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SPATIAL VISUALIZATION BY SHADED IMAGES: 3D SCENES AT 2D GIS ENVIRONMENT

Visualização Espacial por Imagens Sombreadas:Cenas 3D em Ambiente de SIG 2D

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RESUMO

Com o avanço tecnológico e a popularização dos computadores pessoais foi permitido ao usuário gerar produtos para a representação do terreno, e com esse impacto no desenvolvimento de ferramentas computacionais permitiu que investigações científicas e do ambiente pudessem ser rapidamente executadas. Mas essa expansão, por sua vez, pode conduzir a informação que chega até o usuário com um significativo acúmulo de erros. Neste trabalho avaliou-se como a interferência existente na visualização de ambientes 3D em ambientes 2D é capaz de remeter mesmo usuários experientes, a erros de interpretação. Com os resultados obtidos, vale a pena ressaltar que todos os usuários relataram algum problema na interpretação e visualização dos produtos aqui analisados, o que incita a importância de pesquisas que analisam tais estruturas.

Palavras chaves: Visualização Espacial, 3D, Ambiente SIG.

ABSTRACT

Technological advancements and the creation of personal computers allowed that the cartography and its techniques has grown but in other hand in this way the information that reaches to the end user contains a large quantity of error accumulation: is this a guilt of cartographers, GIS environments or users? In this paper we had the intention to examine how the interference in the visualization of 3D environments in 2D GIS environments is able to send experienced users to misinterpretation. With the results of tests we can mentioning that all users reported some problem in the interpretation and visualization of the products here analysed which urges the importance of studies that examine this kind of structures.

Keywords: Spatial Visualization, 3D, GIS Environment.

1. INTRODUÇÃO

Maps are graphical tools very effective in the way of projection of space in both digital and analogical environments. In addition, they can help people in common tasks, or at least could help in many different activities.

With technological advancement and the creation of personal computers, the cartography and the computational techniques have expanded youselves so much that sometimes the information that reaches to the end user contains a large quantity of error accumulation. These errors are inherent of a process of popularization of cartographic products in the stage of mapmaking where there are many professionals that are not educated to make these documents good enough to the reading stage. Now the users have to learn how to work with maps and how to produce the information in the maps. This means that in the process of cartographic communication the user ceases to be an element of "spectator" to interact with the knowledge and to assess the use of maps, in addition, in this context, maps may be viewed as tools of visual analysis, which can be interpreted as a breakthrough in digital mapping (SLUTER, 2001, p. 51).

Caquard (2009, p. 46) indicates that in a virtualized world anyone can easily visit different places, flying through landscapes never seen before, visiting cities, finding shortest paths, measure distances, make comments, see all sorts of data, listen to audio documents and watch videos. Caquard explain also that these different functions summarize the contemporary potential of digital mapping: interactivity, animation, multimedia, spatial analysis, changes in perspective, zooming, instant updating and dissemination of data.

When computational tools are developed and allow that the user understand the phenomena in situations whose purposes may be planning or scientific studies, the use of maps exceeds the paradigm of communication (SLUTER, 2000). In this case, these tools may allow the user to explore the data seeking the acquisition of knowledge and communicate the results.

Cartwright (2009, p. 24) states as Caquard that the maps are the first tools that tourists use to locate an unknown city in order to become familiar with the layout of the elements of the area they are visiting and also states that these maps may come from different sources on the web. Perkins (2008, p. 151) indicates that personal computers allow different types of user interaction with maps and the Internet makes it possible to update the data contained in the maps almost simultaneously with what happens in reality. This idea combines with the propositions of Sluter (2001), Caquard (2009) and Cartwright (2009).

Thus, according to Sluter (2001, p. 46) if maps are analysis tools they are used both to study the characteristics of geographic phenomena and synthesize solutions and also to present results. Maps and its analysis are tools of cartographic visualization process and this is more comprehensive than the process of cartographic communication. In this context, we can say that to meet this new demand for production of maps, who has changed was the paradigm in the communication process: in this case, the map viewing and the ability of expert systems that assists the user in decision-making were themes were that integrated in the research and works in cartography.

On behalf of facilities created to meet the needs of a new society, where information is revealed almost in real time what we see today in the bias of the professionals who produce maps is a certain lack of preparation or some kind of easy-going since the design phase mapping phase until map reading stage. The Geographic Information Systems on the market evolve in relation to the graphical interface and spatial analysis tools on their systems, allowing that each day new users coming to this area without a minimum knowledge about the mapping project.

In this study we do not intend question the universal use of cartographic products or to disqualify the products generated by professionals who use the maps as spatial analysis tools we want to show errors inherent of process and the pre-processing of spatial data which may be associated with this universal and increasing demands. We sought through a semi-structured questionnaire investigate the differences in interpretation of users who have had experiences with the product under consideration (radar images) and made it based on the concepts proposed by Kraak (1988) which will be aimed more at forward. We also used the propositions made by Rosch et al (1976) which describes the hierarchy of mental categorization to classify levels of mental categorization used by the interviewees to manipulate images and information from the profile view of the area mentally. These propositions are clarified subsequently the description of processes of Kraak (1988).

1.1 Processes that have influence in the visual acuity

The world is perceived and seen in the third dimension. Thus, it is natural that emerged over the years products (or ways of viewing) which show the world in the way we see it: 3D.

According to Kraak (1988), if there is a concern with the representations in 2D and its communicative quality and level of information, in 3D could not be different. In this case, it is requested different parameters to analyze the efficiency of cartographic communication in 3D maps than the others whose is used in the evaluation of 2D maps.

Kraak (1988) indicates that it is important to understand the processes that have influence in the visual acuity in relation to representations in 3D to evaluate in the better way the concepts that are applying in the process of production of maps with a good quality. Nevertheless, it is necessary to apply these concepts in the computing environment since sought the demand growing for products that use computer technology in their presentation.

Kraak (1988, p. 53) points the factors that have influence in the visual acuity when we are looking at products in 3D:

a) Physiological characteristics, which are: accommodation, binocular disparity, monocular motion parallax and convergence;

b) Psychological characteristics, which are: retinal image size, linear perspective, area perspective, obstruction / overlay, masks, texture and color.

In this research we will give focus to the psychological characteristics. It does not mean that the physiological factors are not present in testing proposed here but they will have not impact immediately because the authors ensured interviewing people already habituated in the use of the products presented to them. Therefore, we evaluated the interpretation of respondents from the perspective of psychological interference of spatial visualization.

To draw the best discussion of the results in psychological context it is necessary to make a brief reference of the basic level categories proposed by Rosch et al. (1976).

1.2 Basic level categories

According to Bravo et al. (2011), Rosch proposes a hierarchy of cognitive structure or abstraction of the people in which the maximum degree of abstraction demand greater amount of knowledge and reasoning when it intends to recognize objects or to relations between objects this ratio will decreasing until the minimum degree asks the person under commitment to the classification and relationship of objects. The proposed classification is:

a) Superordinate level: high level of abstraction, use of cognition;

b) Basic level: it do not makes relationships very complex, but not so simple (cognition/perception);

a) Subordinate level: low level of abstraction, use of perception.

In his reflections MacEachren (1995) brings these concepts of classification categories proposed by Rosch et al (1976) to Cartographic Science and make them applicable to the categorization of objects of study of this science. He indicates that we can sort and observe the levels of abstraction that people use to read maps. He also mentioned that there are two moments: the first is when the perception is acting and the user has using the partonomy; in a second moment who acts is the taxonomy, guided by cognition of this user. In this context, the partonomy of MacEachren is equivalent to the lower levels of abstraction mentioned by Rosch et al (1976) and the taxonomy with the relationships more complex.

Thus, following these hierarchical relationships we could identified the degree of abstraction and which agents (perception and cognition) are acting “in the mind” of users when they respond to the questionnaire.

2. Materials and Methods

2.1 Methodology

The methodology chosen for the interviews and selection of interviewees was that proposed by Suchan and Brewer (2000) that suggest the qualitative method of analysis.

The qualitative method allows to choose a smaller number of participants. In the case of this research we interviewed four persons without having affected the quality of results and analysis which excludes the need for a statistical analysis of results.

As regards the development of tests followed the schedule presented in the sequence.

2.2 Materials

It was used a radar image (Sheet SF-22-YB), coming from SRTM program (Shuttle Radar Topography Mission), reprocessed by the TOPODATA project (Valeriano, 2005), available on the website of the INPE (National Institute for Space Research - Brazil).

2.3 Processing and introduction of data in GIS environment

The image was imported into the software Spring v.5.1 in the NTM category (Numerical Terrain Model) and two shaded images were generated.

The generation of shaded images was performed using three parameters: the illumination azimuth, elevation and exaggeration of relief. The azimuth is the azimuth of the illumination light source with respect to North (True North or zero degree) (Figure 2), elevation is the angle of this source with the horizontal plane (Figure 3) and exaggeration is the difference between the vertical scale and horizontal scale.

The Figures 2 and 3 depict the azimuth lighting scheme in shaded images and to rise in shaded images.

We developed four different figures: two monochromatic and two color. Only one variable was changed in the preparation of figures: the azimuth of illumination. We made two images with azimuth 45 degrees (with monochromatic form and with color) and two with azimuth 225 degrees with the same method.

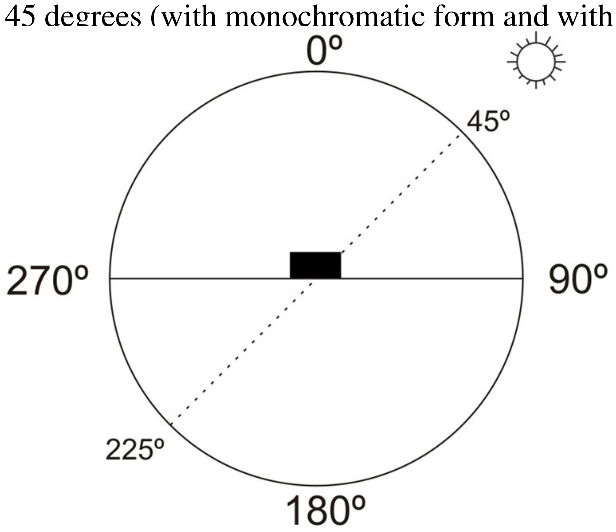

Fig. 1 – Example of azimuth of illumination in shaded images.

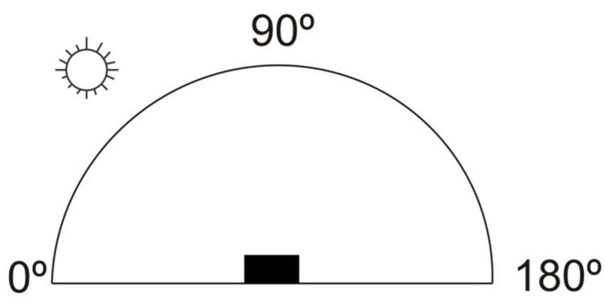

Fig.2 – Example of elevation in shaded images.

2.4 Participants and test environment

All participants had previous contact with others shaded images in theirs life and it is a fact that ruled out the training session because the interest was to know what they were seeing when they are reading this kind of product and what is the difference between them? In addition, volunteers and the education level of participants is: two are Geographers and two are undergraduate students in geography (an academic of 3rd year and the other of the 4th).

It should be noted that each participant had 15 seconds to observe each image and was given a 2 minute interval between one image and another.

The images were shown on the screen with white ground. It was considered the approximate distance of 25 cm to the center point of the delimitation of the screen set. This procedure was adopted to allow discrimination of small details, avoiding problems with peripheral vision.

2.5 Test Questions

The figures were presented separately to the users and were answered two questions for each figure. The first pointed to what they see in the picture and the second was directed to the reading of the elements seen (valley bottoms, high and low areas). Applied the questionnaire the users were asked about the readability of the figures in monochromatic and polychromatic forms.

The questions in the questionnaire were:

1. What do you see in the picture?
2. Why do you see these elements?

In the first question aimed to instigate long-term memory of respondents and the second question was intended to observe the characteristic features of respondents to identifying the elements and evaluate the influence of lighting in monochromatic and polychromatic forms.

3. RESULTS AND DISCUSSIONS

To this research four figures were prepared with suggestions of similar depth defined as pictorial shading. Two of these figures were compiled from different points of lights, with monochromatic values (Figures 3 and 4) and the other two had the same points of light but with polychromatic form (Figures 5 and 6).

After to apply the questionnaires, the answers were summarized and presented in the manner as follows.

The user 1 reported that in all the figures analyzed what was most evident was the presence of drainage channels. According to this user the Figure 3 gives the impression of the topography of the area. In the Figure 4 the first user said that the lighting did not interfere in the analysis. When we asked about Figures 5 and 6 the first user seek drainage channels and said that "the greatest evidence of the difference of the illumination angle is the position of shadows, where this figure has grooves that seem deeper." According to the user this figure is less prone to the phenomenon of inversion of relief. These detailed and more accurately answers indicate the presence of cognitive elements at the time of evaluated. Nevertheless, this user will not fail to interpretation hence the representation given to their proposal presentation. Rosch et al (1976) classify this type of relationship as the superordinate level and MacEachren (1995)

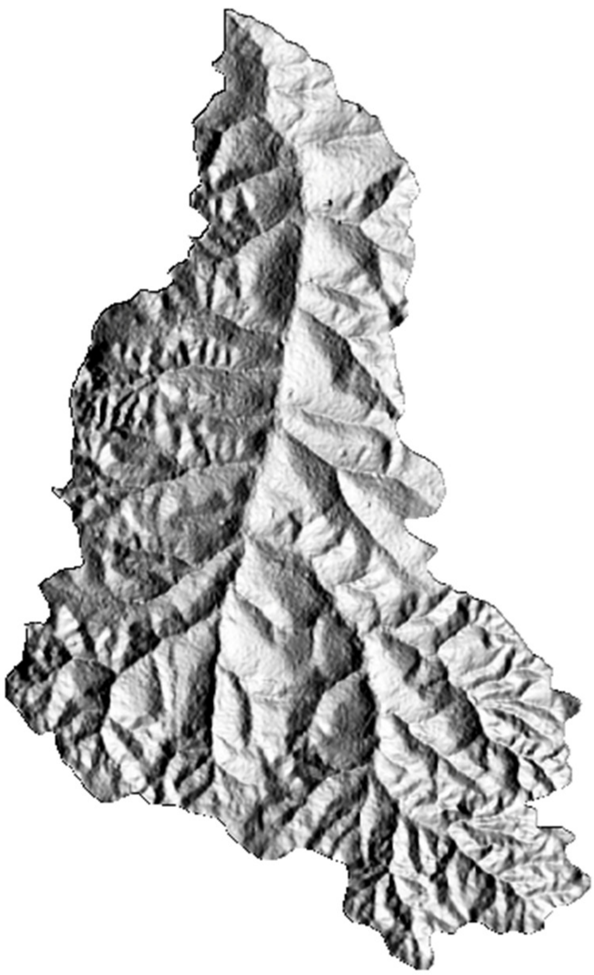

Fig. 3 – Monochromatic shaded image with azimuth of illumination by 45 degrees.

Fig. 4 – Monochromatic shaded image with azimuth of illumination by 225 degrees.

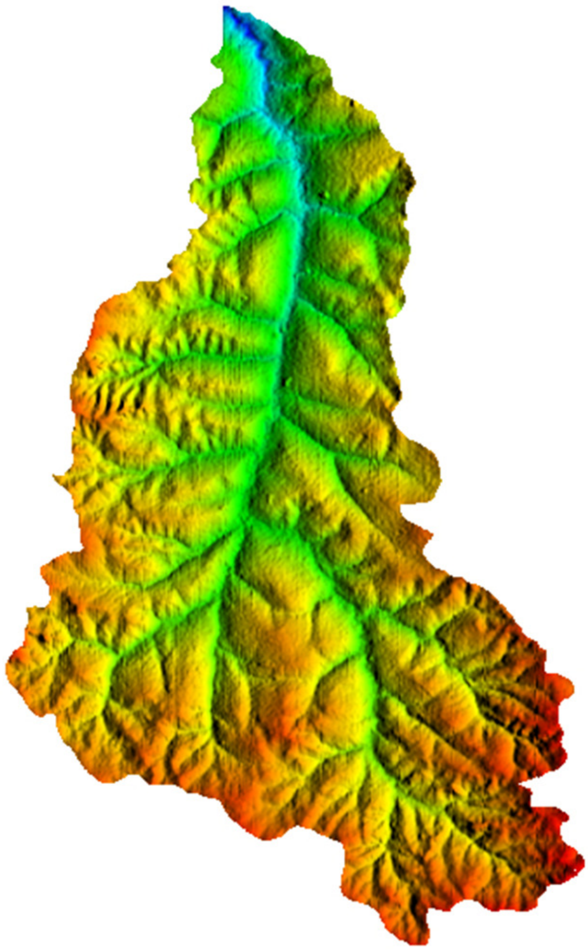

Fig. 5 – Polychromatic shaded image with the azimuth of illumination by 45 degrees.

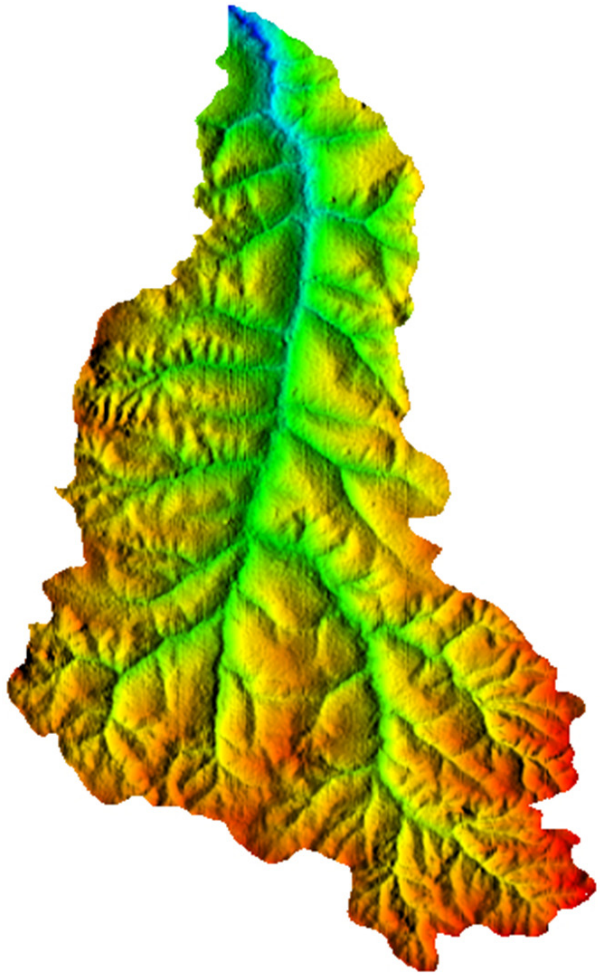

Fig. 6 – Polychromatic shaded image with the azimuth of illumination by 45 degrees.

as taxonomy. In this case, there is no interference of psychological elements proposed by Kraak (1988).

User 2 reported that in all the figures analyzed what was most evident was the presence of drainage channels. On Figure 3, the user said that the difference between the lower and higher areas is clear but at times had the feeling of relief and reversal of the shading signifies that allowed them to visualize the features of relief. With respect to Figure 4, the second user said it was evident the presence of valleys, and these were more apparent than in Figure 3, and further states that the shading in Figure 4 was more satisfactory than that indicated in the third to understand the image. On Figures 5 and 6, the user said the two drainage channels were evident and that this evidence was applied because the colors in the image facilitated the understanding of them. Despite the apparent difficulty, this person used the cognitive elements in its interpretation detailing the objectives and analyzing the observed angle of illumination which is indicated by Rosch as the superordinate level and MacEachren as taxonomy, as had been classified as the first interviewed. The representation reached its proposal with the user as well. There was not interference of psychological elements in the answers.

The user 3 unlike the users 1 and 2 said that higher features (ridges) were more evident in Figures 3 and 5. With respect to Figures 4 and 6 the user said that the drainage channels were highlighted. According to the user the shading of the images was possible that such an interpretation. The smallest detail in the responses indicates the presence of a lower level of abstraction but not a little complex, because the participant was able to observe two images in the correct form of relief. Rosch et al (1976) speaks of similar aspects as concepts of basic level of abstraction at which the relations are not too many complex but not so simple. In MacEachren (1995), the classification is simple: when you see some cognitive relation we can affirm taxonomic action. There was interference of psychological texture and color elements proposed by Kraak (1988).

User 4 said that in Figures 3 and 5 was in evidence drainage channels perceived by shading across the image. From Figures 4 and 6 the user claims to have realized that they were the drainage channels the higher areas (crests). This user also said that it was confused with the images and to observe a period of time after the same figure these were perceived differently. There is an interference of psychological elements in this case by the texture and color that was described by Kraak (1988). To this user the texture is an important factor in visual acuity and it interferes in their interpretation of the space relationships represented. Rosch et al. (1976) could classify their relationships as basic and MacEachren (1995) as taxonomic. The representation has suffered from the failures of the transmission of information, suggested by the interferences.

In addition, users 2, 3 and 4 said that the polychromatic figures were more understandable than the monochromatic figures and they believe that this variable may lead to different analysis.

Goldberg et al (1992) describes a similar situation when they investigate the representations and 3D visualization and the differences that exist when be changed some elements that make up the representations. They indicate that by varying the azimuth and elevation in the 3D representation, users have difficulty viewing the same situation. But they describe that this kind of representation has a very singular effect as the formation of the mental image of the ground. They pointed that the impact of those representations is great in the human ability to form and manipulate the view of terrain.

Despite the intensive use of cognitive elements, and the experience of respondents, there were failures in the transmission of spatial information guided in this case by the psychological elements. This is important to note being possible to reflect on how these products will be presented as well as the purpose and usability of them.

4. CONCLUSIONS

Taking into account the figures presented and their respective azimuths of illumination (Figure 3 and 4 with 45° azimuth and Figures 4 and 6 with 225° azimuth), Figures 3and 5 show a relief with the presence of valleys and Figures 4 and 6 have a layover with valleys reversed giving the appearance of ridges. Only one of the users interviewed could see the three-dimensional scenes in a manner consistent with the data presented at all times. However, this user said he had problems with this view and sometimes the images were perceived differently. In this case, the error is inherent in the process and the pre-processing of spatial data, which encourages the user to interpret the data in a manner that is inconsistent with reality.

The diversity of responses found after search with these experienced users allowed us to understand the necessity of applying different variables to represent three-dimensional scenes into two-dimensional environments, which underscores the importance of research aimed at understanding the 3D spatial visualization in a GIS environment.

Goldberg et al (1992) indicate that it is necessary to have research aimed at understanding the influence that this kind of representation has on the spatial visualization. They also indicate that much of the cartographic activities are concentrated and require the use of 3D representations. So clear are the reasons why we should have care in presenting the products generated 3D environments such as the correct visualization can be difficult at the moment that a variable is set so that the user does not refer to reality.

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