THE GENERALIZATION METHOD RESEARCH OF RIVER NETWORK BASED ON MORPH STRUCTURE AND CATCHMENTS' CHARACTER KNOWLEDGE

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ABSTRACT:

The generalization operation should first make decision of object importance at geographic level, which relates not only to the geometric properties of independent object but also the other context objects. In the channel selection of river network, besides the length and the distribution density, the order, the angle, the distribution pattern, proportion of left river branch and right river branch, distance between neighbor Channels and other parameters should be considered in the selection. How to get the information such as the order, the length, and the watershed area is the point of this article. In this study, these parameters can be extracted from Digital Elevation Model which can describe the terrain correctly. In this article, the channel selection during the river network generalization is four steps, first step is extracting different levels of catchments area and river network from 1：250000 Digital Elevation Model; second step is ordering the river; third step is deciding the river structure in small catchments; the forth step is selecting channel according to some parameters to get 1:1000000 river network data. The goal of first step is to decide the research unit of the river selection. The second step is to decide which channel should be deleted first and which channel is more important than others according to the watershed. The third step is the base of the forth step because the different river structure has different features. This article discussed the relationship between geographic feature of the river, watershed characters of channels and hydrographic generalization. The experiment of channel selection on this method shows it has good generalization effect.

1. INTRODUCTION

Nearly all generalization processes include the initial step of selecting the objects and attributes from an initial database that are to be represented in the generalized dataset. The abstraction of river network is also the initial step of the generalization of river network. Map generalization is the process of "information abstraction" rather than a "data compression" although two processes have associations with each other. For the generalization of river network, the situation is the same. Hydrology is one of the most important geographic features in the geographic information system, so river network generalization is also one of the most important features in cartographic generalization field. Indeed, the selection of river network has to answer two questions:
(1) How many branches to be selected?
(2) Which channel should be selected?

These two questions seem easy, first one is about distribution density of the channels and second one is considering which channel is more important than the others. In fact, these two questions not as simple as they look. Especially the second question, there are so many drainages, why you select this one but not that one. Now the channel selection during the river network generalization is only considering the river length, some about distribution density. In fact, the channel selection like these couldn't get the better result. The generalization operation should first make decision of object importance at geographic level, which relates not only to the geometric properties of independent object but also the other context objects. In the channel selection of river network, besides the length and the distribution density, the order, the angle, the distribution pattern, proportion of left river branch and right river branch, distance between neighbour Channels and other parameters should be considered in the selection. How to get the information such as the order, the length, and the watershed area is the point of this article.

As the river network is the main feature in GIS visualization and traditional map representation, its generalization has attracted interests over years. Richardson(1993) selected river based on Horton order and river length. Thomson and Brooks (2000) apply the Gestalt recognition principles preserving the main channel and deleting unimportant channels. Wuhehai(2007) builds the selection model for geometrical sequence, in his study, he states the mathematic foundation of creating the density control table of map object selection. Since the distribution of river network associates with the terrain surface and drainage catchment, Aitinghua(2007) presents a method of selecting river branch based on river catchment deriving from the Delaunay triangulation. These researches only discuss the selection method, but not the drainage pattern which is the most important factor in drainage selection. We know that generalization is not perfect if drainage pattern is not considered.

For the generalization of drainage, we try to get the simple representation but remaining the main properties of hydrographic meaning. This is to say, for a drainage branch, its

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geographic position, the terrain situation and its importance in the whole river network should be considered in drainage selection. If we just see the independent river without considering its context, the abstraction will dramatically destroy the original structure. So the assessment of geographic and hydrographic meaning plays an important role in river network generalization. Considering the watershed area is an important parameter in river network, in this article, we choose Digital Elevation Model which is true representation of the terrain to extract the drainage and watershed area. The model contributes to extract, order of the river and the basin order. In this paper, we want to abstract drainage based on drainage basins(catchments). The paper is structured as follows. Section 1 discusses the hierarchical structure of river network. in section 2, drainage, basin are extracted from Digital Elevation Model and be ordered. In Section 3, Selection parameter computations (the distance between neighbor rivers, the angle of the river branch, drainage length and the drainage density, etc) are offered. In section 4, using these parameters, a selection model and some examples are given. Section 5 gives the conclusion and future improvement works.

2. THE CONSTRUCTION OF HIERARCHICAL GENERALIZATION MODEL

2.1 Drainage hierarchical structure

An outstanding property of river network is the hierarchy. In hydrographic research domain, three well-known ordering, namely the Strahler order, Horton order and Shreve order describes the hierarchical organization from different perspectives.

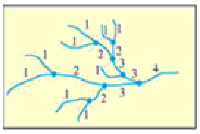

Figure 1. An illustration of Strahler order

The strahler order(strahler, 1957;horton,1945)is based on the structure of the river network and reflects the level of each river reach inthe hierachy of the river network. strahler ordering starts from the smallest reaches having no tributaries, which obrain a strahler order of one(so-called first order channels).when two first order channels join, a second order channel is formed. the strahler system of river network carries information on the dimension and complexity of drainage network and serves as a basis for the calculation of a series of characteristic of the system(strahler 1964).strahler orders are an easy way to group drainage hiearchically.

2.2 Extracting drainage network and basin

Recently, digital elevation models (DEMs) have received considerable attention for the extraction of drainage networks and catchments boundaries at global to continental scales (e.g., Graham et al., 1999; Döll and Lehner, 2002).

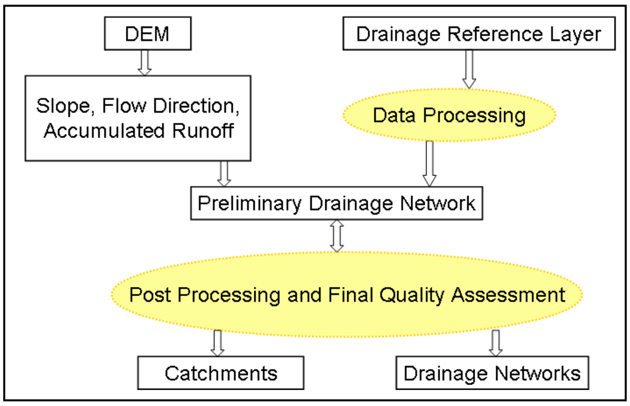

Figure2. Extraction of drainage and catchments

Extraction techniques require the computation of local slope, flow direction, and contributing area for each grid cell, and pose specific challenges for their accurate computation over flat areas. Outputs from these computations are flow direction and flow accumulation matrices. Finally, the so-called contributing drainage area threshold needs to be determined. This threshold represents the minimum contributing area needed to form and maintain a channel.

2.3 Basin order

Basin ordering is a very important factor for the generalization of river network. Each river network has an intrinsic hierarchical structure that can be described by various stream ordering procedures. River network can be schematized as sets of basic unit: links (river segments) and nodes (source nodes, outlet nodes and junction nodes). Based on classification of drainage, a basin ordering is as figure3:

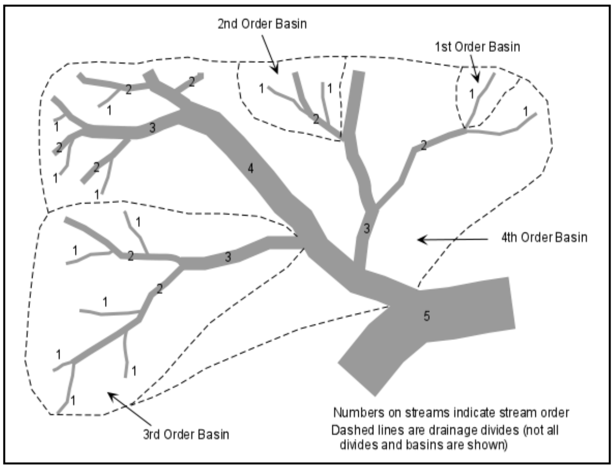

Figure 3. Basin order

In this ordering, the 1st order basin is the lowest level of all the basins which only contains the 1st class drainage. The 2nd order basin is only higher than the 1st order basin which contains the 1st order basin and the 2nd order basin. The 3rd order basin contains the 1st order drainage, 2nd order drainage and the 3rd order drainage……

Figure 4 is the corresponding basin ordering code. When the basins are classified as three levels, the lowest sub-basin is coded as xxx while the basin is coded as x.

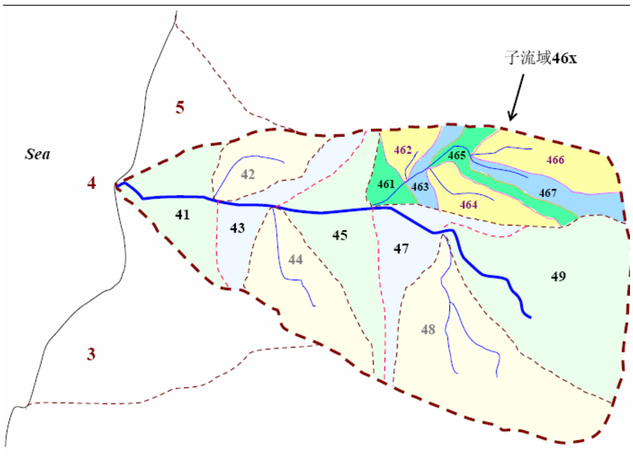

Figure 4. Basin ordering code

3. MODEL CONSTRUCTION

3.1 Determination of the selection unit

How to choose the perfect selection unit is one of the most important problems in selecting drainage to be resolved. The principles of choosing the selection unit are two points: first, the drainage pattern should be single in the unit. If the drainage pattern is more than one in the selection unit, the threshold of selection parameters will be complicated. Second, the large unit is better than small one if only its drainage pattern is single. How can we determine whether it is selected or not if the unit only contains one river. Through these steps, the selection unit(basin) is determined, in this unit, the drainage pattern (such as dendritic drainage patterns、featherlike drainage patterns、and Parallel drainage patterns, etc)should be known before the parameters are computed. Here we choose a featherlike drainage pattern as the example for selecting the parameters.

3.2 Selection parameters

The goal of above step is to decide the research unit of the river selection. The next step is to decide which channel should be deleted first and which channel is more important than others according to the watershed. The first step is the base of the second step because the different river structure has different features. Such as the selection of feather shape channels, the distance between neighbor channel is one of the most important characters, but in tree shape, this character probably couldn't be considered. Although there are so many shapes of channels, considering the complexity of these shapes, in this article we only choose tree shape, feather shape and grid shape of river network as the sample of selection of channels. As to these shape of channels, besides density, order, the key parameters are angle, distance between neighbor Channels, and the rate of left branches and right branches.

3.3 Drainage generalization model

Figure 5 is the model of parallel drainage generalization(selection), first, deciding the drainage structure, second, computing the generalization parameters, third, selecting the unit and selection index, in the end, through evaluating the selection, modify the selection index, then optimum the index and weight.

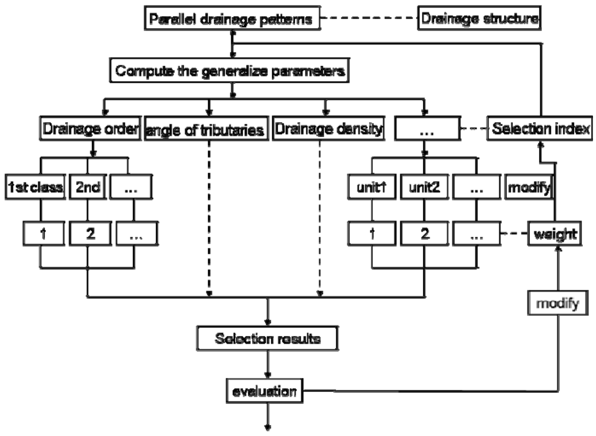

Figure 5. Drainage order

4. DRAINAGE SELECTION APPLICATION

4.1 River network and basin extraction

We choose Nujiang basin as the experiment area. In Nujiang basin, the whole structure of drainage is Parallel drainage patterns. Under different scale, the abstraction parameters are different. In this paper, we choose the scale of the abstraction is from1: 250 000 to 1:1 000 000. DEM resolution is 90 meter. First, we should pre-processing the DEM and the reference drainage (scale is 1: 250 000) before the extraction, such as filling the hole of DEM and dual-line drainage to centred- line, etc. In figure 6, from three units, we choose unit 1 as the generalization unit.

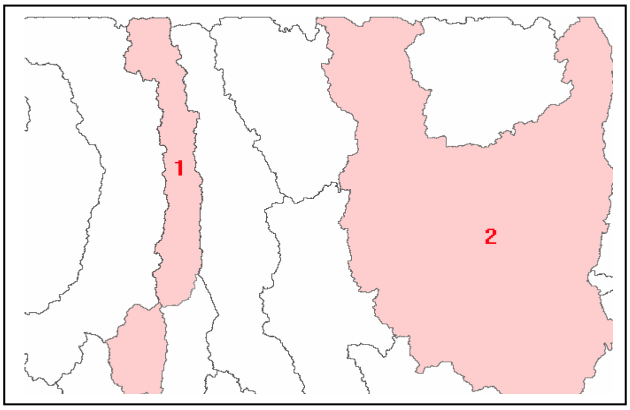

Figure 6. Unit of generalization (unit1, 2, 3)

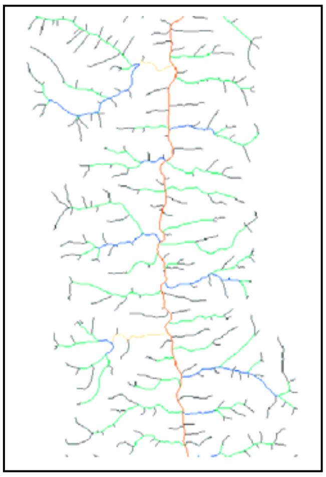

Figure 7. Drainage order

Figure 7 is the Strahler order of the selection unit. The drainage in this unit is classified 5 classes.

4.2 Parameters determination

After extracting and ordering the drainages and the basins, the next step is to maintain the structure of the Nujiang River; here we choose three parameters as the abstract parameters which are drainage density, drainage length and the angle of the tributaries.

Why we choose these parameters as the abstraction parameters is because that drainage density is a measure of runoff potential and degree of landscape dissection. The drainage length, the angle of the tributaries can also reflect the structure of the drainage. The drainage pattern is influenced by geology (permeability, erodibility of surface materials), climate (precipitation and vegetation), slope, and time. Therefore we choose these three parameters as the basis of the abstraction. Through these parameters, summarize the selection rules in different region, it is to say, the selection rules with different river network pattern. It can be the basement of river generalization. The pattern of Nujiang basin is parallel, thus, here we choose three parameters as the abstract parameters which are drainage density, drainage length and the angle of the tributaries.

4.3 Selection results

According to selection model of above three parameters obtaining from DEM, the generalization(selection) results of unit 1 are in figure 8 and figure 9.

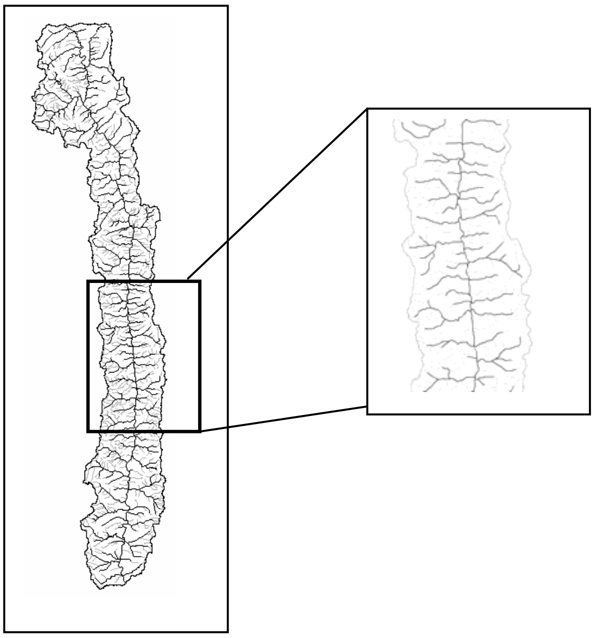

Figure 8. The Selection and Reference Drainage

In figure 8, grey line is 1:250 0000 reference drainage, black line is the selection consequence. In figure 9, grey is the 1:1 000 000 drainage database, the black line is the abstraction drainage.

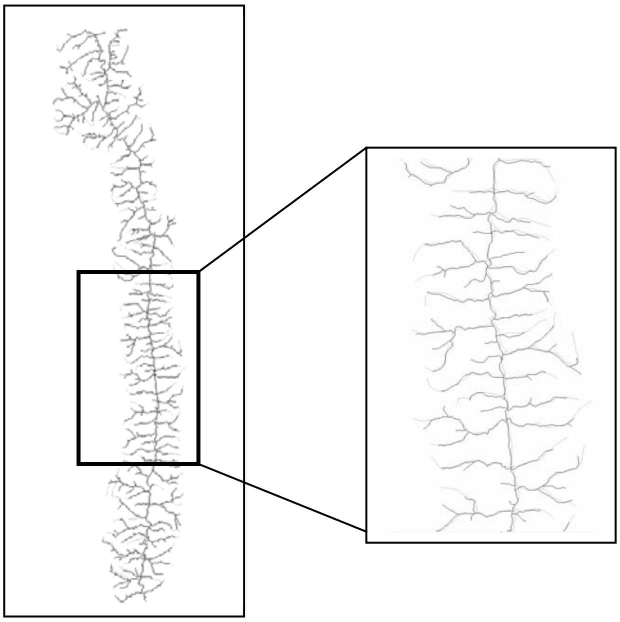

Figure 9. The Selection Results

5. DISCUSSION AND CONCLUSION

This study focuses on drainage generalization deriving from Digital Elevation Model which can supplement the geographical information. From above experiments, this method is an effective method for parallel drainage generalization. There are also some problem to be solved, here we only choose one pattern in some areas as the experiment pattern, do more and more experiments with different pattern in more and more areas and improving our method is the work in the future.

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