Building a map edit tool with the support of Planar Map class in CGAL

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Abstract

A topological map can be the basis for additional thematic layers, successively converting it into a complex system for management and planning purposes. This paper presents the problem and gives our solution of applying Topological Map - Planar Map package of the CGAL library in building a tool to manipulate (includes to edit and to query) spatial objects contained in topological maps such as cadastral maps, route maps… To many developers who use Planar Map CGAL, the most restricted feature of Planar Map class is the ability to store and load a very large data of a real map into Planar Map object to edit because that job takes too much time to accept for real software. The core of our solution is using Planar Map CGAL object as an edit buffer.

We implemented our study in SmartMap Editor, which is an important part of the whole HCM GIS - SmartMap System. SmartMap Editor provides functions to edit and query spatial data in a GIS system which contains several thematic layers. The spatial information in each thematic layer is stored in a topological structure. Some examples of its thematic layers and their usages are presented here. The structure and information content of the map is presented and the processes of map creation, update and query are described.

Keywords: *topological map, planar map, thematic layer, edit buffer.*

1. Introduction

Digital maps of spatial object are really essential for many administrative purposes nowadays. A spatial structure consists of parcel boundaries, ground use boundaries and class boundaries. The land and house in a city is changing day after day. A tool manipulate spatial objects is useful for management jobs.

Topological map is a map in which not only geometry data but also relations among spatial data are stored. Editing primitives, which have topology relations among each other, is difficult because we will have to update many topology relations to maintain the validity of a topological map. The more topology relations and primitives a map contains, the more difficult to edit it. Fortunately, the planar map class of CGAL library provides almost all needed methods to edit a planar map with full topology. We use CGAL[1] (Computational Geometry Algorithm Library) to find a solution for that problem. We implemented our study in SmartMap Editor, which is an important part of the whole Ho Chi Minh City GIS - SmartMap System. All maps used in SmartMap Editor are topological maps. SmartMap Editor provides functions to edit and query spatial data in topological maps. In this application, we use data from a district cadastral map and a route map to test its performance.

In this paper, we represent how we apply planar map class to implement SmartMap Editor. The structure and information content of the map is presented and the processes of map creation, update and query are described.

2. Application requirements

SmartMap Editor is a tool provides functions to edit and query spatial data in topological maps. A topological map can include several layers; each layer contains one, two or three kinds of primitives such as vertex, edges and faces. Together with spatial data, this program can store relative attribute data of spatial data.

3. Topological Map - Planar Map CGAL

3.1. Halfedge Data Structure (HDS)

Topological Map and Planar Map class in CGAL library build the central structure based on halfedge data structure(HDS). HDS is a topological structure, which has three types of primitives : **vertex**, **halfedge** and **face**.

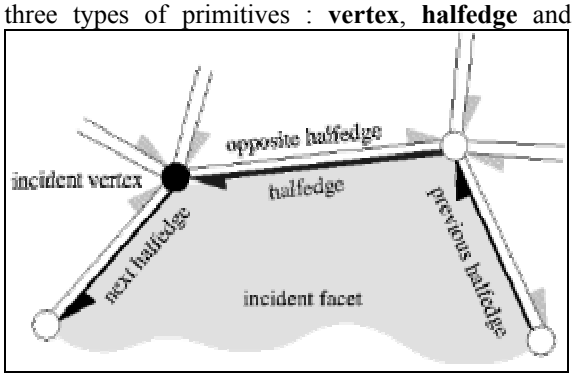
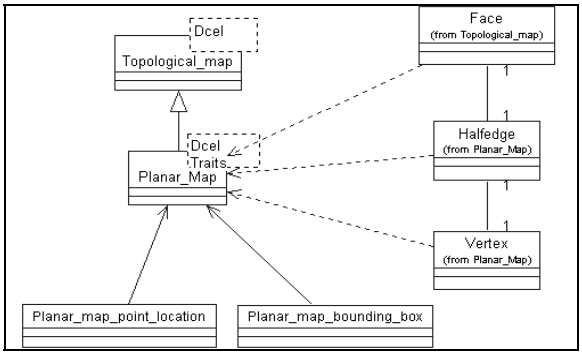


Figure 1 : Halfedge Data Structure

3.2. Class Diagram



3.3. Important functions

Class Planar_Map<Dcel,Traits> has four update functions and two query functions. Update functions are insert, split_edge, merge_edge and remove_edge [1].

4. Applying Planar Map package to implement SmartMap Editor

With the aim to build an application to edit a topological map, Planar Map class of CGAL library has some conveniences and difficulties :

4.1. Conveniences

Planar Map class supports full-topology that means it supports to store info about connected node (vertex), edge (halfedge) and face.

Planar Map class supports three update methods for the edit function of our application. They are ***merge_edge(), split_edge() and remove_edge().***

4.2. Difficulties

First, all methods in planar map class require that all data be loaded in a planar map instance so it will allocate a very large primary memory. Although in most operating systems nowadays, the problem of not enough memory is solved but loading 5-6GB spatial data to create a planar map and maintain it is not a good idea. It will take us long time but wastefully.

Second, all update methods in planar map class always re-update the whole data whenever there is any updates of primitives. It requires much time and it is unacceptable to use in a commercial product because the application will take a long time to finish an edit function.

Third, planar map class does not support I/O function especially the ability to re-create a planar map immediately without re-creating topological relations. We ourselves cannot build topology info to skip the check valid process of planar map class because we do not have information about how to build the search structure inside the planar map. We faced this problem when working with CGAL 2.2. We spent a short time to investigate the newest version of CGAL and found that CGAL 2.3 now supports I/O function for planar map but there still has an important problem. This I/O function supports text file format. With large data, it takes much time to read and write in text format. Furthermore, the data will be not protected as private license.

After thoroughly analyzing those features, we decide to use planar map class in our edit function because this function is very complicated and hardly to implement without the support of planar map class. However, due to difficulties mentioned above, we have developed and changed a little of the planar map class to fit our needs and used it as an edit buffer of our application.

4.3. Implementation

Because our application will work with planar maps, we create a class named CPlanarMap, which is the core component of our application. This class is responsible for all functions related to the planar map. There are four groups of function : edit group, view group, query group and I/O group. We cannot use all system resources for Smart Map Editor, we propose one method to update topology relations, and it is ***partial update***. Our solution is just at its beginning state, we have to develop more to reach a perfect solution.

In our application, we use an instance of planar map class – CGAL as an edit buffer. Because users can only edit and view a small part of the whole map, only this part is loaded into that buffer. When users are editing primitives, planar map class will maintain the validation of this topological map. When users change to another area on the map that is not loaded into the edit buffer yet, the new needed data out of this buffer will be loaded and the data exists in the edit buffer but is not needed any longer will be remove from the edit buffer.

We load a part of the map into the edit buffer based on MBR (Minimum Boundary Rectangle) concept. First, we get MBR of the desire part in the whole map. Second, we search in spatial data of the map and load all primitives that intersect with or lying in the MBR mentioned above. Finally, we have a planar map instance which is our application‘s edit buffer.

There is one problem in the solution above. Each edge that is lying at the imagine boundary of the edit buffer has a halfedge incident to unbound face while it is really incident to a bound face in the whole map. When loaded in the edit buffer, that halfedge is incident to unbound face so when it is re-written into database, its information will change. If we do not solve this problem, the data will become inexact after users edit the map. In this case, we use a variable to set update status of all primitives and customize update functions of planar map class by adding

a command to set this update status. If a halfedge is not edited, its information will not be written back to database.

5. Conclusions and proposals

Designing and implementing a tool to edit topological structure is not very difficult now. We have successively built an appropriate structure that can apply planar map package of CGAL library to store spatial data in geometric information systems. The high value of this structure is that users can even update topology info, not only geometry info and attribute info as most present GIS applications here. Planar Map package of CGAL has made great contribution to this achievement. After applying planar map package to build SmartMap Editor Tool, we have found that the planar map package of CGAL library is really a useful and necessary tool for GIS developers. However, we have also realized some limits of this package. We hope this package will be developed more to provide GIS developers a more convenient tool. Some of our proposals are mentioned below :

- The update methods of planar map class always re-update all primitives contained in the present instance while there really have only some changes in this planar map. Doing this way takes much time wastefully. To cope with this problem, we have to build our own solution to update only a part and this is a complicated and time-consuming job. If the developers of planar map package in CGAL library provide update methods based on partial update method, this package will be more useful and efficient.
- The fault tolerance of planar map package and other packages are rather bad. If we have some mistakes in our data that may lead to un x-monotone edge the program will face a fatal error. We have had to build a small tool to process our data before using the planar map package to create a planar map. The planar map should support this function.
- There is a wasteful resource when planar map class is used to work with not-full topology. That is the case of route map. We really do not need to create faces in this map. Nevertheless, with planar map, faces will be automatically created. There should be an option for planar map objects that if it needs face information or not.
- The number type used in Planar Map class should be leda-real type. We tried using double type and met many errors due to the intersection among edges which are supposed not cutting each others. That error happened because the intersect function does not work exactly with double type.
- Finally, the CGAL library should support display methods on Ms Windows environment.

We hope this package will be developed more to provide GIS developers a more convenient tool.

References

[1] CGAL Reference Manual. http://www.cgal.org

[2] NIMA, Interface Standard For Vector Product Format, 1996.

[3] Duong Anh Duc, Nguyen Dong Ha, Le thi Thuy Hang - Proposing a model to store and a method to edit spatial data in topological maps - Technical Report at University Scientific Meeting 2001.

[4] Nguyen Dong Ha, Le thi Thuy Hang - CGAL library and its applications in developing GIS systems - Bachelor thesis 2001.