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Quality Check in Urban and Rural Cadastral Spatial Data Updating

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Abstract. Cadastral spatial databases quality control and maintenance is a key issue in construction and updating cadastral information systems. The quality of cadastral spatial data includes position accuracy, attribute accuracy, and topological consistency. In this study, different types of topological inconsistency in cadastral spatial data are analyzed, such as node mis-matching, crack, and superposition between cadastral parcels. Methods were developed to check and modify cadastral spatial data.

Keywords: cadastral, topological relationships, spatial data quality, check, modification

1. Introduction

Cadastral is a book that records land basic information such as position, boundary, quantity, quality and property, etc. Nowadays, land resource management conception and mode changed with the development of land management information. Combine with the database technology, computer science, network technology and "GPS,RS,GIS" integration technologies, modern cadastral information system taking cadastral as its object aims at solving data inputting, data indexing, data processing, data storing, decision supporting and result outputting system, whose core is cadastral database. So, the quality of cadastral spatial data is the keystone of feasibility and efficiency of cadastral information system. Spatial data quality control is one of the basic procedures in urban cadastral information system and becomes a hot research in spatial accuracy assessment. The quality of cadastral spatial data includes position accuracy, attribute accuracy and topological consistency. In this paper, the types of topological inconsistency in cadastral spatial data are analyzed, such as node mismatching, crack and superposition between cadastral parcels. Then the corresponding method is used to check and modify the cadastral spatial data.

2. Cadastral spatial data

Cadastral spatial data integrative and seamless management between urban and rural is the requirement of "modern cadastral". The model of urban and rural cadastral management is:

City-District (country)-Street(village, town)-Lane-Cadastral parcel

Cadastral parcel is the minimal management unit of cadastral (as fig.1 shows).

1. Boundary spot: Boundary spot is the inflexion of cadastral parcel boundary line which confirms the property and geography position of cadastral parcel. There are two types of boundary spot in cadastral information system: One is node of the boundary line, such like spot 2,4,6,8,10,etc,in fig.1; Another is shape point of the boundary line, such like spot 1,3,5,7,etc,in fig.1;
2. Boundary line: Boundary line is the division of parcel ownership unit which is the line between boundary spots in cadastral map, such like line 1-2-3,1-9-10-11,etc,in fig.1; There are two types of boundary line in cadastral information system: One is simple boundary line; Another is circlewise boundary line.

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3. Cadastral parcel: Cadastral parcel is the basic unit of cadastral. Cadastral parcel is a polygon which closed by boundary line, such like polygon 025-015-0010-0004-00001, 025-015-0010-0004-00002, etc., in fig.1.

Boundary spot, boundary line and cadastral parcel are the basic components of cadastral. Cadastral parcel locates by boundary lines, and boundary line locates by boundary spots.

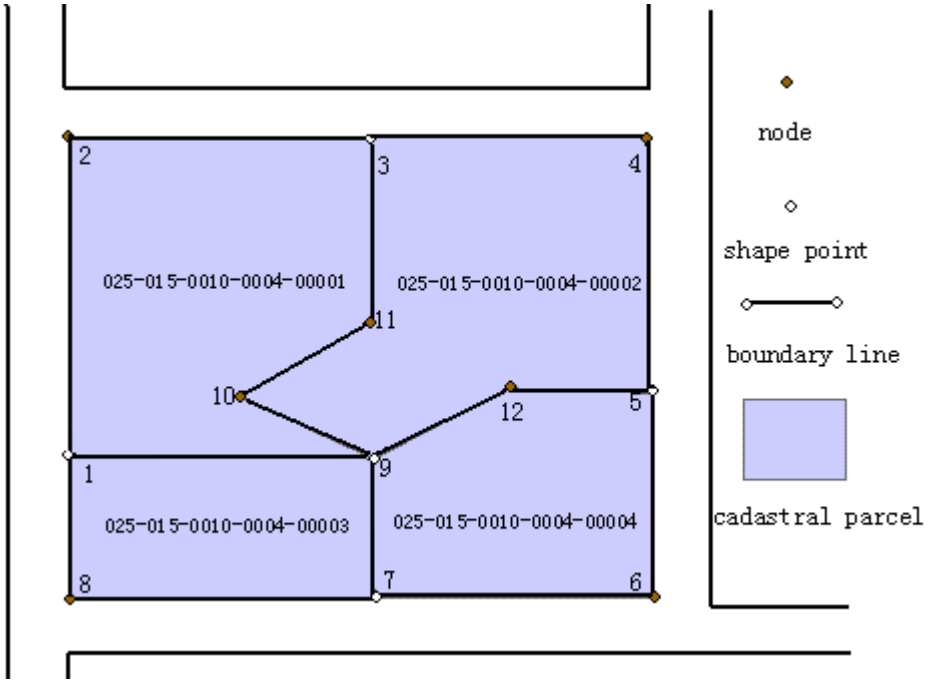


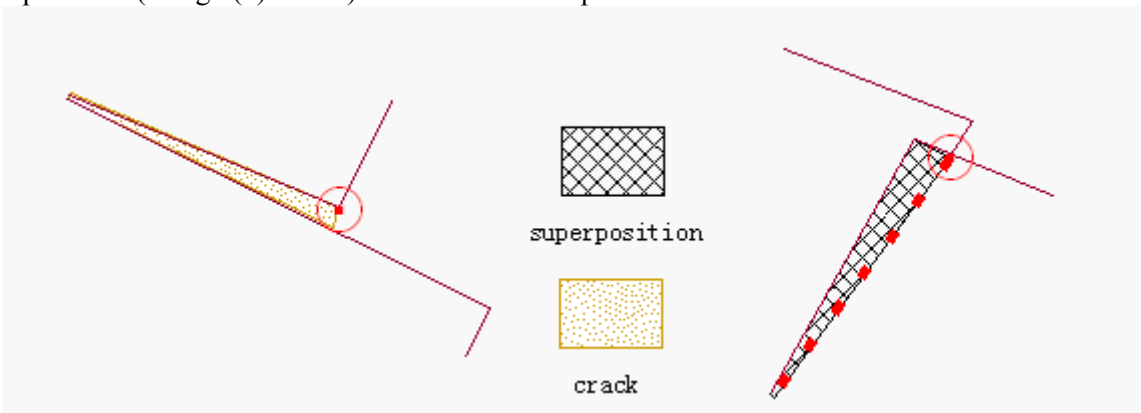
Fig.1: Component of cadastral

3. Topological relationship of cadastral spatial data

Topological relationship is topology invariant when topological variations of spatial data. The topological relationship of cadastral parcel is the relationship of boundary spot, boundary line and cadastral parcel, such like disjoin, meet, in, cover, overlap, etc. There are some topological characteristics of boundary spot, boundary line and cadastral parcel.

1. The topological relationship of cadastral parcels are only disjoint and meet.
2. The topological relationship of cadastral parcel and boundary lines are only disjoint, meet and cover.
3. The topological relationship of boundary lines are only disjoint and meet.
4. The topological relationship of boundary spot and cadastral parcel are only disjoint and meet.

Cadastral parcel has a characteristic of "bespread" which comply with subdivision principle. So, there is no superposition and crack between parcels (as fig.1 shows). But, the illegibility of cadastral property and incorrectness method of cadastral map digitalization, there are cracks (as fig.2(a) shows) and superimpositions (as fig.2(b) shows) between cadastral parcels.



(a)cadastral crack (b)cadastral superposition

Fig.2: Superimposition and crack cadastral parcel

It is necessary to check and modify the superimpositions and cracks using appropriate methods for complying with the characteristic of "bespread" of cadastral.

4. Topological consistency checking of cadastral spatial data

Cadastral spatial data quality control and maintain is a keystone and difficulty problem of construction and updating cadastral information system. And, hotspot research mainly focuses on the position precision control and cadastral spatial data topology consistency control. On the position precision control aspect, Nai.Z.L analyzed the relationship between boundary spot and parcel area, and pointed that the precision of boundary spot can be accepted or rejected along with precision of parcel area. On the topology relationship control aspect, Laurini and Thopson considered that "Topology relationship may be the most credible information in cadastral spatial data quality check", and concluded that "There are nine consistency constraint conditions among cadastral spatial objects".

Topological consistency checking is mainly about detection of topology error between boundary spots or boundary spot and boundary line or boundary lines. The error listed below is the most of the topological consistency check of cadastral spatial data: overlap boundary spot, false boundary spot, short suspension boundary line and long suspension boundary line.

4.1. Same boundary spot recognition

Computing the distance(s) between boundary spot 1 and boundary spot 2.

1. If $s < \varepsilon$ (ε is tolerance), then boundary spot 1 and boundary spot 2 are superposition (as fig.3(a) shows);
2. If $s > \varepsilon$, then boundary spot 1 and boundary spot 2 are not superposition(as fig.3(b) shows);

(a)same boundary spot (b)eliminate same boundary spot

Fig.3: Detection for coinciding boundary spots

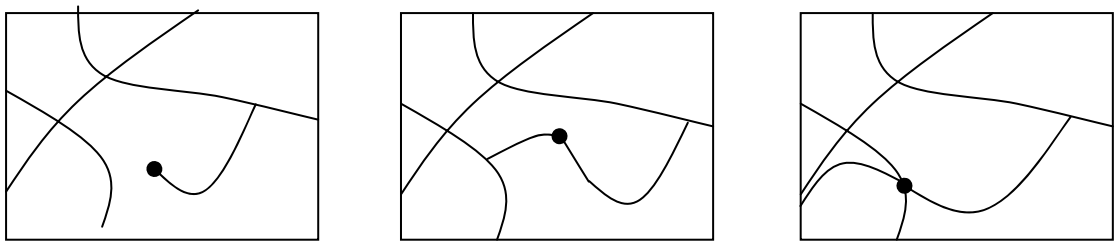
4.2. False boundary spot recognition

Boundary spot has three types: suspension boundary spot, false boundary spot, true boundary spot.

Suspension boundary spot is an end point of a polyline or a line segment that does not superpose with another extreme point of another polyline or another line-segment (As fig.4(a) shows);

False boundary spot is a extreme point of a polyline or a line-segment that superposes with another extreme point of another polyline or another line-segment. And, the two spots are within the tolerance; False boundary spot modification can use topology union to ensure the two spots to meet at a node of a polyline or a line-segment (As fig.4(b) shows).

True boundary spot is a extreme point of a polyline or a line-segment that superposes with another extreme point of another polyline or another line-segment. And, there is only one spot on the superposition (As fig.4(c) shows);



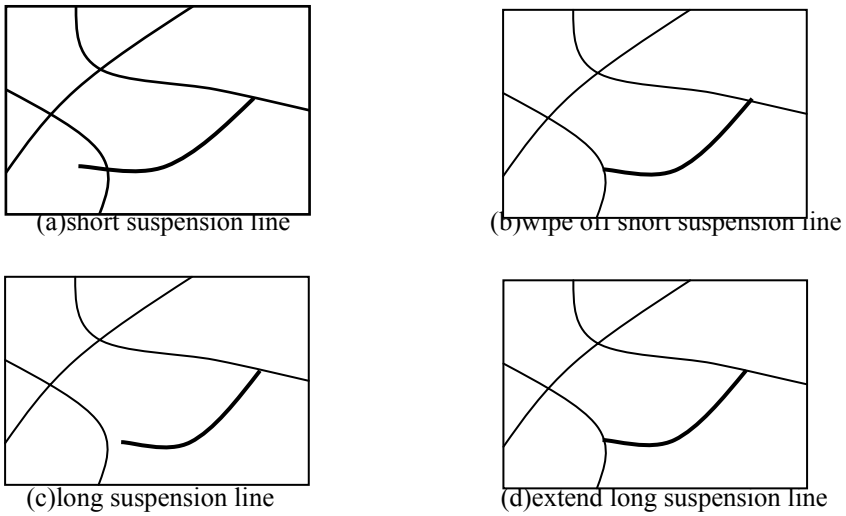
(a)suspension boundary spot (b)false boundary spot (c)true boundary spot

Fig.4: Checking for suspension boundary spots

4.3. Suspension boundary line recognition

Suspension boundary line is a line has suspension spot. And, suspension boundary line has two types: long suspension boundary line and short suspension boundary line. (As fig.5.shows)

Short suspension boundary line is the suspension line that less than the tolerance; Long suspension boundary line is the suspension line that exceed the tolerance. And, when prolonging the suspension line, it can cross another cadastral parcel.



(a)short suspension line (b)wipe off short suspension line

(c)long suspension line (d)extend long suspension line

Fig.5: Suspension boundary lines

5. Topological consistency modification of cadastral spatial data

5.1. Average method

Average method takes the average coordinate of two boundary spots as the new boundary spot p_0 (x_0,y_0) coordinate. As fig.6 shows, boundary spot $p_1(x_1, y_1)$ and boundary spot $p_2(x_2, y_2)$ are the spots that need to be joined.

$$x_0 = \tfrac{1}{2}(x_1 + x_2)$$
$$y_0 = \tfrac{1}{2}(y_1 + y_2)$$

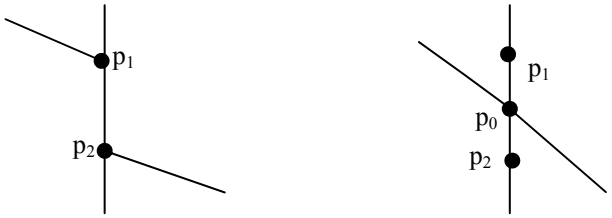


Fig.6: Average method

$$\begin{cases} k_1 = \dfrac{y_3 - y_0}{x_3 - x_0} \\ k_2 = \dfrac{y_0 - y_4}{x_0 - x_4} \\ k_1 = k_2 \end{cases}$$

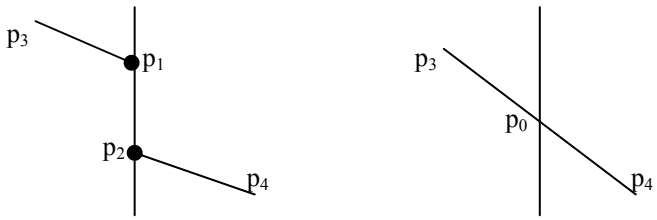


Fig.7: Optimal method

5.2. Optimize method

For the purpose that the new joint line-segments on the same line, we can use optimize method to join the two line-segments. As fig.7 shows, boundary spot $p_0(x_0, y_0)$ is s the new boundary spot that should comply with the principle:

5.3. Distance threshold method

As fig.8 shows, there is a missing boundary spot 1 for the boundary line (AB). There are two conditions that the boundary line has a missing boundary spot:

1. the distance between the boundary spot and boundary line less than the tolerance;

2. the intersection (point 2) between line AB and a line drawn from boundary spot 1 and perpendicular to AB locates between the end points (points A and B) of AB.

Take point 2 as new boundary spot instead of the missing boundary spot 1.

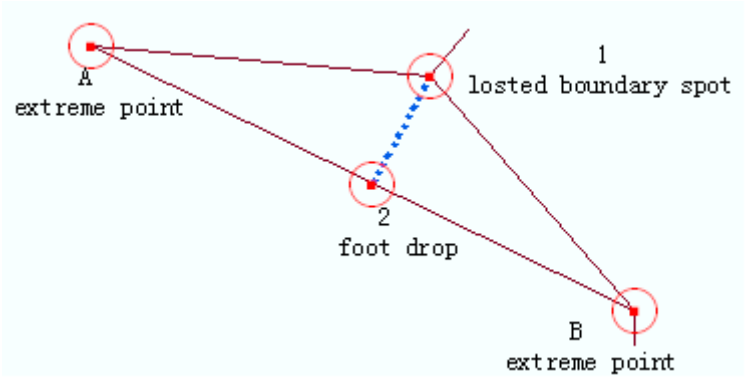


Fig.8: Distance threshold method

6. Experiment and results

This study takes a cadastral map (As fig.9 shows) to experiment whose scale is 1:1000. The cadastral map (redinfo format) contains 400 cadastral parcels. And, there are several types spatial quality problem mentioned above, such like node mismatching, crack and superposition. Using corresponding methods and algorithms, the program found 6 missing boundary spots, checked and modified 17 same boundary spots, 21 false boundary spots, 35 suspension boundary lines in this cadastral map.

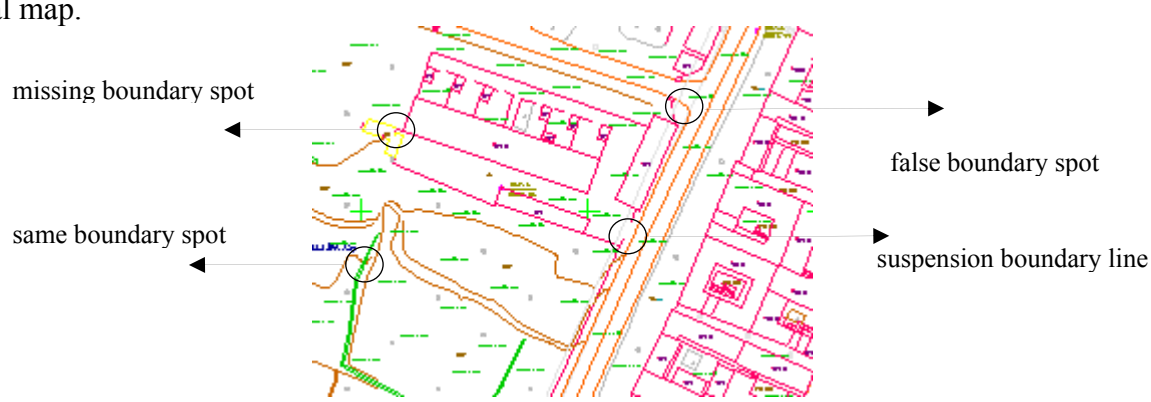


Fig.9: The existed spatial data quality issues in the cadastral map

7. Conclusion and future work

Construction and incremental updating of cadastral database means that the core database is updated when any geometric or semantic changes occur, and then the changes are recorded, the updating process can be tracked. During such a process, a set of editing operations is needed to add, delete or amend cadastral spatial objects, to solve spatial and temporal conflicts problems, maintain spatial and temporal consistency of the records. So far, the updating of core cadastral database is carried out manually and interactively. During this process, a large amount of editing is needed, so the process is an error-prone, labor-intensive and difficult to maintain the topological consistency one. In this study, the types of topological inconsistency in cadastral spatial data are analyzed, such as node mismatching, crack and superposition between cadastral parcels. Then the corresponding method is used to check and modify the cadastral spatial data. Cadastral spatial data quality control and maintain is a keystone and difficulty problem of construction and updating cadastral information system. Further work will continue focus on the precision and efficiency improvement of these methods.

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