

An Integrated Open Source Desktop GIS for Population Mapping

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Introduction

Geospatial data are growing exponentially because of ubiquitous and various devices (Goodchild et al., 2007; Stefanidis et al., 2013). To deal with challenges caused by data increasing require an efficient open GIS desktop software that can store, query, analyze, and visualize spatiotemporal data.

The map visual representation of statistical data is a restoration of the spatial characteristics of statistical data, and provides a potential method for exploring and mining statistical information (Gastner and Newman, 2004). In order to overcome the logical inconsistency between the spatial reference and the map expression, the area cartogram map has become a reliable statistical data expression scheme.

Method

Architecture of Cross-platform Desktop GIS

The open source GIS desktop not only supports cross-platform desktop GIS applications and development, but also support a variety of geospatial data and spatial databases (Wang et al., 2019). It was devolved based on SuperMap Universal GIS Core (UGC) under OSGi framework. And it provides geographic spatial data processing and management, 2D/3D integration, spatial analysis, mapping and visualization of GIS functions, and supports custom development. The Architecture of open source desktop GIS is shown in Figure 1.

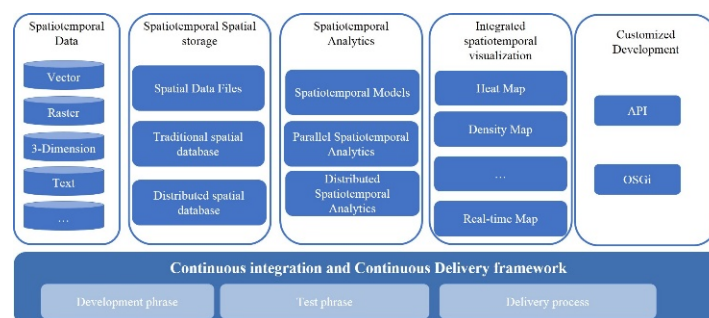


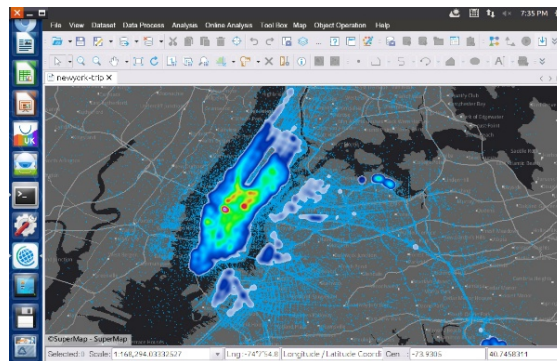
Figure 1: The architecture of open source desktop GIS.

Implementation

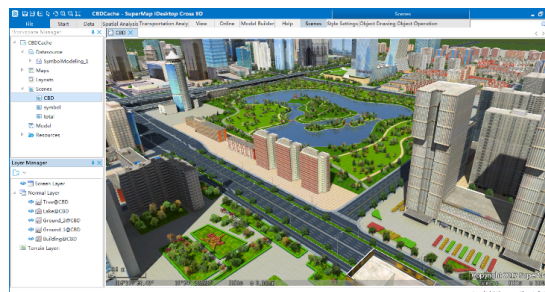
As for the complexity of GIS applications and high performance requirements, C++ is used to implement GIS Functions. At the same time, with the help of automation scripts and continuous integration technology, the component code will be compiled and tested under the CPU platform which automatically triggers the different instruction set architecture. Additionally, a large number of basic libraries have been written in this study to support the different platforms of data storage and efficient management of the spatial database engine.

Moreover, we used JNI technology to package the C++ components of GIS, and realized the API that can be called by Java. Based on Java Swing Graphic Interface Technology, the Interface Layout of Standard Toolbar was realized, which eventually realized the Function Display and User Interaction Experience of Desktop GIS.

OSGi is considered to be a dynamic model system for the Java (Alliance 2005). As for software development, OSGi has two distinct advantages of component decoupling and Equinox unified scheduling. Specifically, dynamically installing, uninstalling, starting and stopping different modules in the software without restarting the container can be implemented. And for a particular module in the software, the container can run multiple versions of the module at the same time. In this study, the OSGi framework was adopted, followed by the OSGi international extension standard, the development framework of SuperMap iDesktop Cross was implemented by Java (Fig.2a and Fig.2b).



(a) Density Map of New York Taxi



(b) 3-dimensional visualization for CBD in Beijing

Figure 2: The interface of SuperMap iDesktop Cross

There are six categories of interfaces for the development framework according to the function. 1) GIS C ++ kernel interface. 2) Data conversion interface, data editing interface, data processing interface, data topology interface, data browsing and visualization interface. 3) Map interface, map browsing and visualization interface. 4) Table browsing and visualization interface. 5) Spatial analysis interface. 6) Auxiliary interface, control interface, frame interface. Users for geospatial analytics can make use of these API interfaces to achieve more new GIS function modules. The iDesktop Cross is open source desktop GIS project (iDesktop Cross 2020).

Improved method of Diffusion-based method for cartogram

However, the existing area cartogram algorithms are often not applicable to grid statistics (Gastner and Newman, 2004; Shimizu and Inoue, 2009), mainly as follows: 1) Small-scale grid statistics have the characteristics of rich detailed information and large local differences. 2) Existing area-based schematic map algorithms are sensitive to local differences in data, and they are not suitable for schematic maps with large local differences. This paper, aiming at this problem, proposes an algorithm to express a schematic map of the grid area based on the local scale effect index modification and applies it to the demographic data of Beijing.

The large-scale data can be used at the target scale to overcome the effect of the algorithm's failure due to the large difference in attribute density. The specific method is:

Step1: Initialize $\rho(\mathbf{g}, 0)$ to acquire the attribute density distribution grid $\rho(\mathbf{g}, 0, lev_x)$ and $\rho(\mathbf{g}, 0, lev_{x-1})$ on scaling lev_x and lev_{x-1} in order to provide the value of $\rho(\mathbf{g}, 0, lev_x)$ to $\rho(\mathbf{g}, 0)$;

Step2: Examine $\rho(\mathbf{g}, 0)$ grid to calculate the partial scaling effect index S_{ij} based on lev_x and lev_{x-1} , if $S_{ij} > thres$, it is suggesting $\rho(\mathbf{g}, 0, lev_x)$ has abnormal density at the parent grid $\rho_{ij}(\mathbf{g}, 0, lev_{x-1}) (i, j)$ hence it is essential to upgrade the grid scaling of $\rho_{ij}(\mathbf{g}, 0)$ to lev_{x-1} by using the grid $\rho_{ij}(\mathbf{g}, 0, lev_{x-1})$ to replace its child grid's lev_x and provide the value of $\rho_{ij}(\mathbf{g}, 0, lev_{x-1})$ to $\rho_{ij}(\mathbf{g}, 0)$;

Step3: Examine all the grids in $\rho(\mathbf{g}, 0)$ with the scaling of lev_{x-1} to acquire the parent grids of lev_{x-1} on scaling lev_{x-2} as well as conducting examination to lev_{x-2} like that in Step2 until all grids in $\rho(\mathbf{g}, 0)$ reach desired scaling values.

Step4: Acquire the distribution speed of grid points: Use $\rho(\mathbf{g}, 0)$ as the initiator

and category two border condition to solve the partial differential formula $\nabla^2 \rho - \frac{\partial \rho}{\partial t} = 0$,

and calculate the distribution speed of grid points $v(\mathbf{g}, t) = -\frac{\nabla \rho}{\rho}$;

Step5: Acquire the final position of the grid point: Based on $v(\mathbf{g}, t)$, calculate

$\mathbf{g}(t) = \mathbf{g}(0) + \int_0^t v(\mathbf{g}, t') dt'$ in order to confirm the position of every target point on the grid.

Results

Aiming at the above problems, this paper uses the grid data based on the scale effect to modify the map algorithm to carry out preliminary experiments on 100m grid population density data. Anomaly grids of population density were screened using the scale effect index of grid statistics, and the anomalous grids were replaced with superior parent grid attribute values based on the characterization of the grid data until 100m population grid density data all met the conditions. The Diffusion-based method algorithm was called to generate a cartogram of the population area of the 100m grid in Beijing's district counties (cartogram of some districts and counties are shown in Figure 3).

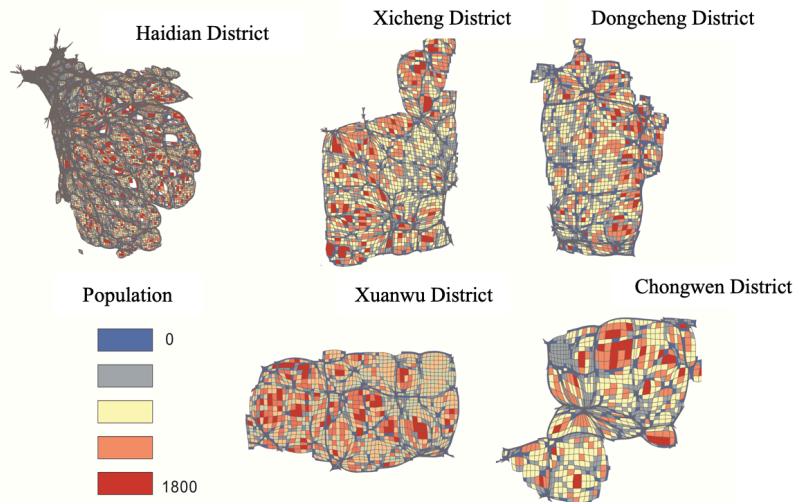


Figure 3: Gridded population area cartogram of some districts in Beijing (2010)

Compared with the 100m grid map, the population area schematic maps of some districts and counties in Beijing have better visualization effects, revealing the characteristics of population distribution differences within the city, especially the map. The method reflects that the population inside the city is divided by urban roads, and the spatial relationship between the characteristics of urban roads and the distribution of urban population is very obvious.

Discussion and Conclusion

In this study, we propose an open GIS desktop software-SuperMap desktop Cross which can run across the platform. It greatly benefits the full-featured geospatial data processing and manipulation of Linux for researchers. This study uses Java language to develop its user interaction interface. Based on the C++ GIS function kernel was developed, which ensures the high-performance GIS software among different operating systems. It is essential for data-intensive and compute-intensive GIS applications. This paper adopts the scale correction method to modify the local density data so that Gastner-Newman's Diffusion-based method can be applied to the visualization application of grid statistics. And it has achieved a good application effect on Beijing grid statistics.

References

- Alliance, O. (2005). OSGi Service Platform Service Compendium Release 4. Draft, July.
- iDesktop Cross. (2020, January 22). iDesktop Cross. The iDesktopCross project. Retrieved from <https://github.com/SuperMap-iDesktop/SuperMap-iDesktop-Cross>.
- Gastner, M. T., & Newman, M. E. (2004). Diffusion-based method for producing density-equalizing maps. *Proceedings of the National Academy of Sciences*, 101(20), 7499-7504.
- Goodchild, M. F., Fu, P., & Rich, P. (2007). Sharing geographic information: an assessment of the Geospatial One-Stop. *Annals of the Association of American Geographers*, 97(2), 250-266.
- Shimizu, E., & Inoue, R. (2009). A new algorithm for distance cartogram construction. *International Journal of Geographical Information Science*, 23(11), 1453-1470.
- Stefanidis, A., Crooks, A., & Radzikowski, J. (2013). Harvesting ambient geospatial information from social media feeds. *GeoJournal*, 78(2), 319-338.
- Wang, S., Zhong, Y., & Wang, E. (2019). An integrated GIS platform architecture for spatiotemporal big data. *Future Generation Computer Systems*, 94, 160-172.