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METHOD TO MIMIC ENVIRONMENT SHAPES AND COLORS USING FRACTAL THEORY

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Abstract. This paper presents a scientific solution for generating shapes and colors to mimic the environment. The replication model for the shapes and colors from the nature presented in this paper is based on using intelligent software programming solutions that are able to identify colors, shapes and their distribution from a set of digital images. The achieved replication model covers a broader range of spatial frequencies, which offers the advantage of using the same pattern for multiple observation ranges. The pattern and spatial frequencies of the shapes are generated so as to provide an accurate mimic for a defined range.

Key words: shapes, colors, replication, fractals, camouflage, mimic.

1. INTRODUCTION

One of the military clothing objectives is to ensure protection by camouflage in order to not be detected by an opposing site. This attribute is generically called indirect protection. In this way, clothing must provide adequate mimic of the environment where the military conducts the missions.

Achieving the mimic involves finding scientific solutions to accurately reproduce the environment represented by shapes and colors. This is possible by using such intelligent programming solutions that are able to identify the colors, shapes and their distribution in nature.

The models used for shapes and colors replications are composed of a set of irregular patterns. The pattern dimensions are designed to provide a certain observation range. Obviously, the generated colors must ensure the replication of the environment colors.

A particular model for shapes and colors replications has specific dimensions associated to irregular patterns of the environment; so, if the shapes are too large or too small they will be different from the structure of the environment and will be easily detected. Therefore, we can predict that a certain model for shapes and colors replication is effective in a particular environment and for a narrow range of observation distances.

A replication model developed following the scientific research using fractal theory can cover a broader range of spatial frequencies, which offers the advantage of using the same model for multiple ranges [1, 2, 3].

2. MODELING METHODS

2.1. GENERAL APPROACH

To achieve the proposed objective, namely the generation of models for shapes and colors replication from the nature, in the research process it was used the fractal theory, based on the assumption that fractals are shapes that have similar characteristics at different scales and that a fractal has similar geometric characteristics when it is observed from different ranges.

An ideal fractal should be formed of an infinite amount of points, although this is impossible to achieve in numerical computations. The examined set has to be consisted of a large enough number of points so the fractal properties could become apparent. Thus the fractal dimension depends on the amount of points [4].

Fractals used in the replication process were built by repeating infinitely a certain generation rule, whereby the original picture, called base is replaced with another one, called the subject, in which the original picture is found several times at a low scale, rotated, mirrored or translated (Fig. 1).

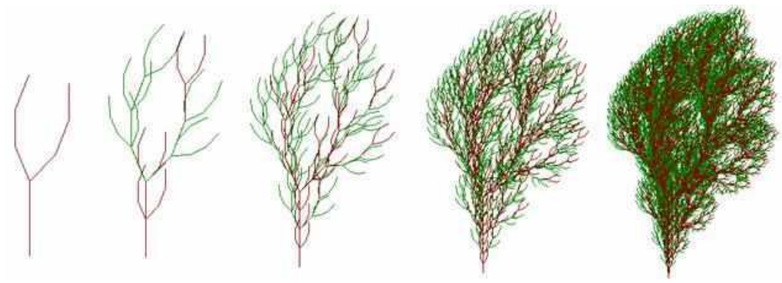

Fig. 1 – Example of sequentially generation of a tree [5].

In the process of shapes and colors replications from the nature, the created fractals contain [6]: *the initiator (base)* – represents the geometric shape from which fractal generation begins (typically, the initiator is a simple geometric figure shaped like a line, triangle, square); *the construction law* – it provides fractal generation method (it specifies what is changed when passing from an iteration to the next); and *the generation process* – is the one that actually builds the iterations of fractal object, starting from its current iteration and applying the construction law. Each of the iterations defines a new generation of fractal crowd (Fig. 2).

Fig. 2 – Example of fractal landscape [5].

2.2. APPLIED MODELS

Determination of shapes from nature involves, first of all, creating a process of segmentation of a digital image with a 512×512 pixels resolution, which identifies each pixel positioned at the edge of the image segment.

This process was based on the fact that the human visual system uses a two-dimensional examination (2D) to access the memory and operates also two-dimensional, not three-dimensional (3D). The specialized literature indicates that object recognition by the human visual system is performed following an image segmentation process [7].

The phenomenon of object detection is presented in specialized literature rather insufficient. The segmentation process is a mandatory condition for a system fitted with the ability to identify objects in the scene. However, there may be situations in which the internal structure of the contours determination mechanism is sufficiently robust to ensure identification of the object, without prior segmentation [8]. This phenomenon may occur even in the human visual system.

In this case, the segmentation of the digital image acquired from the field was performed by three methods based on pixel decomposition, contour detection and region detection [6, 7].

In order to generate replication patterns shapes and colors of nature, based on a series of digital images acquired in the field, mathematical techniques were developed that apply to certain features of the images, such as color content, texture, gray scale statistics, pixel correlation and spatial frequencies in the image. All these processes have led to some artificial images that reproduce with some fidelity, an area of interest in nature [9]. This algorithm is schematically illustrated in Fig. 3.

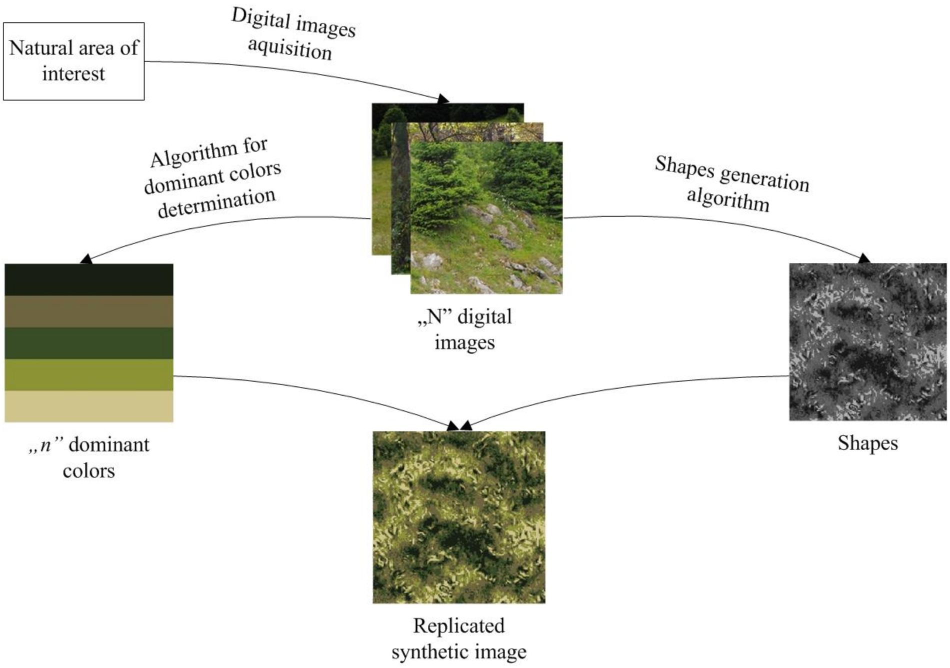

Fig. 3 – Schematic representation of the process for generating synthetic replication image.

3. DISCUSSION

The algorithm for camouflage pattern generation by replicating the shapes and colors from nature, as shown in Fig. 3, has several determinant steps. Thus, the replication requirements should contain information about the geographical area of interest and considered observation ranges.

In the acquisition process of the images used for camouflage pattern generation procedure, the images were calibrated for color matching. For this, we used one of the methods available for color correction [10] according to image acquisition conditions. Also, the images needed to contain representative scenes, avoiding unique elements, like water surfaces or sky. The database with images from area of interest contains almost all geographic regions of Romania.

Extracting dominant colors from a geographical area of interest was achieved by processing the digital images acquired with special software designed for this purpose.

For Romania's geographical area, on a sample of 1500 digital images, there were obtained the following five dominant colors, as presented in Table 1.

Table 1

Dominant color values and their weight

	RGB* value	CIE L a b value [11]	Percentage	Pantone** counterpart
Color 1	R=24 G=31 B=20	L = 11 a = –5 b = 6	28,22%	Pantone 419C
Color 2	R=56 G=74 B=37	L = 29 a = –13 b = 20	21,50%	Pantone 574C
Color 3	R=140 G=146 B=56	L = 59 a = –11 b = 45	20,35%	Pantone 7495C
Color 4	R=110 G=100 B=63	L = 43 a = 0 b = 22	16,44%	Pantone 7497C
Color 5	R=207 G=196 B=139	L = 79 a = –2 b = 30	13,49%	Pantone 4525C

*R = Red, G = Green, B = Blue.

Camouflage pattern generation in order to apply it on a fabric involves overlapping dominant colors, with their respective weights, on the shapes extracted from acquired digital images. This process will result in an artificial image (Fig. 4) with characteristics similar to source images.

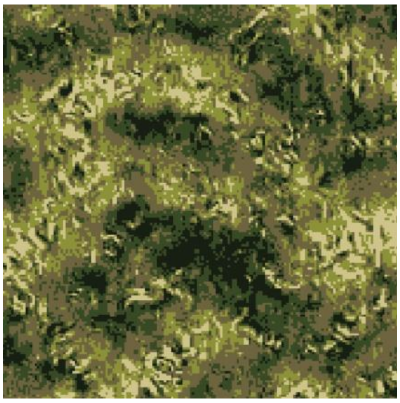

Fig. 4 – Example of replicated digital image.

The resolution of the replicated digital model and the color range largely depend on the application process of the model on the support material. Thus, painting involves larger pixels and fewer colors, while printing involves much smaller pixels and more colors can be realized.

From considerations of ensuring the effectiveness of camouflage for a minimum range, assuming that the subject should not be detected by the human visual system [12], the pixels size impressed by both painting and printing process is determined using the following mathematical relationship:

** Pantone® is a registered Trademark of Pantone Inc., Carlstadt, New Jersey.

$$l = D/\mathrm{tg}(\alpha), \tag{1}$$

where l is the maximum size of the pixel, D is the minimum range that ensures efficiency of camouflage, and α is the angular resolution of the observation system.

4. CONCLUSIONS

The algorithm of generating a replication model shapes and colors of nature can be applied to any digital image, regardless of natural fractal characteristics of the image. If the source image contains few elements of natural fractals, obtained replication model may not fit well with the scene of interest. If the source image contains many elements of natural fractals, texture obtained model will maintain its characteristics change scale artificial image generated. This means that the image synthetically replicated observed from high ranges, will present the general characteristics similar to those of the environment, and at short ranges will notice fine details like the background observed at the same distance. This phenomenon does not happen in the case of traditional camouflage patterns that imitate the background only for high observation ranges.

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