Method of Pseudo Update for Building Shape in Road Ledger Digital Map and its Evaluation

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Abstract: - Recently, in the area of GIS (Geographic Information System), lots of researchers are attracted to efficient update of a digital map data. However, its update cost in the conventional methods is not low. Furthermore, in the case of carrying out some works in a municipal government using GIS, the following problem occurs. That is, it is not easy to carry out them because the shape or ‘existence or not’ of a building on a base map of road ledger generated from GIS is not always relevant to its truth. In our discussion, we limit the scope to building shape. Authors have investigated semi-automatic and pseudo update of a building by employing an urban design map which has higher update frequency but less precision than the base map of road ledger. In here, ‘pseudo’ means that we put the major interest to carry out the municipal government works and provide the first priority with the relevance to the truth on the shape or ‘existence or not’ of a building, even if we sacrifice its precision of the map. In the present paper, we propose its concrete method and evaluate it. Our proposition is feasible in both qualitative and quantitative evaluation.

Key-Words: - GIS (Geographic Information System), update, frequency, recall, precision, evaluation, municipal government work.

1 Introduction
The conventional methods in update of digital map include the one which employs newly taken aerial or satellite images. Klang et al. try automatic detections of changes in road database using satellite imagery[1]. Watanabe et al. detect building changes using epipolar constraint from aerial images taken at different positions[2]. Nakagawa et al. propose an algorithm which detects building change by employing aerial imagery and precise 3-D data[3]. Liu et al. detects building change using UltraCamD images which is large format area sensor and existing CAD data[4]. However, the update cost in these methods is not low
mainly due to the data structuring phase from these images[5]. Another direction of the conventional method overlaps the information obtained by a field test to an older map, finds some changes, and updates them[3]. However, if we try to detect all of building changes by the field test, we need lots of time and effort.

Yamazawa et al. try a method which positions a 1/2500 digital map to a base one and update it by employing 1/500 digital one[6]. However, we can not say it is practical, because an update frequency of 1/500 digital map is usually lower than 1/2500 one. If we take into account only the update frequency, it is more practical that we position a 1/500 digital map to a base one, and update it by employing 1/2500 one.

On the other hand, in the case of carrying out some municipal government works such as ‘evaluation of fixed properties tax’, ‘road design’ or ‘route design of water supply’ using GIS, the following problem occurs. That is, it is not easy to carry out them because the shape or ‘existence or not’ of a building on a base map of road ledger generated from GIS is not always relevant to its truth.

Authors have investigated semi-automatic and pseudo update of a building shape by employing an urban design map which has higher update frequency but less precision than the base map of road ledger. In the present paper, we propose its concrete method and evaluate it.

2 Proposition

In our discussion, we employ 1/500 Shape file which is representative for road ledger map, and 1/2500 DM data representative for urban design map. Hereafter, we use the following notations:
- \(1/500 \text{Shape}(t)\): 1/500 Shape file at the time \(t\)
- \(1/2500 \text{DM}(t+dt)\): 1/2500 DM data at the time \(t+dt\)
- \(1/500 \text{Shape}(t+dt)\): 1/500 Shape file at the time \(t+dt\).

We show our proposition of pseudo update process in Fig.1.

2.1 Preprocess Phase

The format of \(1/2500 \text{DM}(t+dt)\) is different from the one of \(1/500 \text{Shape}(t)\). Therefore we put preprocess phase in order to enable to mutually compare each building shape.

2.2 Pseudo Update Phase

We mutually compare each building shape of \(1/500 \text{Shape}(t)\) with the one of \(1/2500 \text{DM}(t+dt)\) in the same area, and determine that it should be updated or not. We update only the buildings which should be updated.

2.2.1 Update pattern of building shape

The paper [5] shows that we can classify update pattern of building shape into seven of the following: appearance, disappearance, mergence, split, size change, shape change, and movement(Fig.2).

We can replace a single ‘movement’ into a ‘disappearance’ and an ‘appearance’ in a translated position. In this paper, we discuss six patterns except for ‘movement’. 
2.2.2 Algorithm of pseudo update

Fig. 3 shows our algorithm of pseudo update. It is update support type which employs user’s judgment. Its aim is to reduce the lost of precision in minimum, and to obtain building shape data as relevant as possible to the truth.

**begin**

calculate each center of gravity $g_i$ in all buildings $BS_i$ ($i = 1, ..., S_{num}$) of $1/500Shape(t)$; calculate each center of gravity $g_j$ in all buildings $BD_j$ ($j = 1, ..., D_{num}$) of $1/2500DM(t+dt)$;

/* Based on the distance between $g_i$ and $g_j$, we carry out the following two classifications.
0: We should delete it.
1: We should keep it.
2: We should defer the decision of deletion or keeping.
0: We should not use it for pseudo update.
1: We should use it for pseudo update and adopt it.
2: We should defer the decision of using or not. */

$e_{500} = 0.25; /* maximum error in 1/500 digital map. Its unit is meter. */$
$e_{2500} = 1.75; /* maximum error in 1/2500 digital map. Its unit is meter, too. */$

if there are not any $g_j$ within radius $(e_{500} + e_{2500})$ from $g_i$

then $BS_i = 0 /* BS_i could be considered deleted. */$

else if there are multiple $g_j$ within radius $(e_{500} + e_{2500})$ from $g_i$

then /* Precision of $1/2500DM(t+dt)$ is more inferior than the one of $1/500Shape(t)$. If we can observe a division, they could be considered updated. */

$BS_i = 0; /* delete BS_i */$

All corresponding $BD_j = 1; /* update by them */$

endif;

endif;

if there are not any $g_i$ within radius $(e_{500} + e_{2500})$ from $g_j$

then $BD_j = 1; /* We can consider the size of the building has changed. We should adopt the DM side. */$

else if the vertex number of $BD_j >$ the vertex number of $BS_i$

then /* We can consider the shape of the building has changed. We should adopt the DM side. */

$BD_j = 1; BS_i = 0;$

endif;

endif;

endif;

endif;

if there are not any $g_i$ within radius $(e_{500} + e_{2500})$ from $g_j$

then $BS_i = 2; BD_j = 2; /* We defer the decision and determine it manually. */$

endif;

endif;

calculate each area of the corresponding buildings $BS_i$ and $BD_j$;

$S_{big} =$ its area of broader side;

$S_{small} =$ its area of narrower side;

$a =$ the length along horizontal axis on the minimum bounding block around $S_{small}$;

$b =$ the length along vertical axis on the minimum bounding block around $S_{small}$;

if $S_{big} > (a + e_{500} + e_{2500}) (b + e_{500} + e_{2500}) S_{small}$

then /* We can consider the size of the building has changed. We should adopt the DM side. */

$BD_j = 1; BS_i = 0;$

endif;

endif;

endif;

endif;

Process the building $BS_i$, $BD_j$ whose value is 0 or 1, automatically;

Process the building $BS_i$, $BD_j$ whose value is 2, manually;

end

Fig. 3 Algorithm of pseudo update.

3 Evaluation

3.1 Quantitative Evaluation

As a concrete example, we use $1/500$ Shape file and $1/2500$ DM data of Morioka-City in Iwate prefecture, which is near our university. Our evaluation is carried out by using 317 buildings in the Shape file and 322 ones in the DM data near Morioka station.
Table 1 Evaluation result

<table>
<thead>
<tr>
<th></th>
<th>appearance</th>
<th>disappearance</th>
<th>mergence</th>
<th>split</th>
<th>size change</th>
<th>shape change</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. visual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>observation</td>
<td>(correct answer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>69</td>
<td>41</td>
<td>20</td>
<td>12</td>
<td>7</td>
<td>196</td>
</tr>
<tr>
<td>B. proposition</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>75</td>
<td>37</td>
<td>16</td>
<td>11</td>
<td>6</td>
<td>187</td>
</tr>
<tr>
<td>C. number of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correct answer</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>64</td>
<td>35</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>170</td>
</tr>
<tr>
<td>recall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>((C/A)*100)</td>
<td>87.2%</td>
<td>92.7%</td>
<td>85.7%</td>
<td>75.0%</td>
<td>83.3%</td>
<td>71.4%</td>
<td>86.7%</td>
</tr>
<tr>
<td>Precision</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>((C/B)*100)</td>
<td>97.6%</td>
<td>85.3%</td>
<td>94.5%</td>
<td>93.7%</td>
<td>90.9%</td>
<td>83.3%</td>
<td>95.7%</td>
</tr>
</tbody>
</table>

We evaluate recall and precision until before manual phase using correct answer determined by visual observation.

Table 1 shows the results. We have achieved 86.7% recall and 95.7% precision in total. We can consider it is feasible.

3.2 Qualitative Evaluation

In the evaluation division of fixed property in the Morioka municipal government, we have carried out the presentation and hearing concerning our proposition. We have obtained the following three comments:

1. It is difficult to grasp the change of building shape completely in the conventional work manner. It is feasible if we develop a tax evaluation support system for fixed property based on the proposed method.
2. Since tax imposition error is terribly serious in municipal government, ‘disappearance’ is the most important in seven update patterns.
3. Although precision lost in pseudo update is certainly drawback, it is more important and worthwhile that the shape or ‘existence or not’ of building is relevant to the truth.

4 Conclusion

We have proposed a pseudo update method of building shape in 1/500 Shape file which is representative as a road ledger map by employing 1/2500 DM data.

We are planning to several future works: (i) to deal with overlap between updated building and ‘road or other building’, (ii) investigation on reduction of multiple vertices. These lead to modification of our proposition.

References: