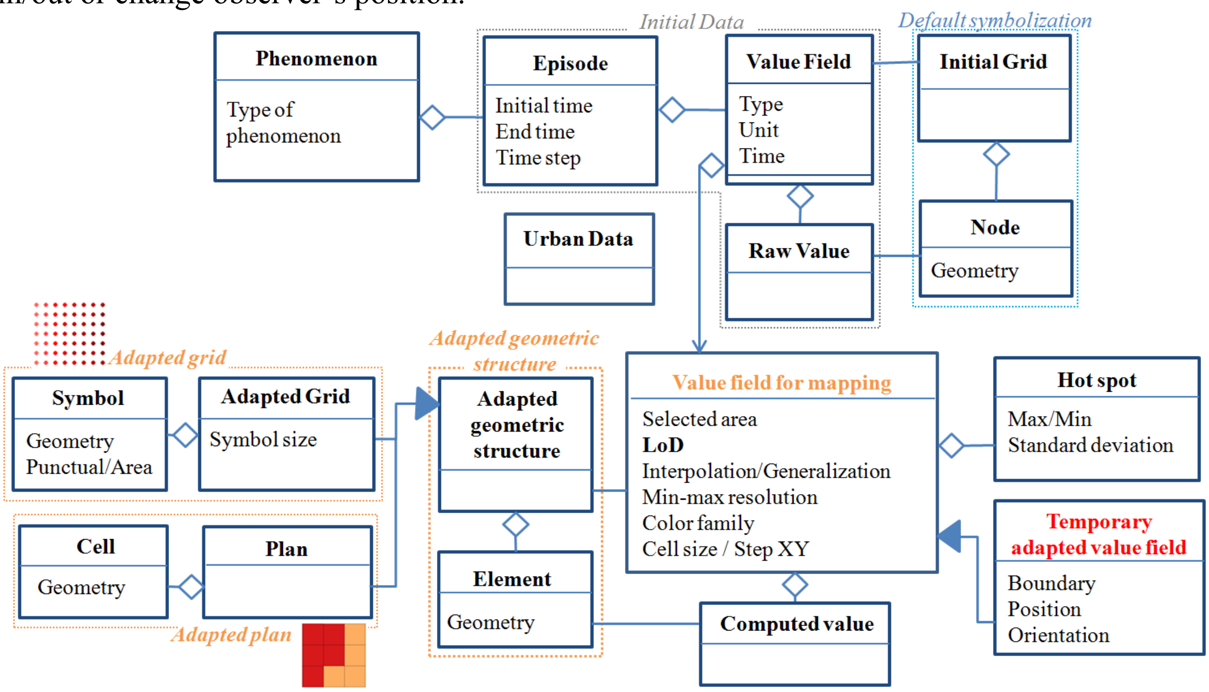

Figure 1: Model to facilitate the representation of data fields

3. Process to optimize phenomena mapping

We are in the process of writing a plug-in in QGIS to allow the automatic optimization of phenomena mapping. Once a user chooses an area, the plug-in automatically optimizes the corresponding information in the database and reloads the optimized data. We describe the optimization process hereafter (Figure 2).

3.1. Preliminary optimization

This preliminary process consists in preparing LoDs by generalization or interpolation (Pham *et al.*, 2015) that will be used for the interactive optimization. It is based on two steps: data analysis and creation of appropriate LoDs.

Step 1: Analyze data

From user's requirements, scale of phenomenon and its context, we define the necessary quantity of LoDs for the phenomenon's interpretation, maximum resolution and minimum resolution for each LoD.

We also detect the *hot spot* by looking either for the extreme values on the area or for most variables values (important standard deviation). Extreme values are important to make an alert when values exceed a safety threshold.

Step 2: Create LoDs

To represent a phenomenon at different LoDs, we create new data tables for each LoD:

- Grids to visualize the phenomenon with its geographic context: at least one grid for punctual symbols (low LoD), and one grid for area symbols (high LoD). Area symbols are very efficient for large zoom (Ruas *et al*. 2015)

- One plan to visualize the phenomenon continuously, which gives an overview of the phenomenon. Plan is perfect to represent our LoD1.

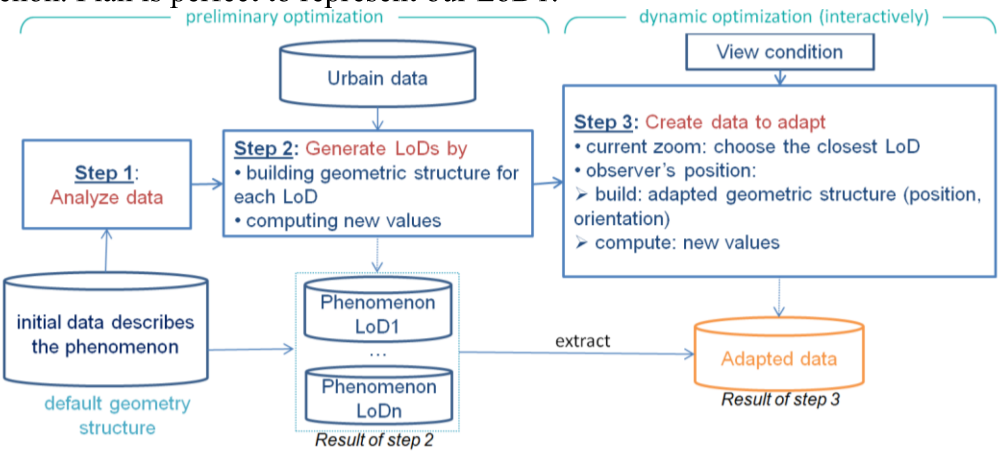

Figure 2: Principe of optimization

3.2. Dynamic optimization

To optimize the visualization of a phenomenon, we propose the adjustment of grid parameters (density, position, orientation) in accordance with each view condition defined by zoom, environment or observer's position.

Step 3: Adapt the grid for view condition

- Adapt grid density for current zoom

The grid density depends on the distance between two nodes (grid step). When we zoom in, we wish to view the phenomenon with more details. So we can create a data table for each possible LoD. But if we store too many tables in the databases, the step 2 becomes time consuming (cf 3.1.). On the other hand, building one or two LoDs is fast but the visualization may be rough. We propose to make the grid density dynamic in between stored LoDs. Thus anytime we change the zoom, the system automatically chooses the closest LoD among the tables saved in the database (step 2) and computes the new grid from the chosen one (figure 2). Current research aims to propose efficient methods for this step.

- Adapt grid orientation for environment

The grid orientation is defined by the angle between the axis of the grid and the abscissa. Optimizing consists here to find the orientation that minimizes the obscure rate of the grid in an area, or to maximize the number of non-overlapped nodes.

When an area is selected by a user, we count the number of intersections between the phenomenon data and the background (here the buildings). The obscure rate is measured by the ratio between the quantity of nodes hidden by buildings and the total ones: $R_{ob} = \frac{N_{hidden}}{N_{total}}$

If the rate of obscure is less than 10%, we validate the orientation. Otherwise, we vary the orientation angle from 0 to 45°, the best position is where R_{ob} is the smallest.

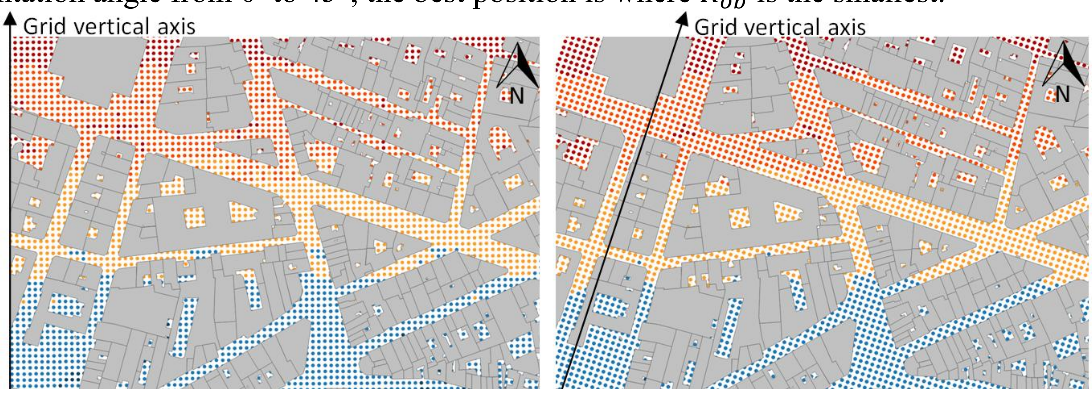

Figure 3: A selected area of the initial grid before (left) and after global optimization (right)

- Adapt grid for observer's position

We propose to create a visual field to simulate the point of view of a human that walks in the geographical space. The grid readjusts according to the observer's position.

Figure 4: Visualization with point of view of an observer

If user focuses on one street, we orient the grid according to this street in order to maximize the number of visibles nodes.

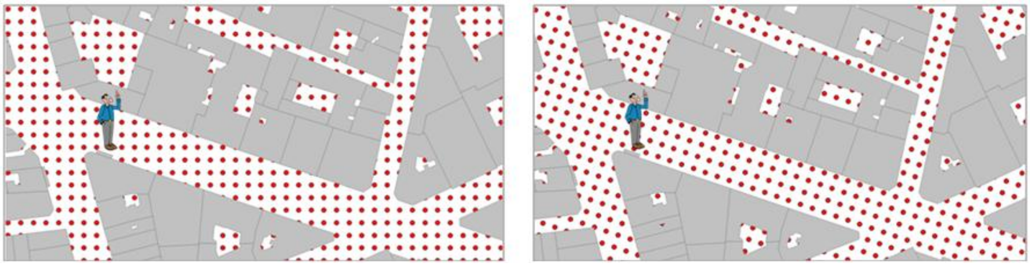

Figure 5: Initial grid before (left) and after optimization according to the street orientation where observer is located (right)

Conclusion

In this paper we propose methods for optimizing visual perception by visualizing a phenomenon at different LoDs and adapting the representation to view condition. Our current work is to complete optimization methods including symbolization. Future research will focus on evaluation.

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