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THE ISSUE OF VISUALIZATION OF POINT OBJECTS

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Summary

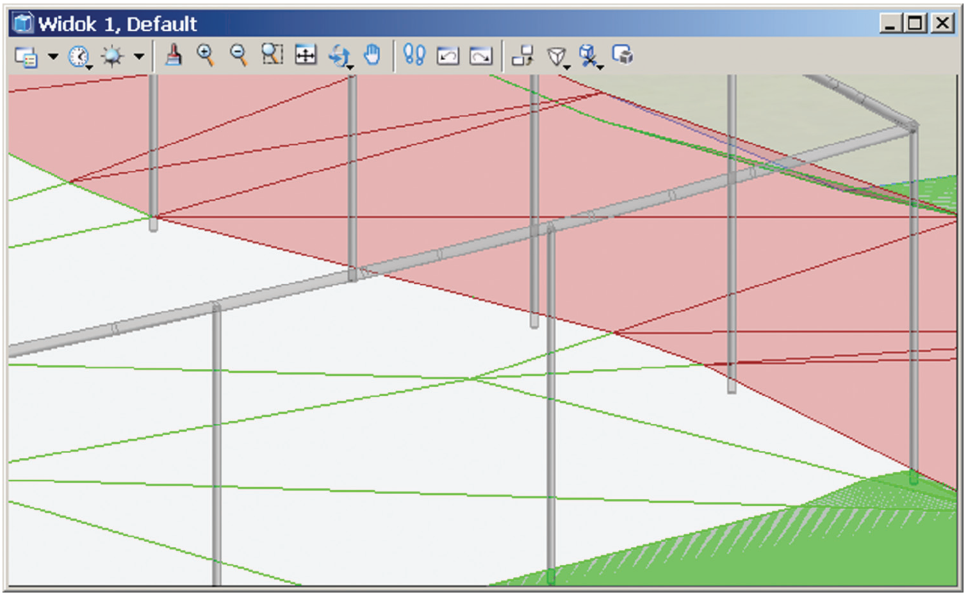
This article discusses the problem of point object placement in 3D space for the purposes of visualization. We have to deal with this kind of task, when we have to place objects on a DTM (Digital Terrain Model), which most often is an irregular triangle grid. Unfortunately, the case when the point objects are placed on a horizontal surface is very rare. This is the reason why there is a need for a technology that allows us to prepare the data required to work on the digital terrain coverage model development. The approach presented is an attempt to solve this problem in a simplified yet sufficient model for this kind of elaborations.

Keywords

Digital Terrain Model • 3D visualization • photorealistic visualization

1. Introduction

The digital terrain model (DTM) can be obtained in many ways [Longley et al. 2006]. However, almost every time we have to develop a digital terrain coverage model we have to deal with the deficiency of data required. This issue applies to point, linear, and surface objects. Additionally, in order to obtain greater realism, we have to deal with the problem of displaying point objects as surface objects. Dependent on the object, in many cases this problem can be omitted – e.g. poles (Figure 1). However, for some objects it can be a problem, which has to be solved differently – usually by analyzing one XY coordinate as a representative. The technology which has to be applied for this kind of elaboration should also take into account the geometrical shape of the base of the point object. There seems to be a contradiction here, because we are analyzing a point object in terms of its surface. However, we have to remember about the difference between the way the object is stored in the database and the way it is presented graphically. The greater the generalization of point objects, the more troublesome their placement is. This applies specially to the point objects of larger sizes, e.g. small architecture objects.



Source: authors' study

Fig. 1. Point objects on a DTM

2. Point objects

The point objects that we have to deal with, when preparing the visualization, should be placed on a DTM in such way so that they create a realistic image of the reality that surrounds us. Unfortunately, depending on the kind of surface object, its real dimension can significantly influence the visualization of the digital terrain coverage model. Lowering the objects, so that the base is completely below the DTM grid, is a commonly used practice. Most often they are lowered by a defined constant value Δz (Figure 2).

Unfortunately, such an approach has its risks. The most important one, is that the object's dimension may not correspond to the real dimension. This does not matter in terms of aesthetics. However, it may lead to incorrect data obtained from such an elaboration. A function that automatically returns the height of a selected object does not have to take into account that only a part of the object is above the DTM surface. The next disadvantage in the use of this method is the necessity to present this kind of elaboration only with a fully filled DTM grid. Only then we can obtain an image which does not contain unnatural objects located below the DTM surface. Working in the grid mode can be very tiring. Depending on the DTM complexity, lowering the point objects can influence the possibility of the user's error. It accustoms the user to the unnatural contents of the elaboration. Unfortunately, advanced visualization methods, such as the ones involving lighting and in consequence the shadows, often show reality incorrectly (Figure 3).

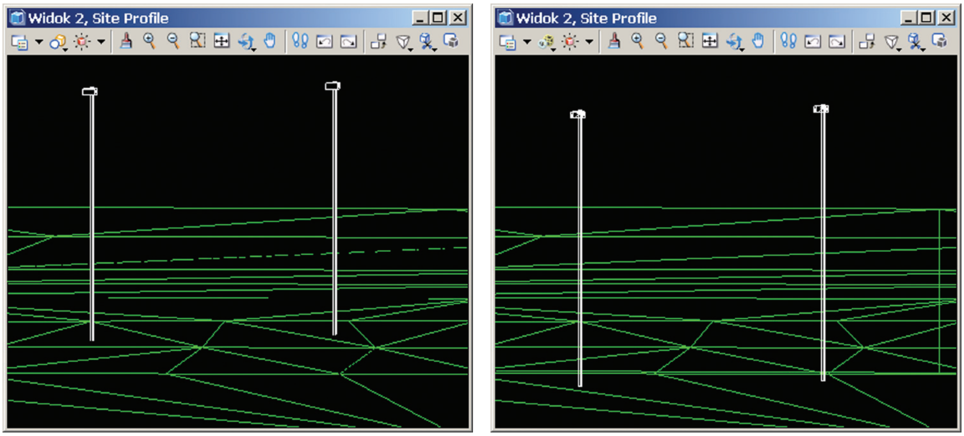


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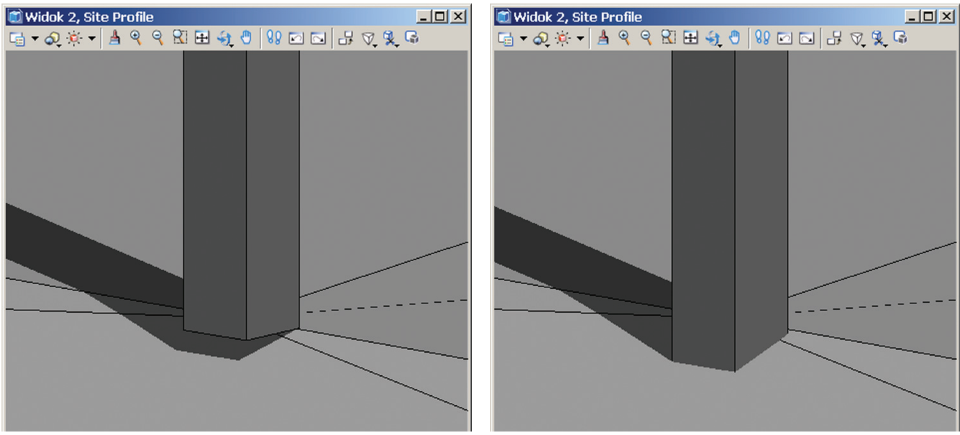
Fig. 2. Lowering the objects by a constant value



Source: authors' study

Fig. 3. A shadow cast by an object. On the left, the object is placed on the surface of the DTM, on the right its base is lowered

3. Proposal

Due to their representation the point objects should be treated in a simplified manner. According to the authors, there is no reason to analyze the bases of such objects as surface objects. However, their placement on the DTM should take into account the local configuration of the triangle grid. This means that the DTM drop analysis in the area of the base should be simplified, and it becomes necessary to adjust the placement point to the lowest vertical coordinate. However, one should remember that in most cases, we are dealing with objects like trees or poles. The suggested solution is to determine the theoretically lowest vertical coordinate possible to obtain when placing the object on the DTM and use it as a point of reference. To determine the Z coordinate from the reference point we have to find the triangle(s) on which the base is located and identify it/them.

This is done using the following algorithm:

```
For i = 1 to n; n – all the triangles necessary to be searched
   If point (XY) Is_in_triangle (i) then
      m = i : exit for
   End if
Next i
```

Identification of a triangle of index m is required to calculate Z. The calculations can be performed using the following formula [Gaździcki 1990] (Figure 4).

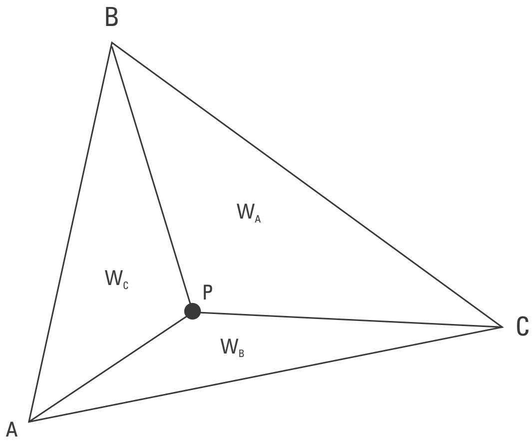


Fig. 4. Calculation of the height of point P. A, B, C are the vertices of the triangle, W_A, W_B, W_C are the areas of the opposite triangles, weighing the calculations

$$Z = \frac{Z_A \cdot W_A + Z_B \cdot W_B + Z_C \cdot W_C}{W_A + W_B + W_C}$$

Another method is to calculate the equation of a plane for three points A, B and C; and to calculate on its basis the Z coordinate of point P.

The next step is the classification of the triangles, located in the search RANGE, defined by the size of the base. We can accomplish this by checking the intersections of the base with the sides of all the triangles classified for verification. Using "RANGE" function we mark the quadrangle containing the base of the object. For this area, we build a list of triangles, which are at least partially located in the analyzed RANGE.

This is done by the following algorithm:

```
For i = 1 to n; n – all the triangles classified to be searched
   If RANGE(base) Is_Intersection_triangle (i) then
      Add triangle (i) to list_triangle
   End if
Next i
```

We search all the triangles classified for processing. We are searching for the one with the largest gradient – α_{max}. Note that the output value α_{max} had been estimated based on the found triangle, that contains the analyzed point object.

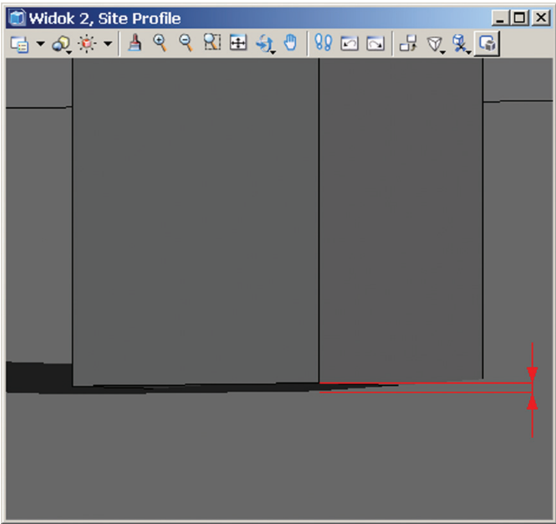
We use the algorithm:

$\alpha_{max} = \alpha$ In_triangle (m)
For i = 1 to n; n – all the triangles from the list classified for searching.
   If $\alpha_{max} < \alpha_{triangle}$ then $\alpha_{max} = \alpha_{triangle}$
Next i

Having obtained the biggest inclination angle α_{max} for the found triangle, we use it for the calculations for lowering the surface object height (Figure 5).

$$Dz = Hi - RANGE/2 \cdot \tan(\alpha_{max})$$

Using only half of the RANGE value results, from the necessity of lowering only the part located over the plane surface, defined by the triangle inclined by α_{max}.



Source: authors' study

Fig. 5. Lowering of a point object by a values resulting from the maximal drop

4. Discussion

The application of the presented algorithm requires making additional assumptions. These assumptions are related to creating the RANGE extent of the base of the point object. For example, if the analyzed object is a chimney, then the RANGE of the cell in the base matches the geometrical RANGE of the object. The situation gets complicated during calculations related to objects like trees [Gryboś et al.]. The RANGE of the cell is greater than the RANGE of the base. It has a large meaning in case of such big proportions like the ratio of the tree crown diameter to the trunk diameter. This means it is necessary to assume by default the values related to particular types of objects, e.g. for RANGE trees we assume 0.3 m on the level of 1 m., etc. This is another way to add descriptive information regarding the RANGE of the base of a point object. The authors recommend the second method. One should remember that the information can be an integral part attached of a point object saved in the library. This solves the problem of many kinds of objects in the same category (e.g. poles with and without lanterns). Optionally, scaling of a point object will then be considered in order to calculate the final RANGE of the base.

5. Conclusions

The presented approach is the result of searching for a solution of presenting point objects on DTM surface. Despite its great simplification, it eliminates the necessity to change the placement height by a constant value.

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