Quantitative and Qualitative Terrain Analysis Based on Digital Terrain Model

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Abstract. Within the Digital Terrain Models (DTM) processing and consequently qualitative and quantitative analysis, it is possible to gain a credible imagination of real terrain shape. In order to obtain an appropriate DTM, it is necessary to decrease the influence of the gross errors that have negative effects on the final DTM. These gross errors may degrade and in the worst case also ruin the calculations and the final outputs. The gross errors have a greater impact and are harder to define in complicated terrain and pointing out these types of errors depends on the editor’s experiences and terrain knowledge.

1. Introduction

The DTM creation is directly dependent on the acquisition of topographic data. In the past, classic terrestrial geodetic methods were used for the adequate acquisition of the topographic data. The terrestrial measurements in the terrain were from the point of time very difficult and had an influence on the final price. The land surveyor had to face the questions of correct station positioning to be as effective as possible. The character of the terrain, vegetation, surveyor experiences, instrumentation and required DTM precision affected the measuring process. The most important outputs of the terrestrial measurements were precise quantitative and qualitative terrain characteristics. According to the progress within the satellite data acquisition, the quantitative and qualitative analysis has become easier and more effective due to the data density and data collection velocity [1]. Important is calibration of measuring system and influence analysis to ensure precise data acquisition [2].

2. Quantitative Terrain Analysis

Quantitative (morphometric) parameters are used for the complicated area characteristics as well as characteristics of georelief. Morphological parameters express shape properties of the area as the morphological terms. These parameters are more precise and more important whereas they are used in geomorphology more often. The quantitative parameters include elevation, exposition, slope, vertical division, horizontal division, vertical and horizontal curvature.

Elevation

The elevation is the elementary morphometric value. The other values of morphometric parameters may be defined from spatial resolution of the elevation. The elevation of the points placed on the contour lines is defined by the contour line value [3].
Exposition

The exposition significantly manifests within the directed land processes (such as weathering, etc.). The strong influence on the exposition towards the cardinal direction, as well as georelief, has the impact on the major wind direction effect but mainly, the sun radiation intensity. The exposition importance increases with the increasing georelief sloping (vegetation types and heights) [3]. More slope curves converge to the singular points. In these points, it is not possible to define the exposition. The same problem is with exposition of the points on the horizontal planes. In these cases, the georelief exposition is undefined.

Slope

Slope defines the intensity of gravitational conditional morphological processes. It is defined as vertical gradient (maximal vertical fall) [3]. In the predefined point, the slope is the angle of the horizontal plane and tangent terrain plane. It may be expressed in degrees, percent values and units per mille. (Figure 1)

![Figure 1. Example of slope analysis](image_url)

Vertical division

The vertical division is defined as the difference between the highest convex point and the lowest concave point (the georelief amplitude). It is used as one of the limiting factors within the morphographical type definition. It is also used as a characteristic entity of morphographical stylization. The average values of vertical division in elementary units depend on the examined area [4].

Horizontal division

The horizontal division expresses the density of the georelief division according to the convex and concave terrain boundaries. It is used for morphographical stylization as well. The valley line calculation has a direct impact on the horizontal division hand in hand with plane stylization.

Vertical curvature

It is also known as normal slope line curvature. By using this parameter, it is possible to express the velocity changes of geomorphological processes. The slope line might not be curved only in a single direction because of the curve specification as a spatial curve. [4, 5] The normal slope line curvature values may be defined similar to the contour line curvature. Three types of slope lines are defined. The
linear one, in the plane of normal, has the same slope in every single point. The linear slope lines have no impact on the velocity changes of geomorphological processes. The second one is the convex slope line. The velocity of geomorphological processes is increasing in the slope direction. The last one is the concave slope line and it causes the decrease of the velocity of geomorphological processes.

**Horizontal curvature**
It is also called a contour line curvature. It represents the contour geometric form which expresses the georelief exposition change in the contour direction. On the linear contour lines, the flow is parallel (slope lines network is parallel). Within the concave contour, the energy flow is concentrated in the slope direction. On the other hand, within the convex contour, the flow disperses in the slope direction. The total curvature may acquire positive and negative values. The positive values represent convex georelief forms and the negative ones represent the concave georelief forms. The relief form has the impact on the mass gain or loss during the erosive processes.

**Illumination**
This quantitative parameter is very important during the agricultural model purposes. The most important parameter from illumination point of view is the level of incident sun shining on an examined area.

**Visibility**
The visibility analysis depends on the sequential visibility definition between the observed point and the points in the rest-processed area. It is used in the field of telecommunication, civil engineering, environmental issues, tourism etc.

**Slope length**
The total slope lengths influence the water flow velocity, water flow intensity, mass transportation capacity and water erosion effect. It is possible to determine the sourcing research areas of observed parts as well as to calculate the maximal distance of the first mineral fragment from the source.

**Shading**
The shading enables relief visualization using pseudo spatial sensation (highlights, darkfalls) using the shading method by colour selection. The shading effect of the terrain by using the pre-set lighting source creates the highlight or darkfall effect.

### 3. Qualitative Terrain Analysis
Morphographic units express the qualitative analysis of the georelief shape. In order to capture the terrain course, it is needed to measure the points and lines representing the orographic scheme. The correct measure of these qualitative terrain landforms is the only way of correct interpretation of the terrain real shape.

**Plain**
In topographic meaning, the plain is the part of terrain that is horizontally flat (Figure 2). This landform has almost no elevation changes. The shape on the edges may be straight, convex or concave. The transition from the summit to the hillside is characterized by a significant slope change on a sharp or rounded side. [6]

**Ridge**
It is an elongated higher landform with rounded and elongated part with opened ground plan. It consists of a chain of the mountains or hills that form a continuous elevated crest. The characteristic terrain line is called the ridgeline. It connects the point with the highest section dimension. (Figure 2)
Figure 2. Course of the contour lines in the plain (left) and the ridge (right)

Saddle
The saddle is the lower area within the ridge. Two generalized delineations of watershed and two valley lines meet there. The lowest point of saddle is called saddle summit, which is described and dimensioned in the maps and the surrounding area is made up by the extra contour lines. (Figure 3)

Terrace
This is the most occurring step-like topographic landform. It consists of a flat or gently sloping tread. The terraces may often consist of a tread bounded on all sides by a descending scarp (or riser). The special case of the terrace with a narrow character is called a bench. (Figure 3)

Valley
The valley is an elongated unclosed low landform. Valleys are divided into two types, the main and the minor ones. The main sign is the size parameter of the valley (big landform type) and relatively minimal fall due to the neighbouring slopes. There are main valley shape types: valleys with narrow ground, valleys with concave ground, valleys with convex ground and valleys with notch.

Figure 3. Course of the contour lines in the saddle (left) and the terrace (right)
4. Conclusions
The data from the DTM may be applied to study and better understand the qualitative and quantitative terrain characters. The change in the data collection influences precision and informative values of the terrain analysis. This analysis may be performed in the GIS environment. The DTM data collection makes the observation of terrain easier, and more complexly allows to capture the hard-to-reach terrain forms. The quality of the final results after DTM processing is comparably better than terrain surface created from terrestrially measured data.

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