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# VISUAL SELECTION OF SURFACE FEATURES DURING THEIR GEOMETRIC SIMULATION WITH THE HELP OF COMPUTER TECHNOLOGIES

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**ABSTRACT**
For visual pictorial presentation of three-dimensional geometric objects with the help of modern computer engineering it's necessary to have effective program realization of programmatic selection of specific points and also feature lines of the surfaces represented with the help of function of two variables. This article gives technical approach from the position of the surface type allowing to undertake visual selection of the surface features during their geometric simulation with the help of computer technologies.

**Keywords**: three-dimensional geometric simulation, surface feature.

## 1 INTRODUCTION

One of the dynamically growing directions in software development today is development of new information technologies and methods of visualization of the program performance results [1, 2], that is such a presentation of them which is perceived by a person in the most adequate way.

The theme of the work is actual as visualization is one of new instruments for getting new knowledge about the object under consideration while designing complicated engineering constructions.

The following terms, determining basic types of the surface, are used in the work.

**Hill** – cone-shaped elevation on the surface. It has a characteristic point – peak.

**Peak** - the point of the surface of the maximum height.

**Slope** - side surface

**Ridge** - elevation on the surface, going down in one direction and having two steep slopes.

**Depression** - deepening in the surface in the form of a bowl. The lowest point of the depression is the point of the surface of the minimum height.

**Ravine**- prolate deepening in the surface, going down in one direction.

**Saddle** - the lowered part of the surface between two peaks.

Surface shape can be described as its feature that has six basic visualizations: **peak, ridge, slope, ravine, saddle, depression** [3].

The generally accepted three-level hierarchy of the presentation of the surface geometric model in three-dimensional space served as analogue while determining levels of the model of the characteristic forms. The surface model can be determined by three basic levels. At the lowest level the model is limited to point presentation (by the set of co-ordinates of points ***x, y, z***). The second level includes the first one with the additional description of the topology of connections between points (wire-frame model). On the third level connections unite in closed boundaries (facet model). Description of the surface model from the position of form has a similar structure (table 1)

**Table 1:** Surface model according to shape

| Level number | Geometric model | Model of characteristic shapes |
|---|---|---|
| 0 level | Point | Hill, saddle, depression |
| 1 level | Edge | Ridge, ravine |
| 2 level | Bound (facet) | Slope |

These visualizations make set $\dot{V}$.

In scheme the un ambiguity of characteristic shapes is achieved by analysis of four directions of the conditional sink, as shown in fig.1.

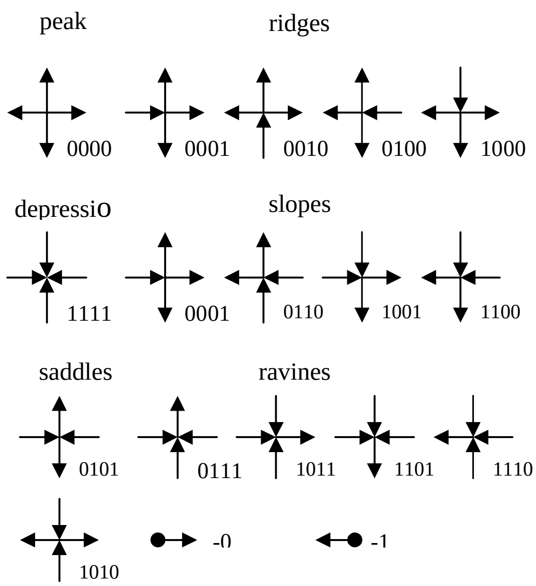


**Figure 1:** Main visualization of typical shape

## 2 TECHNICAL APPROACH TO VISUAL SELECTION OF THE SURFACE FEATURES DURING THEIR GEOMETRIC SIMULATION WITH THE HELP OF COMPUTER TECHNOLOGIES FROM THE POSITION OF SHAPE.

By conditional sink we'll mean the direction from a higher point to a lower one. The direction of the conditional sink is shown with an arrow in the scheme.

Template encoding stipulates the following. If the direction comes from the central point, we will consider it as zero. Otherwise, when the direction comes into the central point, we will define it as unit.

Thus, the peak in the indicated scheme is determined by four zero directions, and the depression - by four unit directions. For determination of the schemes of the rest of the forms it is necessary to set to tracing of the four directions of the conditional sink.

Let's set to clockwise direction. The beginning of the tracing will be the direction "upwards". As a result we have a four-bit set, determining in its different combinations the decimal values from "0" to "15" (set *V*). Hence, the area of the form is characterized by the following classification (table 2).

**Table 2:** Classification of surface types

| | *A* | *O* | $\dot{V}$ | *E* | *V* |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | *6* |
| 1 | 0000 | → | peak | ↔ | ***0*** |
| 2 | 0001 | → | ridge | ↔ | ***1*** |
| 3 | 0010 | → | ridge | ↔ | ***2*** |
| 4 | 0100 | → | ridge | ↔ | ***4*** |
| 5 | 1000 | → | ridge | ↔ | ***8*** |
| 6 | 0011 | → | slope | ↔ | ***3*** |
| 7 | 0110 | → | slope | ↔ | ***6*** |
| 8 | 1001 | → | slope | ↔ | ***9*** |
| 9 | 1100 | → | slope | ↔ | ***12*** |
| 10 | 0111 | → | ravine | ↔ | ***7*** |
| 11 | 1011 | → | ravine | ↔ | ***11*** |
| 12 | 1101 | → | ravine | ↔ | ***13*** |

| | | | | | |
|---|---|---|---|---|---|
| 13 | 1110 | → | ravine | ↔ | ***14*** |
| 14 | 0101 | → | saddle | ↔ | ***5*** |
| 15 | 1010 | → | saddle | ↔ | ***10*** |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 16 | 1111 | → | depression | ↔ | ***15*** |

After generalization the table looks as follows (Table 3).

**Table 3:** Unambiguous shape presentation

| ***A*** | ***O*** | $\dot{V}$ | ***e*** | ***V*** |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| All directions from the center | → | Peak | ↔ | ***0*** |
| One direction to the center | → | Ridge | ↔ | ***1*** |
| Two directions on one line to the center | → | saddle | ↔ | ***3*** |
| Two perpendicular directions to the center | → | Slope | ↔ | ***5*** |
| Three directions to the center | → | ravine | ↔ | ***7*** |
| All directions to the center | → | depression | ↔ | ***9*** |

Generic variable *V* for the concrete variable $\dot{V}$ is determined with the help of abstractive function $e^{-1}:\dot{V}\rightarrow V$ [4]. This function must be isomorphic as to ordering to *V*. Thus, function *e*, according to the scheme (see fig.1), can be defined as function of transition from the decimal presentation of the integer to the binary Eq. (1).

$$e^{-1}\left(k_{(2)}\right)=k, \qquad (1)$$

*where*

$$k\in\{0,1,3,5,7,9\}.$$

The set of decimal values of shape visualization is mutually unambiguous reflection of the set $\dot{V}$ and makes the set *V*. Set $\dot{V}$ consists of six subsets $\dot{V}_i$, where *i*=1,6. Set *V* contains sixteen different elements which as a result of mutual unambiguous reflection passes to the elements of subsets $\dot{V}_i$ of set $\dot{V}$. According to the decimal value of each of six concrete forms the dominant direction of the conditional sink is determined.

## 3 VISUALIZATION OF GEOMETRIC FEATURES OF THE SURFACE, DETERMINED THROUGH FUNCTION OF TWO VARIABLES

Let's consider function of two variables *F*(*x*,*y*). To determine the decimal value of the surface form visualization of the given function *F*(*x*,*y*), it is necessary to consider the direction of the conditional sink.

Let's designate:

- *Meaning Function (i),[i=0,3]*- as meaning of function *F(x,y)* in four directions of the conditional sink*;*
- *Meaning Function _Center* - meaning of function *F(x,y)* in the central point of the template;
- *Signeq. (2)* - decimal value of the surface form visualization of the considered template.

The successive comparing of values of *Meaning_Function(i)* with the value *Meaning_Function_Center* gives an opportunity to define the decimal value of the form visualization.

$$Sign=\sum_{i=0}^{3} Sign(i), \qquad (2)$$

if

$$\begin{cases} Sign(i) = 2^{i}, \\ Meaning\_Function > Meaning\_Function\_Center; \\ \qquad\qquad Sign(i) = 0. \end{cases}$$

It is conceptually suggested that a many-sided pyramid with the regular base figure and amount of faces multiple to four should be considered an element of the form. Let's consider an example with a pyramid with regular base.

Application of an ***n*** - angle with the regular base and amount of sides multiple to four enables to use *n /4* templates, outgoing from the vertices of the ***n*** - angle. As a result we get *n/4* schemes as auxiliary templates (fig.2).

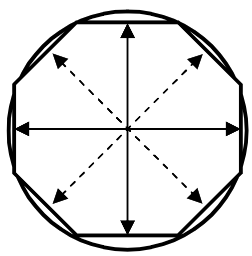

**Figure 2:** Placing of templates orientation for an

The task consists in visual selecting of point and linear forms of the studied surface by means of iteration clarification of the form visualization of the examined area

The principle of visual selection of forms consists in researching of the direction of the conditional sink by means of determination of decimal value of form visualization. As every turn of the template increases the amount of combinations of form visualization, it is suggested that only some unambiguously determined ones should be selected.

The following four main types should be considered unambiguously determined ones: **hill, depression, ridge** and **ravine**

As hill and depression presuppose the single direction of the conditional sink either to the central point of the studied area or from it, the decimal value for hill is determined as equal to zero, and for depression as $\sum_{i=0}^{n-1} 2^{i}$ , where $n$ is the amount of the studied directions of the conditional sink on the area being analysed

Ridge and ravine come to light as existence of the unique direction of the conditional sink which is oppositely directed as to the other directions of the conditional sink of the analyzed area. Thus, the decimal value for ridge is determined as check for equality of the derived decimal value to the combination of values $2^{i}$, *where* $i$ is an amount of directions of the conditional sink. Similarly to that for ravine the decimal value of the form of the area is compared to the combination of values $\sum_{i=0}^{n-1} 2^{i} - 2^{i}$ , where $i$ is the amount of the directions of the conditional sink.

The other variety of combinations is not unambiguous and is eliminated from consideration. By filling of the convex areas (hill, ridge) with green color and concave areas (depression, ravine,) with dark blue colour, we get an image consisting of the special points and lines of the studied surface.

In the test example (fig. 3.) with the use of octahedron as an element of the shape on the rectangular area, it's shown the result of the performance of the method of visual selection of special points and characteristic lines on the surface fractures.

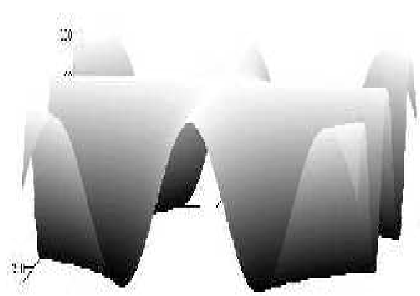

**Figure 3 a:** surface described by the function

$$z = 100 \cdot \cos\left(\frac{\pi}{150} \cdot \frac{x}{13} \cdot \frac{y}{13}\right)$$ (***Math CAD***)

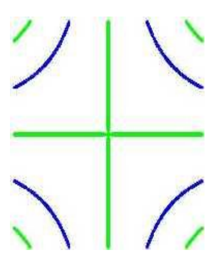

**Figure 3 b:** Visualizations of specific points and characteristic fractures.

## 4 CONCLUSIONS:

1. In this work it is suggested a method of the data ware of the conditional sink for the selection of the specific points and characteristic lines of the surface fractures of the shape, during their geometric simulation with the help of computer technologies, which allows to improve quality of the graphic image of the object being designed.

2. The suggested method of the data ware of the conditional sink allows to provide good and validated graphic presentation of geometric shapes which is especially important while designing complicated engineering constructions.

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