VISUALIZATION OF ROAD SLOPE ASPECT FOR FIXED PROPERTY APPRAISAL OF LANDS USING DEM

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ABSTRACT:

In order to estimate proper current land price, various factors such as environment, communication, regulation of land use and so on are established by local government. Road slope is one of the land price factors for land form, and land price is corrected by road slope aspect based on road slope for the north. For example, road slope aspect is corrected so that land price face to northern slope road is able to become cheaper, or land price face to south slope road is able to become higher. Therefore, road slope aspect correction is one of important factors for local government where locate undulate area. However, the road slope aspect is appraised by primitive method with great time and labor, such as using contour map or field investigation using surveyor's level.On the other hand, airborne laser surveying has been receiving more attention as a useful tool for real-time 3D data acquisition, and many applications such as city modeling, DTM generation, monitoring electrical power lines and detection of forest areas were proposed. Therefore, it is expected that DEM which is generated by airborne laser surveying is enormously contribute to generate road slope map so that land price estimation can be performed effectively.With these motives, generation of road slope map and visualization of road slope aspect for fixed assets appraisal of lands using DEM were investigated in this paper.

1. INTORODUCTION

Japanese local government tax the fixed property tax based on appraisal of Real-estate such as lands, houses, depreciable properties. Appraisal of Real-estate is performed every three years, and investigation of streets for appraisal of land is performed since the property values of land are appraised by street value (Fixed property tax study group, 2007). On the other hands, Investigation of streets for appraisal of land consists of various factors (Reserch Center for Property Assessment System, 1997) such as environmental conditions (residential density, store density), traffic conditions (accessibility of station, accessibility of public facilities), street conditions (width of road, paved of road condition), and regulation by statute (use district, ratio of building volume).

Here, correction of road slope aspects is one of the appraisal of land factors in the street conditions (Reserch Center for Property Assessment System, 2005). For example, road slope aspect is corrected so that land price face to northern slope road is able to become cheaper, or land price face to south slope road is able to become higher from the viewpoint of sunshine.

Therefore, road slope aspect correction is one of important factors for local government where locate undulate area. However, the road slope aspect is appraised by primitive method with great time and labor, such as using contour map or field investigation using surveyor's level.

In these circumstances, it is expected that DEM is enormously contribute to generate road slope map so that appraisal of land can be performed effectively. This paper describes generation of road slope map and visualization of road slope aspect for fixed property appraisal of lands using DEM.

2. DATA AQUISITION

2.1 Case study area

In order to generate of road slope map for fixed property appraisal of lands, residential area of Tokyo metropolitan region including flat and slope area was selected as case study area in this paper. The residential area is 2km in East-West and 1.5km in north. Figure 1 shows the aerial photograph of case study area.

Figure 1. Case study area (Aerial photograph)

2.2 Road polygon data

In order to express roads as polygon on the road slope map, road polygon data which was provided by fixed property affairs are prepared from digital map as black line. Furthermore, road polygons were divided by red arrow in each street section so that each street section is able to distinguish by different ID numbers in GIS. Figure 2 shows the road polygon data which was overlaid with aerial photograph.

Figure 2. Road polygon data

2.3 Airborne laser surveying

Recently, airborne laser surveying has been receiving more attention as a useful tool for real-time 3D data acquisition, and many applications such as city modeling, DTM generation, monitoring electrical power lines and detection of forest areas were proposed. Furthermore, it is expected that DEM which is generated by airborne laser surveying is enormously contribute to generate road slope map so that land price appraisal can be performed effectively. In these circumstances, Airborne laser surveying was performed in this investigation (December 23 to 24, 2006), and the flight altitude and laser pulse repetition frequency were 1,200m and 25,000KHz - 71,300KHz so that high point density (1 point/m^2) is achieved.

3. VISUALIZATION OF ROAD SLOPE ASPECT

Generation of road slope map and visualization of road slope aspect for fixed property appraisal of lands using DEM were investigated by following procedures.

①DEM generation.

②Calculation of terrain aspect.

③Smoothing for terrain aspect.

④Visualization of road slope aspect.

3.1 DEM generation

Airborne laser scanning enables to acquire point cloud 3D data using laser pulses which are reflected from the surface of the ground or objects. In order to generate DEM, the trees, houses, and the other objects also should be removed by filtering.

With this motive, DEM was generated by filtering from DSM which was acquired airborne laser scanning data, and DEM was converted to 1m grid data which were transformed from random data. Figure 3 shows the elevation map for DEM.

Figure 3. Elevation map for DEM(1m grid)

3.2 Calculation of terrain aspect

As the first step for generate the road slope map, terrain aspect for DEM was calculated by following equation. Here, (Z_N, Z_S, Z_E, Z_W,) means neighboring grid nodes from center of grid(Z_0) for calculation of terrain aspect. Furthermore, the terrain aspect was divided into 8 directions and each direction was colored.

$$A_t = 270 - \frac{360}{2\pi} \times A\tan^2\left(\frac{Z_N - Z_S}{2\triangle Y} \bullet \frac{Z_E - Z_W}{2\triangle X} \right) \qquad (1)$$

where *At* = terrain aspect (0～360°)

$\triangle X$, $\triangle Y$ = grid spacing

Z_N, Z_S, Z_E, Z_W = neighboring grid nodes from Z_0

Figure 4 shows terrain aspect map with 1m grid. It is understood that many small aspect areas were appeared. In order to calculate the macroscopic terrain aspect, smoothing was performed by the average filter.

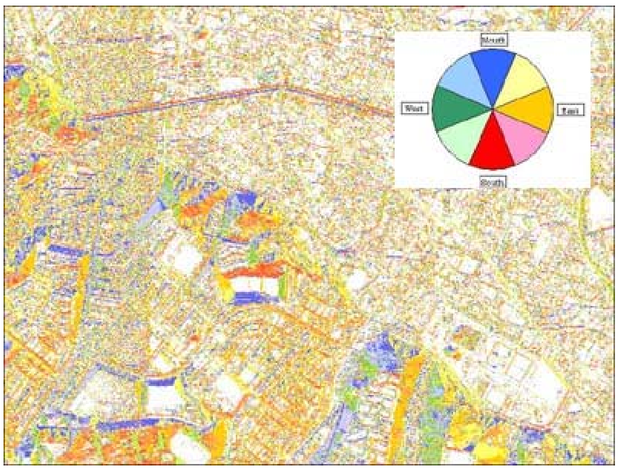

Figure 4. Terrain aspect map for DEM(1m grid)

3.3 Smoothing for terrain aspect

In order to evaluate fixed property appraisal of lands efficiently, macroscopic DEM is requested. In addition, Smoothing is commonly used for generating macroscopic DEM. However, reasonable and efficient smoothing area should be considered.

Therefore, it takes into account that sites area for 6 houses is adopted as minimum area, let assume that sites area is rectangular and sites area for each house is $100m^2$. This means that less than site area for 6 houses should be smoothed as the same terrain aspect. Figure 5(a) shows basic concept of the minimum site area for 6 houses ($600m^2$) and figure 5(b) shows maximum site area ($3600m^2$).

In order to generate macroscopic DEM, $3600m^2$ area was adopted as smoothing size, and smoothing for 1m grid DEM was performed by the average filter in this paper.

Figure 6 shows shading map with 1m grid DEM and Figure 7 shows after smoothing. It can be seen that small unevenness parts in Figure 7 is removed on the macroscopic DEM.

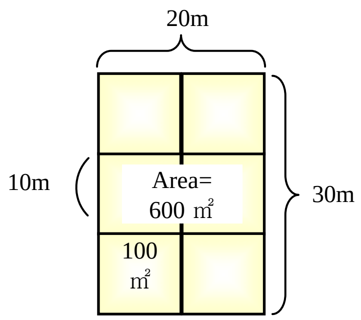

Figure 5(a). Minimum site area ($600m^2$)

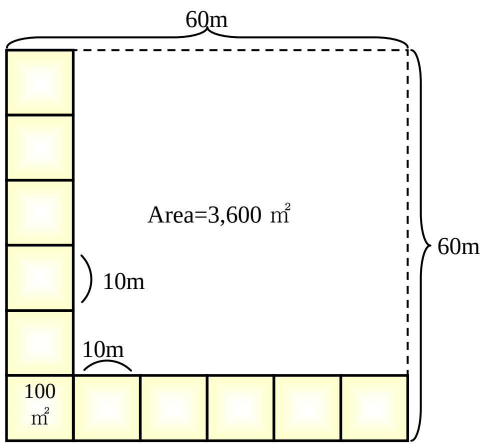

Figure 5(b). Maximum site area ($3600m^2$)

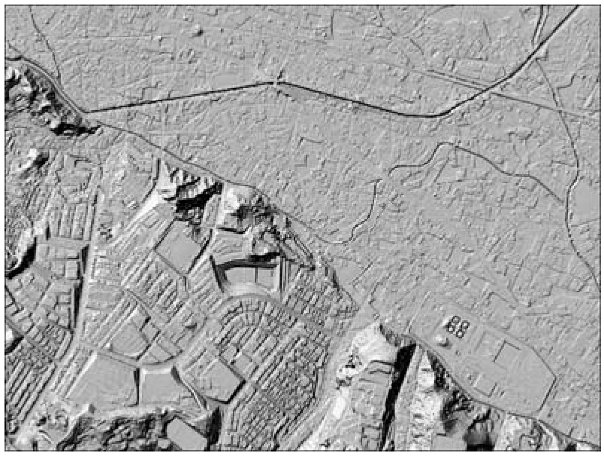

Figure 6. Shading map for DEM(1m grid)

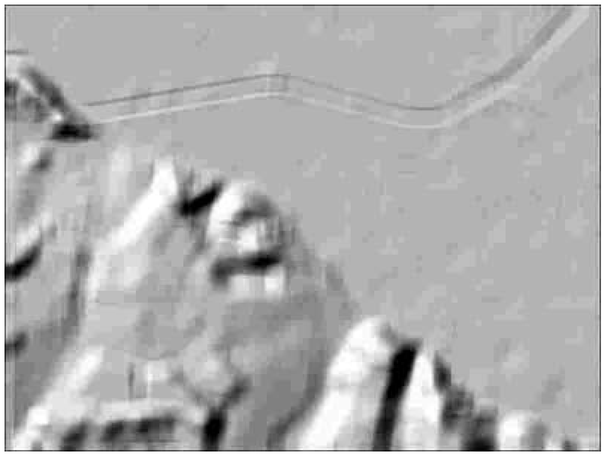

Figure 7. Shading map for after smoothing

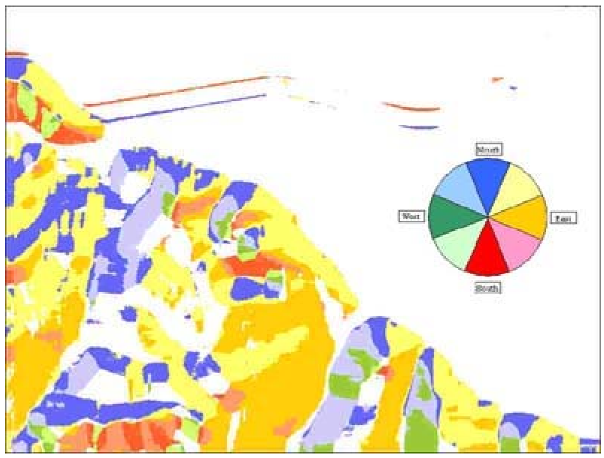

Figure 8. Terrain aspect map for after smoothing

Figure 8 shows terrain aspect map for after smoothing. It is understood that many small aspect areas were disappeared by the smoothing. However, it can be found that some small aspect areas are still appeared. Therefore, the small areas less than $600m^2$ are interpolated by the nearest terrain aspect for the area so that the site area was assumed as the minimum site area is $600m^2$ (figure 5(a)).

Figure 9 shows after interpolation of terrain aspect map, and it can be seen that the small aspect areas are interpolated.

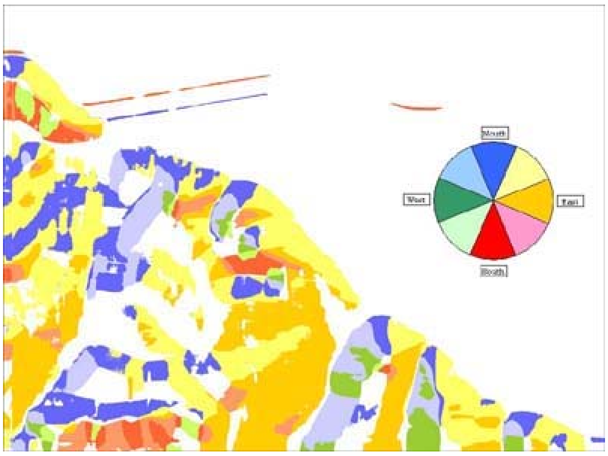

Figure 9. Terrain aspect map for after interpolation

3.4 Visualization of road slope aspect

In order to achieve visualization of the road slope aspect, road slope aspect for each street section was computed. Furthermore, the computed road slope aspect was divided into 8 directions, and each direction was colored.

Figure 10 shows the colored road slope aspect which was overlaid with aerial photograph and terrain aspect map.

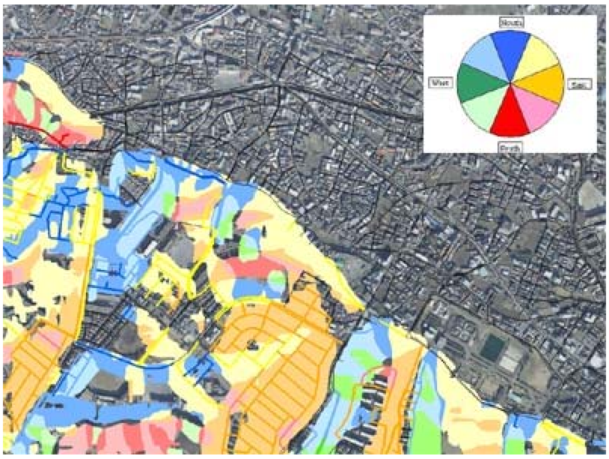

Figure 10. Visualization of road slope aspect

4. EVALUATION OF ROAD SLOPE ASPECT

In order to evaluate the road slope aspect, each road slope aspects were investigated using contour map and field investigation. As a result, the road slope aspects were differences in 159 of 840 street data. Furthermore, it is confirmed that most of different aspects were neighbor aspect cause of individual differences. Figure 11 shows the evaluation of road slop aspect, and different aspect of street in Red color.

However, the road slope aspect is estimated by primitive method with great time and labor, such as using contour map or field investigation using surveyor's level. Therefore, it is expected that DEM which is generated by airborne laser surveying is enormously contribute to generate road slope map so that land price estimation can be performed effectively. AND, it is thought that the proposed method become effective and useful method for fixed property appraisal of lands.

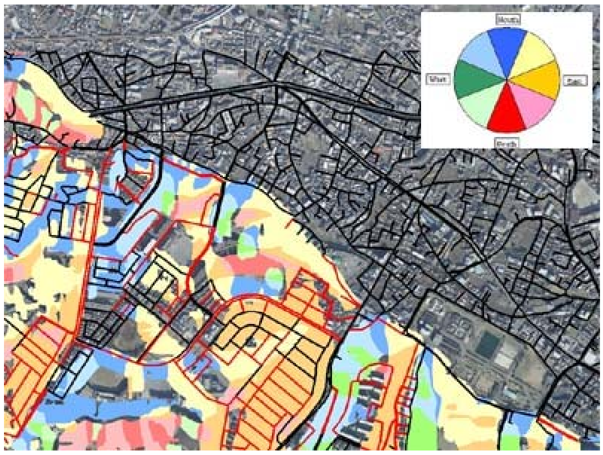

Figure 11. Evaluation of road slop aspect

5. CONCLUSION

Generation of road slope map and visualization of road slope aspect for fixed property appraisal of lands using DEM were investigated in this paper, and it was verified that visualization of the road slope aspect enormously help to make understanding fixed property appraisal of lands. Furthermore, the visualization system which was proposed in this paper have ability to customize depends on various factors such as street condition, traffic approach condition, environmental condition, administrative condition and so on. Therefore, it is concluded that the visualization system for road slope aspect is expected to contribute in various estimation of fixed property appraisal of lands.

REFERENCES

Fixed property tax study group 2007. Guideline of fixed property valuation standards.

Geographical Survey Institute 2000. The landform investigation work regulations reguration

Reserch Center for Property Assessment System 1997. Study on land appraisals

Reserch Center for Property Assessment System 2005. Study on land appraisals,pp.3-38

Nathaniel A.Jackson., 2002. UNDERSTANDING ASSESSMENTS AND PROPERTY TAXES.