INCREMENTAL CONTOUR FUSION BASED ON LINE/LINE TOPOLOGICAL RELATIONS

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KEY WORDS: Incremental Updating, Line/line Topological Relations, Characteristic Object, Local Contour Fusion.

ABSTRACT:

Incremental contour fusion plays a very important role in updating topographic database. The most popular fusion methods in current use depend on manual work basically, in which it results in large workload, low efficiency and it can't ensure the quality of the spatial data. Therefore, the automatization of contour fusion should be developed exactly. Topological relation between unchanged contour and changed one is an important topic for contour fusion. In this paper, a new approach based on whole object is pursued to compute the binary topological relationship between them, in which "FL Points" are introduced, intersection and difference operators are selected from set operators to distinguish the topological relations between neighboring spatial line objects; three types of topological invariants are used for the computational results of set operations: contents, dimension and connectivity-number. Then 14 fusion rules are concluded and a prototype system for automated fusion is implemented. The proposed approach is examined to be reasonable and practicable by real and simulated experimental data.

1. INTRODUCTION

Incremental updating of contour means local contour fusion when the local terrain changed, as well as the core topographic database is updated when any geometric or semantic changes occur, and that the changes are recorded, the updating process can be tracked, the updates are provided successively to users. It is understandable that out-of-date maps might not be as useful as they should be: they need to be updated frequently. Indeed, frequent updating of map data has become a huge task for national mapping agencies. Incremental updating is a reasonable and efficient way to update [Cooper & Peled, 2001; ZHOU, et.al, 2004; CHEN, et.al, 2007]. Topographic database's updating is an important content of updating of spatial database. Furthermore, the contour is one of the most important components of topographic database, and hence incremental updating of contour is increasing of importance.

Existing methods of contour fusion are often incapable of updating topographical database, which depend on manual work basically and force the users to reduce the problems manually in order to adapt them to the capabilities of the methods. In the process of these methods, many departments should constantly detect the changes of geomorphic features in the real world, determine incremental contour and update the topographic database. The process generally involve more or less: 1) Collecting elevation points of the local area which has been changed.2) Mapping local contours manually or automatically according to topographical character by experienced surveyors.3) Disposing the original and new contours by deleting disappeared ones, modifying changed ones and publishing the redundant components .4) Connecting and fusing the new and original contours by the manipulation such as curve fitting, etc. Such a process is costly, time consuming, large workload, difficult to update, and not efficient and practical. It is also difficult for the application to ensure the quality of the spatial data and hence cannot be fully converted into a form suitable for automatic processing. Moreover, there is lack of systemic and further research and analysis on change situation of geomorphy and it's impact on incremental updating of spatial database, as well as the automatic (or semi- automatic) method of incremental contour fusion in international. Therefore, the way to overcome this weakness is, in principle, urgent and clear: developing the method of automatization(or semi- automatization) of contour fusion exactly. Our study in this paper aims to automate the process of contour fusion.

Since the topographic change is mostly local, only a few objects involved in a local area need to be updated one time, the method of reconstructing entire contours is unnecessary; furthermore, according to the manual fusion process we have mentioned above, we can clearly find that the unchanged contour correlates to the changed contour which has the equal elevation value. These two kinds of contours have many topological relations (in Fig.1, *L* denotes unchanged one and *L'* means changed contour).

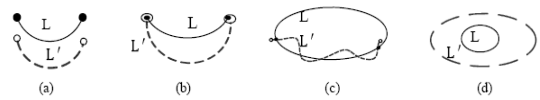

Figure. 1Example: Topological relationship between unchanged and changed contour

As Figure 1 (a) shows, *L* and *L'* are unclosed lines; *L* disjoints *L'*; we can't determine the fusion operation in the updating process. In Figure 1 (b), *L'* replaces *L* in the fusion process because *L'* crosses *L* in the first and last point of intersection. As illustrated in Figure 1 (c), many points of intersection exist; among them, the first point and last point of intersection where *L'* and *L* are split can be determined. And then, *L'* is split into three components and *L* is split into two parts at one time. Thereby, we can determine the fusion operation. In Figure 1 (d), *L'* contains *L*, the fusion operation is that *L'* replaces *L*. Thus it can be seen that topological relations between the two kinds of contours correspond to the relevant fusion operation. Topological relation between unchanged and changed contours which have the equal elevation value plays a very important role in contour fusion. Apparently, we can relate the topological relations between contours with contour fusion facilely, thus it is a valid way to realize automatization(or semi- automatization) of contour fusion based on contour topological relations.

The rest of the paper is structured as follows: in Section 2, the relevant definition and topological relations' computation are presented. The fusion rules based on the results of topological relationships' computation are presented in section 3. Section 4 is the experimental results. The conclusion is given in section 5.

2. TOPOLOGICAL RELATIONS BETWEEN UNCHANGED AND CHANGED CONTOUR

2.1 Calculation of topological relation between contours

Currently, many studies have been conducted on topological relation between contours [QIAO, et.al, 2004; LIU, et.al, 2004]. In these methods, contour relation can be divided into two kinds, i.e. enclosure and adjacent. However, the approach used in these works analyzed the simultaneous contour relations, didn't consider the time factor.

In the former, a spatial object is represented in terms of the set of its components, and relations are described and determined by the combinatorial relations of those components. In the latter, the spatial relations between spatial objects are described and determined by the interaction between whole bodies of these objects instead of their components [Egenhofer & Franzosa, 1991; LI & ZHAO, 2002]. The most fundamental one is the 4-intersection model [Egenhofer, et.al, 1991], making use of the interior and boundary of a spatial object. Later, this model was extended to a 9-intersection model [Egenhofer, et.al, 1993] which also has a fundamental deficiency. The 9-intersection model was later modified by CHEN [2001], in which the exterior of a spatial object replaced by its Voronoi region. Other related researches included the whole-based approach [Randell, et.al, 1992], and the integration of whole-based and Voronoi region approach [LI & ZHAO, 2002]. Unfortunately, most of these models are limited to describe and determine the contour topological relation in the process of fusion. Moreover, these models didn't consider the time factor either.

The computation approach of topological relations based on Euler-number was developed by ZHOU [2006, 2007], in which a spatial object was treated as a whole object, as well as intersection and difference operators were selected from set operators to distinguish the topological relations. In this method, almost possible topological relations between lines in the real world, i.e. 50 kinds of topological relations between simple lines ,12 kinds of relations between loop line and simple line, and 5 kinds of relations between loop lines, are described and determined. In deed, it is essential to consider time factor for distinguishing topological relations between asynchronous objects, i.e. objects before change and after change. However, the deficiency of Euler number-based approach in contour fusion is shown in a critical example (in Figure 2). Using Euler-number based method, the result is $[02，11，11]^{-1}$ in figure 2(a),while the result is $[03，12，12]^{-1}$ in figure 2(b).Since the result is different, we should take unlike operation in the fusion process. Nevertheless, the same operation, i.e. *L'* replacing *L*, should be adopted here. Hence, in order to calculate and determine the contour topological relation in the process of contour fusion, the additional character objects should be introduced.

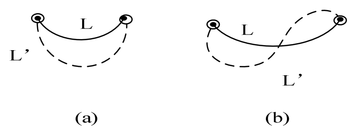

Figure. 2 Example：contour fusion can't be fitted by the result of whole objects' intersection and difference

2.1 Topological relationship calculation between contours after introducing "FL Points"

For convenience of discussion and calculation the relationship between contours, we make some definitions as follows.

Definition 1: Topological relations between unchanged and changed contour can be classified as two groups according to topological character and elevation property:

(1) Contains

One contour after change lies in the area of another after changes, we define the topological relations between them as contains. As Figure 3 shows, if L_1 and L_2 are both contours after change, the topological relation between them is contains.

(2) Parataxis

The elevation values of one or more contours in the original map are equal to the contour after change, while their topological relations are parataxis. The topological relations between them are defined as parataxis. As Figure 3 shows, the topological relation between L_1' and L_1 is parataxis. The relation between L_1' and L_3 is also parataxis.

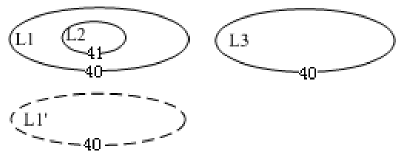

Figure. 3 The definition of topological relationships between closing contours

Definition 2: Correlative contours

L' (i.e. contour after change) and *L* (i.e. contour before change) intersect and they have the equal elevation value. We call that *L'* correlates to *L*. If *L'* and *L* don't intersect and their topological relation is parataxis, we also call *L'* correlates to *L*.

Definition 3: FL Points

It is assumed that *L* is an contour before change, while *L'* is a contour after change which correlated to *L*, *S* is intersection points in sequence, P_1 and P_2 are the *first* and *last* element in S. We suppose that an equation, i.e. $P= \{P_1，P_2\}$, and then *P* is called "FL Points" (as shown in Figure 4).

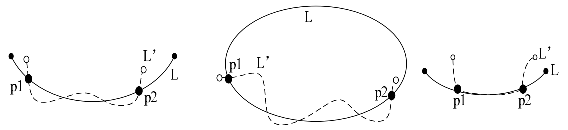

Figure. 4 The definition of FL points if the count of intersection points exceeds 1

During the process of contour fusion, we can clearly find that only two points of intersection, i.e. the first and the last point in set of points of intersection, are acted on contour fusion. Therefore, "FL points" which have been defined above is essential in our study. Now, let us take an example (as Fig.5

shows) to illustrate the method of seeking "FL points". L_1 denotes a polyline, as well as we assume that A is the starting node. L_1 is broken into several simple line segments, i.e. line segment from A to B, etc., in queue with the starting point A. Then judge the points of intersection in every simple line segments in turn. In Figure 5, line segment from A to B in which the intersection point exits has the smallest sequence number toward point A. The first point of "FL Points", i.e. point d_1 which has the nearest distance toward point B (point B is the starting node in line segment from B to C), can be determined. Similarly, we also can find the last point of "FL Points", i.e. point d_2 which has the nearest distance toward point D (point D is the end node in line segment from C to D).

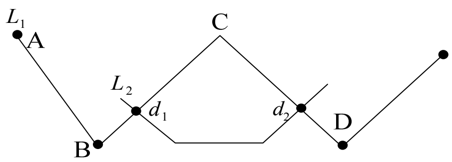

Figure. 5 The process of searching "FL points"

Some set operators, such as union, intersection, difference, difference by, symmetric difference, etc, have been utilized in judging spatial relations [LI & ZHAO, 2002; ZHOU, et.al, 2006]. Among them, intersection operator is the most important to use for the determination and description of spatial relations, mainly topological relations. In fact, the content of intersection can easily distinguish the contour topological relations (i.e. disjoint, and meet). However, some relations may be easily distinguished by the difference operator which can reflect the difference in size between objects but not by intersection. In this study, only the intersection together with difference operators are utilized, meanwhile according to the character of contour fusion, "FL points" we have defined above is taken into account. In addition, the value of the results of set operators can take three different forms: content, dimension, and the number of connected components. Mathematically, the value of each element in the operator set ,if f is a function to take dimension, donated by f_D, while if f is a function to take the number of connected components, donated by f_N. Meanwhile, if the result of set operators consists of multiple parts, then the highest dimension should be used for the value of f_D. Since contour in this paper is considered as line object, the content as well as dimension of $L'\backslash P$ and $L\backslash P$ is nothing but 1, they can be omitted. Then, the contour topological relation between contours L' and L can be represented by Eq.(1) where "∩","\",P representing intersection, difference and "FL points". As Eq.(1) illustrated, *Content* is a quality measure: either empty or non-empty. *Dimension* is a quantitative measure, i.e. either 0-dimension (point) or 1-dimension (line). For the case of "empty", the number of (-1) is used to denote dimension. Calculating the value of $f_N(L'\cap L)$, in the case of "empty", the number of (-1) is usually used, otherwise, the number could be any integer larger than 0.Apparently,the value of $f_N(L'\backslash P)$ and $f_N(L\backslash P)$ should take three numbers: 1,2,and 3.

$$R(L',L)=\begin{bmatrix} f_D(L'\cap L), f_N(L'\cap L) \\ f_N(L'\backslash P),\ f_N(L\backslash P)\end{bmatrix} \quad (1)$$

Equation (1) can be regarded as a simple spatial algebra for the description of contour topological relations. According to it, the contour topological relations between L' and L can be calculated as follows (the logical flow chart is illustrated in Figure 6):

1) Judge L' or L ,if either of them is null, dispose the next contour.
2) Calculate the value of $f_N(L'\cap L)$.If the result is 0, we can determine their relation is disjoint. Otherwise, calculate the value of a (Let a denote content as well as dimension) and b (b represents the number of connected components).
3) Calculate the value of m (m denotes the result of $f_N(L'\backslash P)$) and n (n represents the result of $f_N(L\backslash P)$).

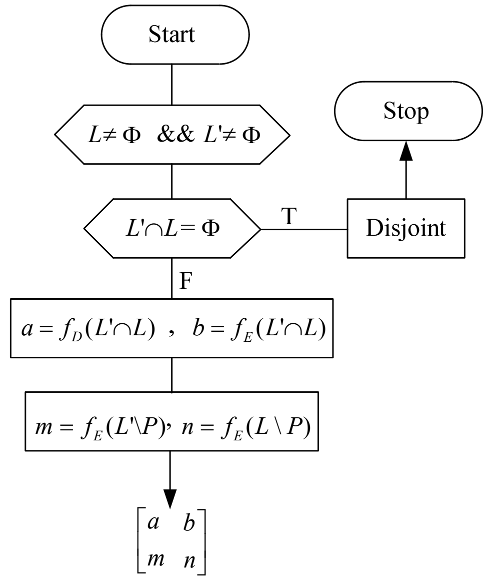

Figure.6 Logical flow chart of topological relationships' computation between contours based on FL points

3. RULES FOR LOCAL CONTOUR FUSION BASED ON LINE/LINE TOPOLOGICAL RELATIONSHIPS

During further research, we can clearly find that relations between contours can be classified as two groups, i.e. closed and open ones. According to the characteristic of contour fusion, fusion condition is divided into two types, i.e. closed contour and open contour. It is assumed that L is an contour before change, L' is a contour after change which correlated to L, P_1 and P_2 are FL points, is the line between P_1 and P_2 in L', $L'^{E}_{p1p2}$is the line except L'_{p1p2} in L', L_{p1p2} is the line between P_1 and P_2 in L, L^{E}_{p1p2} is the line except L_{p1p2} in L. Then deleting objects can be denoted as "*Delete*". Adding and combining the line objects can be denoted as: "*AddCombine*"."*WaitDeal*" means not deal at present because of the insufficiency of fusion condition.Closed and open contours are respectively denoted as: "*CloseContour*" and "*OpenContour*". "*Parataxis*" means the relationship between contours is parataxis. The relationship of containing is denoted as "*Contains*".

3.1 Rules for closed contours after change

According to further analysis, the rule is same in this condition whether the contour before change is closed or not. There are two cases, and the rules are as follows.

Rule 1: if (CloseContour(L') = true and $f_N(L'\cap L)$ = -1 and Parataxis(L',L)=true) then (WaitDeal(L',L))

Rule 2: if (CloseContour(L') = true and (($f_N(L'\cap L)$ = -1 and Contains (L',L)=true) or ($f_N(L'\cap L) \geq$ 01))) then ((Delete(L)

and AddCombine(L'))

3.2 Rules for open contour after change

3.2.1 Contour object L is open

There are two types according to the number of points of intersection:

(1) When $f_N(L'\cap L) = -1$ (i.e. there is no intersection between L' and L in Figure 7(a)) or $f_N(L'\cap L) = 01$ (Figure 7(b)), the rule is:

Rule 3: if (CloseContour(L') = true and OpenContour(L) = true and (f_N $(L'\cap L)$ = -1or f_N $(L'\cap L)$ = 01)) then (WaitDeal(L',L))

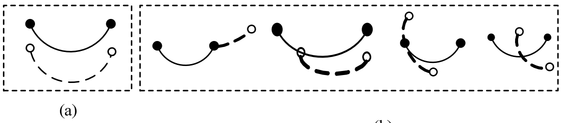

Figure 7 Two cases when $f_N(L'\cap L) < 02$

(2) When $f_N(L'\cap L) \geq 02$, there are two points in "FL Points". Since the value of $f_N(L'\setminus P)$and $f_N(L\setminus P)$ can only take three numbers:1,2 and 3; there exists 9 (i.e. 3×3=9)types:

A. When $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 1$, as shown in Figure 8, the rule is:

Rule 4: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 1$) then (Delete(L) and AddCombine(L'))

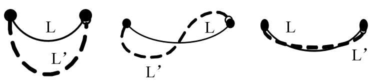

Figure 8 The case when $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 1$

B. When $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 2$ (in Figure 9),

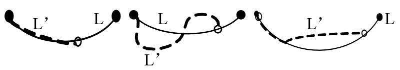

Figure.9 The case when $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 2$

C. When $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 3$ (in Figure 10),

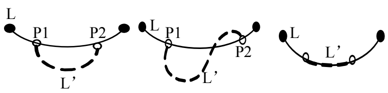

Figure.10 The case when $f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 3$

The two cases (i.e. B and C) can be judged by the same rule:

Rule 5: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and ($f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 2$) or ($f_N(L'\setminus P) = 1$ and $f_N(L\setminus P) = 3$)) then (Delete(L_{p1p2}) and AddCombine(L', L^E_{p1p2}))

D. When $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 1$ (Figure 11), it can be judged by the follow rule:

Rule 6: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 1$) then (Delete(L) and AddCombine(L'_{p1p2}))

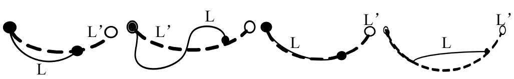

Figure.11 The case when $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 1$

E. When $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 2$ (Figure 12),

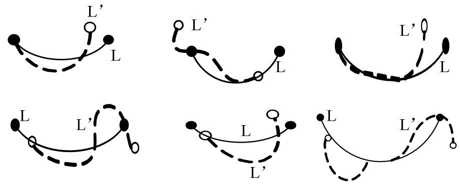

Figure 12 The case when $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 2$

F. When $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 2$ (Figure 13),

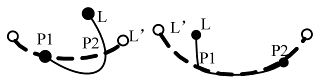

Fig.13 The case when $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 2$

These two cases (i.e. E and F) can lead to:

Rule 7: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and (($f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 2$) or ($f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 2$))then (Delete(L_{p1p2}, L'^E_{p1p2}) and AddCombine(L^E_{p1p2}, L'_{p1p2}))

G. When $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 1$ (Figure 14), the case can be judged by the rule:

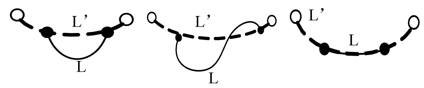

Figure 14 The case when $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 1$

Rule 8: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 1$) then (Delete(L, L'^E_{p1p2}) and AddCombine(L'_{p1p2}))

H. When $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 3$ (Figure 15(a)),

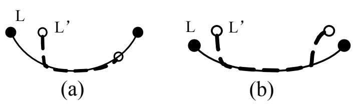

Figure 15 Two cases when $f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 3$ and $f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 3$

I. When ($f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 3$ (Figure 15(b)),

The two cases (i.e. H and I) can be judged by the same rule:

Rule 9: if (CloseContour(L') = true and OpenContour(L) = true and $f_N(L'\cap L) \geq 02$ and (($f_N(L'\setminus P) = 2$ and $f_N(L\setminus P) = 3$) or ($f_N(L'\setminus P) = 3$ and $f_N(L\setminus P) = 3$)) then (Delete(L') and AddCombine(L))

3.2.2 Contour object L is closed

There are two types:

(1) When $f_N(L'\cap L) = -1$ (i.e. there is no intersection between L' and L in Figure 16(a)) or $f_N(L'\cap L) = 01$ (as shown in Figure 16(b)), the rule is:

Rule 10: if (CloseContour(L') = true and CloseContour(L) = true and (f_N $(L'\cap L)$ = -1 or f_N $(L'\cap L)$ = 01)) then (WaitDeal(L',L))

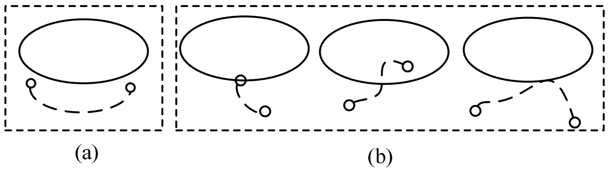

Figure.16 Two cases when $f_N(L'\cap L) < 01$

（2）When $f_N(L'\cap L) \geq 02$, there are two points in “FL Points”. Because L’ is open and L is closed, the values of $f_N(L' \backslash P)$ can only take three numbers: 1, 2 and 3; as well as the value of $f_N(L \backslash P)$ take the number: 2. There exist 3 (i.e. 3×1=3) types:

However, it is difficult to judge L’ combining with the top or bottom of L when $f_N(L'\cap L) = 02$, as illustrated in Figure 17(a). Hence, we should dispose this case separately and there are three types:

① When $f_N(L' \backslash P)= 1$ and $f_N(L \backslash P) = 2$, the rule is:

Rule 11: if (CloseContour(L') = true and CloseContour(L) = true and $f_N(L'\cap L) = 02$ and $f_N(L' \backslash P)= 1$ and $f_N(L \backslash P) = 2$) then (WaitDeal(L',L))

② When $f_N(L' \backslash P)= 2$ and $f_N(L \backslash P) = 2$ (Figure 17(b))

③ When $f_N(L' \backslash P)= 3$ and $f_N(L \backslash P) = 2$ (Figure 17(c))

The two cases (i.e. ② and ③) can be judged by the following rule:

Rule 12: if (CloseContour(L') = true and CloseContour(L) = true and $f_N(L'\cap L) = 02$ and ($f_N(L' \backslash P)= 2$ and $f_N(L \backslash P) = 2$）or ($f_N(L' \backslash P)= 3$ and $f_N(L \backslash P) = 2$)) then （Delete(L'^{E}_{p1p2}) and WaitDeal(L'_{p1p2} ,L))

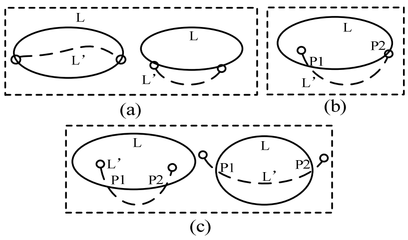

Figure. 17 Three cases when $f_N(L'\cap L) = 02$

When $f_N(L'\cap L) \geq 03$, the three types are as follows:

① When $f_N(L' \backslash P)= 1$ and $f_N(L \backslash P) = 2$ (Figure 18(a)), it can be judged by the rule:

Rule 13: if (CloseContour(L') = true and CloseContour(L) = true and $f_N(L'\cap L) \geq 03$ and $f_N(L' \backslash P)= 1$ and $f_N(L \backslash P) = 2$) then (Delete(L_{p1p2}) and AddCombine(L', L^{E}_{p1p2}))

② When $f_N(L' \backslash P)= 2$ and $f_N(L \backslash P) = 2$ (Figure 18(b))

③ When $f_N(L' \backslash P)= 3$ and $f_N(L \backslash P) = 2$ (Figure 18(c))

The two cases (i.e. ② and ③) can be judged by the same rule:

Rule 14: if (CloseContour(L') = true and CloseContour(L) = true and $f_N(L'\cap L) \geq 03$ and ($f_N(L' \backslash P)= 2$ and $f_N(L \backslash P) = 2$) or ($f_N(L' \backslash P)= 3$ and $f_N(L \backslash P) = 2$)) then (Delete(L_{p1p2}, L'^{E}_{p1p2}) and AddCombine(L'_{p1p2}, L^{E}_{p1p2}))

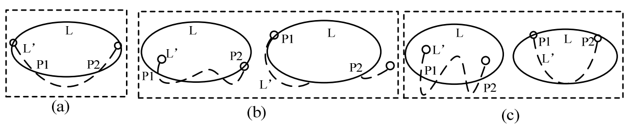

Figure.18 Three cases when $f_N(L'\cap L) > 02$

Contours are divided into closed ones and unclosed ones, as to each type, the values of $f_N(L'\cap L)$exist three probability: -1,1 and any integer larger than 1,while the value of $f_N(L' \backslash P)$ together with $f_N(L \backslash P)$ can take three numbers:1, 2 and 3. Apparently, through combining these different values, the possible types of contour can be presented and described. Based on the result of topological relationships’ computation presented above, we can determine the possible types of contour in fusion process. The sketch of fusion and its disposing process are presented in detail. A particular logical flow chart of local contour fusion is concluded based on the fusion rules. And then, introduced into the operation function of contour fusion we defines, 14 fusion rules are concluded in this paper and almost probability of the contour types in fusion process was considered in these rules.

4. EXPERIMENT

4.1 Logical flow of local contour fusion

The contour fusion is the process to match the calculated contour relations and the pre-defined rules. Whenever a rule is violated, a contour is fused. First, we should map local contours according to topographical character, and then compare the calculated contour topological relationship with the rule defined in this research. If they are matched, then a contour fusion is implemented. The detailed fusion process is illustrated in figure 19.

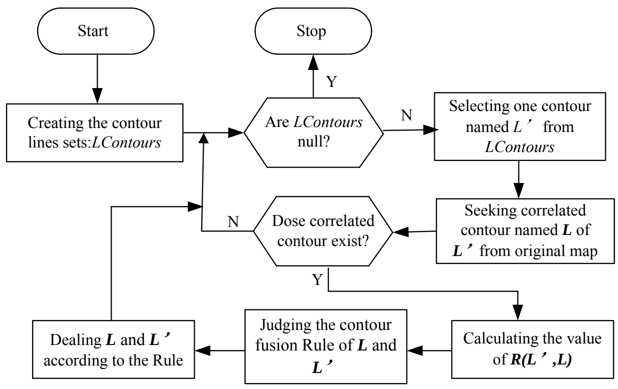

Figure. 19 Logical flow chart of local contour fusion

4.2 Experimental result

The approach of calculation relations between contours was implemented using VC++ on the platform of MapX to examine the methods and models presented in this paper. As figure 20 (coarse line denotes contours before change and fine line denotes contours after change) shows, it is the validating of calculation relations between contours, while Figure 21 shows the result of fusion.

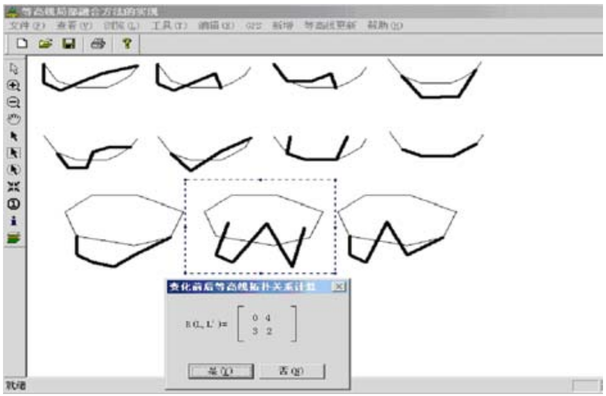

Figure 20 Decision of topological relations between contours

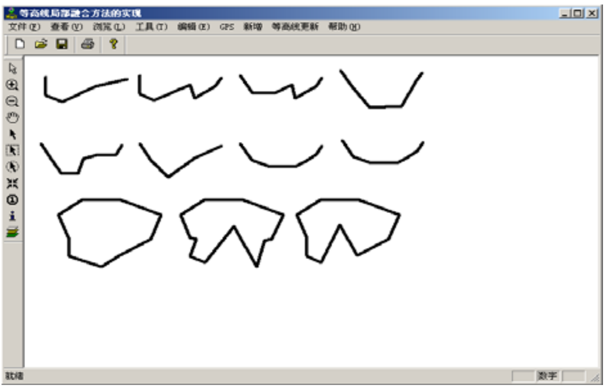

Figure 21 Decision of contour fusion

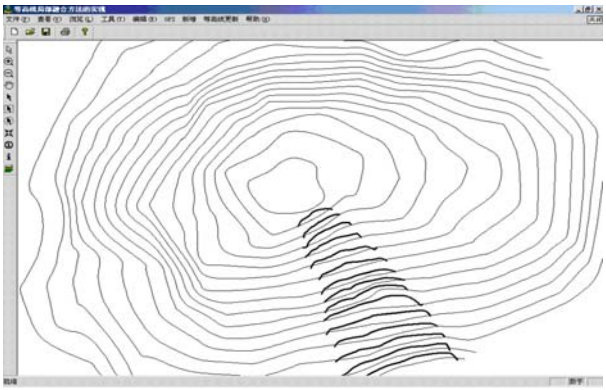

Figure 22 The data of test

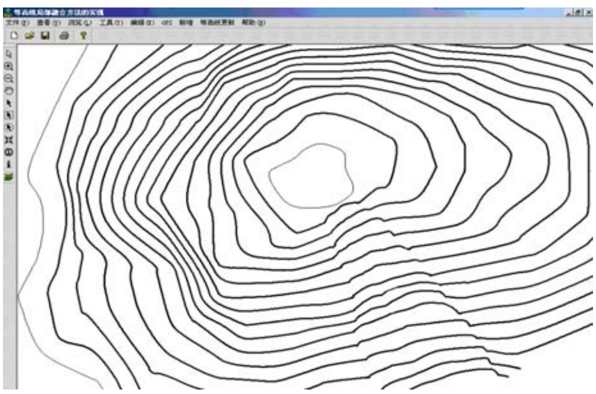

Figure 23 Decision of local contour fusion

In addition to examining the practicability and accuracy of automatic (or semi-automatic) incremental contour fusion, real and simulated experimental data is essential in our research. As an experiment, using the contour data in installation file of Cass6.1 as original contours which were expressed in broad line in Figure 22, as well as simulating 56 local elevation points relative to original contours in order to create local contours which were expressed in fine line in Figure 22 on the platform of Cass6.1,it was reasonable, and then 15 changed local contour data which was transformed into tab format as well as was expressed in fine line in Figure 22 was employed in our experiment. Experimental results (as Figure 22 shown) showed the reasonability and practicability of the contour fusion approach presented in this paper.

5. CONCLUSION

In this paper, we have analyzed topological relationship between changed and unchanged contours. A new topological relationship's computation approach which characteristic object called "FL points" is pursued to compute the binary topological relationship between corresponding contours. The particular computation formula and logical flow chart of topological relationships' computation between contours are introduced. According to the result of topological relationships' computation between corresponding contours, we can determine the fusion operation , and then introduced into the operation function of contour fusion we defines, 14 fusion rules are concluded in this paper. As to each rule, the sketch of fusion and its disposing process are presented in detail, and a prototype system for automated fusion of changed and unchanged contours has been implemented. Real and simulated experimental data has validated the reasonability and practicability of the incremental fusing method presented above.

Further research will be conducted on developing the calculation methods of topological relationship between complex objects, integrating topological calculation approach with practical application system, as well as improving the automatization of related system.

ACKNOWLEDGMENTS

This research was supported by the National Natural Science Foundation of China under grant (No. 40571122 and No. 2004009) and the National Science & Technology Pillar Program (No. 2006BAJ09B0601).

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