THE TECHNIQUE OF RELIEF SHADING WITH MULTI-DIRECTION LIGHTS

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ABSTRACT

Many experiences are accumulated about manual relief shading, and with help of it, a relief shading with a well artistic effect can be created. In this paper, the exited theories of automated relief shading are analyzed, and the cartographic knowledge about relief shading is discussed. In order to improve cooperative efficiency between computer and people, an interactive environment of color relief shading is given. In our test, the relief shading map by means of this method is better than the relief shading map with a single light direction.

Keywords: Lights, Relief, Shading, Cartographic Knowledge

1. PREFACE

At present, relief shading is one main method of the stereoscopic appearances of geography on a plane, and it is also the best relief expression method in a planar projections. Based on the grayness of the earth surface shined by the supposed light, this method is used to draw the shade with the different color or gray to display the configuration of up-and-down relief. Its characteristic mostly is that a planar simulation is used to reflect stereoscopic change. Moreover, non-professional readers can know the mainly shape of relief at a glance.

Relief shading methods include a manual method and an automatic one. With the former, the production time is long, and the cartographers must have good abilities of map interpretation、color controlling and artistic decoration. So, generally only professional cartographer can do it, and once the product is completed, it can't be modified and adjusted any more. In contrast with the manual one, automatic relief shading has many merits: user can select and change the position of supposed light according to his own feeling, and change the contrast of brightness, etc. In order to enhance the feeling of three-dimensional, the vertical proportion may be magnified properly, and the relief stereo-appearance is more visible. But, for a complicated terrain region, a good relief map only with a single light source usually can't acquire perfect impression. Some scholars have done a great lot of research works on multi-light automatic relief. On the field of manual relief map drawing, cartographers have accumulated plentiful experience about mixed-light application, and these experiences also are the roles of automatic process. Therefore, we use these roles well and analyze the existing theories and methods.

2. THE ANALYSIS OF EXISTING RELIEF SHADING METHOD

In relief shading, the relief is mainly represented with help of the change of light direction and shade of hue. In automatic relief shading, calculating the gray value of every micro-cell is essential precondition. And the method is explained in many textbooks about computer graphics and computer-assisted cartography. In order to gain a good relief shade map, many scholars have done a lot of research on the improvement of automatic relief shading, specially Prof. Lorenz Hurni of ETH in Switzerland had discussed the analyzed method of relief mapping, and also developed his relief map-made software. Because Switzerland is a country with many mountains, the visualization of mountain takes a important station in Switzerland's cartography.

Many software automatically for producing relief shading have been developed, for example, Arc/ Info and TNTmips (http:// www.microimages.com) etc. And they directly use the exited method to calculate grayness value, for example, Phong model etc, but can't consider different relief characteristics and complexity of geography.

Relief maps are different with remote sensing photos and scenic pictures. They describe the relief characteristics by a way understood easily by reader, and reflect the understanding of cartographer. With the different scale of geographic space, the relief configuration is abstracted on different extents. For example, under the high mountain's shadow, the grayness value of small hill is added and which weaken the description of this hill's shape. The change of main light direction results in different relief shading effects. For resolving these problems and improving the result of relief shading, many cartographers try on many ways. Yoeli first researched the adjustment of the direction of light in local

area. Brassel (1974) continued this research and brought up more complicated model to calculate automatically the direction of main light. Zhou and Dorrer used wavelet transform of DEM to decide the direction of main light and to adjust the local light direction. Based on the analysis of these research results, Lorenz Hurni has given the modified method, and developed software using the interactive mode to change local light directions for modifying gray-values on a local area.

3. THE STRATEGY OF RELIEF SHADING MAPPING

In order to produce a good relief shading map, considered factors include: the DEM data that can describe relief shape exactly, the right model for calculating the grayness, the modification way of color and grayness, and cartography rules.

The first factor is not considered in this paper. Unwanted details can be deleted by simplification of DEM. The model used to calculate grayness is usually named as "illumination model". Because the different relief shading way is sometimes needful on different areas, therefore an interactive tool for relief shading mapping is very necessary. But the interactive tool can't take the cartographer many troubles. In order to solve this problem, we try to design a human-computer cooperation mode. The computer gives the convenience to cartographer. From the experience of manual relief shading, we can know that the key of relief shading is the application of light and color. The color on a map should satisfied people's visual habits. Based on the analysis of manual relief shading, we take the modification on application of light and color in analyzed relief shading.

3.1 The application of lights

In the manual relief shading, three kinds of lights are used, which are the straight light direction (that is to say, the ray is gotten down from the top of the head), the oblique light direction and the combinative light directions. In automatic relief shading, the regular light direction is the oblique light direction.

It is generally used in the region of high mountain or skyscraping mountain, and this can make the mountain higher and more outstanding. Relief shading must not only express the general modal characteristics of relief and the contrast of grade, but also reflect the height contrast and the modal characteristics of relief of different mountains.

From the experience of manual relief shading, the general rules of light directions and dark change can be completed through illumination models. But relief shading has great relations with the location of the light direction. Different light direction can produce different gray values, thus there are different shading effect. In order to achieve artistic effect that manual relief shading desires, we must use different light directions for different cartographic regions.

The main reason is the complexity of relief and the different intention and purpose of users. We can select the region that needed to adjust light direction according to the experience of cartographic persons. Firstly, one or more polygon regions are selected artificially. Then the gray value is recalculated, according to different azimuth angles of light direction that can improve the solid visual effect.

3.2 The rules about color in relief shading

Colorized relief shading possesses abundant expressive ability, comparing with homochromous shading. In manual relief shading, the color of different changes in temperature reflects the different height of hypsography. Warm color is used to produce nearby sense in low hypsography, and neutral or cold color is used to express forane sense in high hypsography.

In the process of relief shading mapping, rules of the color distribution can be found according to the theory and method of physical geographic layout, and take such factors as relief, soil and vegetation into account. The color design is mainly determined according to vertical zone, and also considers the local characteristic of relief type, and then reflects the natural scene of whole map area. These rules can be stored in a parameter table. This way to formalize knowledge can be in favor of the match of rules and the concept redefined by user.

4. THE EXPERIMENT ABOUT THE LIGHT DIRECTION AND THE APPLICATION OF COLOR

In order to make emphases on the adjustment of the light direction and the application of the color in relief shading, we directly make use of the illumination model provided by Arc/Info to calculate the value of grayness. The test data is DEM with GRID data format. The original contour data is collected from "China Typical Relief Atlas".

Generally, the light direction often is northwest. Here, we use the statistical method to calculate the light direction. Firstly, we reclassify the aspect into many classes and take statistics of the frequency within every interval, then select the interval whose frequency is maximal to calculate the main direction. Supposed that the cartographic data is a raster data with a size of $m \times n$, for a cell (i,j), the elevation, slope and aspect value are respectively E_{ij}、S_{ij}、A_{ij}. The aspect value is reclassified into M class, and every interval is $[R_t,R_{t+1}]$, the cell number in it is N_t, and the original value as 0.

For the cell (i, j), if S_{ij} is not bigger then 20°, then stop the statistic work of this cell. If yes, then if $A_{ij} \in [R_t, R_{t+1}]$, and if A_{ij} lie in the nth class then $N_t = N_t + 1$. After all cells are handled, the maximum of N_t can be calculated. If $\max(N_t) = N_a$, then azimuth = $(R_a + R_{a+1})/2$.

Table 1 is a color table often used in color relief shading, the color is denoted by parameter of RGB mode. Certainly, the option and design of color is not single. Different request and taste can make different result. The color table is only an experience, so in fact, we can adjust it according to the relief feature and special purpose and other principle. Figure 1 is the relief shading map with the default condition, and the solid black line on it shows the bound of the area being adjusted, in this region, the dash line is used to decide the main ridge direction, then according to dash line, the of new light direction is perpendicular to the ridge direction. Figure 2 is an adjusted result.

Table 1. The parameter table of the rules about colors

The range of elevation (Meter)	RGB Value		
-99999~ -200	101	146	186
-200~0	98	176	245
0~200	0	136	66
200~500	0	189	98
500~800	68	235	133
800~1000	215	238	178
1000~1500	255	222	154
1500~2000	255	210	140
2000~3500	230	146	96
3500~5000	197	162	139
5000～5500	185	159	139
5500～6000	140	133	132
6000～7000	100	123	132
7000～8000	255	255	255
8000~	153	154	242

Figure 1. Hill-shading with the default light

Figure 2. Hill-shading with local adjustment

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Principal Research Fields:
Thematic map design.
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Automated map generalization
Intelligent geographic information handling
Development of GIS software
Geographic spatial reasoning and its application in map design and generalization
Visualization of geographic information
Web map design and generalization
Land suitability evaluation model and LIS