

Research on Digital Camouflage Design and Camouflage Material of Tent Cloth

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Abstract—Aiming at the distortion of texture details in Digital Camouflage design, as well as the poor camouflage performance, fast fading and short life of camouflage tent cloth, this paper presents a design method of Digital Camouflage based on target background, develops a camouflage coating with good weather resistance, color difference and spectral reflectance meeting the limited requirements, and realizes the paint printing of camouflage tent cloth. The results show that the digital camouflage pattern designed by this method can be printed on the surface of camouflage tent cloth by coating printing process, which can effectively change the original contour of the target tent, make it better integrate with the surrounding background, reduce the probability of detection, and achieve good camouflage effect.

Keywords-Digital Camouflage; Tent Cloth; Target Background; Design; Camouflage Coatings; Paint Printing

I. INTRODUCTION

With the rapid development of space and space reconnaissance technology, the resolution of satellite

imaging reconnaissance to the ground is getting higher and higher. Camouflage camouflage, as the most basic measure against military reconnaissance and weapon attack, is a common method of "weapon equipment" anti-reconnaissance detection, and also an important symbol of the camouflage technology level of a country.

In the reconnaissance environment of multi-dimension, intelligence and fine resolution, the camouflage function of traditional camouflage is basically lost. As a new type of camouflage pattern, digital camouflage is a kind of camouflage pattern which uses computer image technology to extract the basic features of natural background such as color, texture, structure and so on, and displays in the form of digital "pixel" dot matrix. It copies the camouflage pattern on the target surface by camouflage paint, imitates the background or divides the outline of the target shape in color and texture, greatly improves the adaptability of digital camouflage to different landforms, and has greater concealment advantage than traditional camouflage.

As the backbone equipment of army camping, military tents play an important role in training and executing tasks. Tent cloth is the main material for making military tents. Its camouflage performance determines the camouflage effect of the tent. Therefore, the key to improve camouflage performance is to design scientific Digital Camouflage Patterns and print them on tent cloth.

This paper studies the design and implementation process of camouflage. Firstly, a new design method of digital camouflage is proposed. The digital camouflage pattern is designed by simulating the color and texture of the target background. Secondly, the camouflage pattern will be printed on the tent cloth by using inorganic pigment printing technology, and then the tent cloth will be made into military camouflage tent, which can improve the camouflage performance, weatherability and service life of the tent.

II. MAIN PROBLEMS OF CAMOUFLAGE TENT CLOTH AT PRESENT

Tent cloth is the main material for making military tents. At present, there are two main problems in military tent cloth.

First, the texture details of the camouflage pattern are distorted, so that the fusion effect with the natural background is not good. At present, many army tents still use traditional camouflage patterns, which are not in harmony with the surrounding background.

Second, the camouflage performance of tent cloth is poor, weatherproof performance is not good, and the service life is short. At present, most camouflage tent cloths are printed and dyed with organic dyes. Their camouflage performance can not meet the requirements of spectral reflectance limitation. Moreover, they are affected by strong ultraviolet rays, high temperature and high humidity in the field. After three months, the camouflage pattern will fade seriously and disappear, so they can not be used normally.

In order to solve the above problems, three measures are adopted. Firstly, by extracting the basic features of natural background, the size of digital unit that can simulate the texture features of background is determined, and then the digital camouflage pattern is designed [1]. Second, by developing inorganic functional pigments and researching the weather resistant printing emulsion synthesis technology, the camouflage of camouflage patches can meet the requirement of spectral reflectivity, and improve the weatherability and service life of the tent. Thirdly, paint printing technology of inorganic functional pigments was used to print the surface of tent cloth, and good simulation performance was obtained.

III. DESIGN OF DIGITAL CAMOUFLAGE PATTERNS

The steps of digital camouflage design are shown in Figure 1[1-3].

Assuming the number of dominant colors in the target background is $N(3 \leq N \leq 6)$, the main steps of digital camouflage design are as follows:

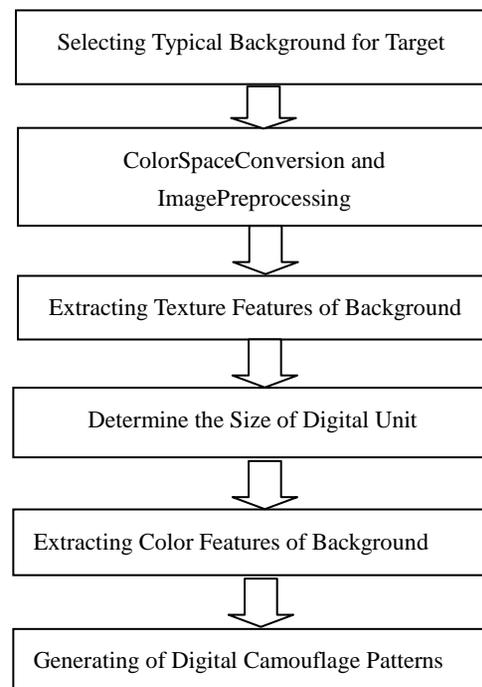


Figure 1. Design flow of Digital Camouflage

1) *Select the typical background of the target*

Analyzing the surrounding environment of the target, the selected background area is within 16-32 times the size of the target area. The background image of the target is captured by digital camera, UAV and other image recording devices. The background types that can represent typical environmental characteristics are analyzed and determined. Several typical background images are selected as background image M to be processed.

2) *Color space conversion and image preprocessing*

The principle of choosing color space is to see whether it is suitable for human visual characteristics and color perception characteristics. At present, the commonly used color space is HIS, HSV, Lab model, etc. Image M should be converted from RGB space to other color space, calculated and processed accordingly, and then converted back to RGB space for display. Before image M processing, appropriate filtering methods should be adopted to eliminate and reduce the noise of the image, so as to increase the reliability and validity of the image.

3) *Texture feature extraction of image M. For N-color Digital Camouflage design, 2N-1 order texture needs to be extracted.*

4) *Determine the size of digital units (i.e. mosaic squares), and design the arrangement and layout of mosaic squares.*

5) *Color feature extraction of image M. According to the region divided by each gray scale corresponding to the target image M, the individual color features of each region are calculated to obtain the characteristic color, and these colors are arranged according to the gray value.*

6) *Digital camouflage pattern generation.* The above arranged colors are filled into the corresponding areas of mosaic gray-scale image in turn, so that the digital camouflage pattern can be obtained.

After obtaining the final Digital Camouflage pattern, we are ready to print the pattern onto the tent cloth.

IV. DEVELOPMENT OF CAMOUFLAGE PIGMENTS AND PREPARATION OF COATINGS

Inorganic pigments determine the weatherability and camouflage performance of tent cloth[4], and can solve the key problems of fast fading and short life of tent cloth materials in the field environment. In this paper, the green camouflage ceramic pigments system was developed by firing green camouflage functional ceramic pigments. Aiming at the technical requirements of camouflage camouflage background, a set of camouflage coatings with good weatherability, color difference and spectral reflectivity to meet the limited requirements was developed by studying the special printing emulsion and functional inorganic pigment system of acrylic ester.

Through a series of experiments, four camouflage colors, dark green, medium green, yellow green and black, were identified, and polyacrylate emulsion was synthesized. Finally, the camouflage coatings with four colors were prepared through the formulation test of the coatings. Table 1 shows the formulation of woodland inorganic pigment printing paint.

TABLE I. FORMULATION OF INORGANIC PIGMENT PRINTING COATING ON WOODLAND TYPE

Camouflage type		Woodland			
Item		Forest green(g)	Medium green(g)	Kelly (g)	Black (g)
Raw material	Polyacrylate emulsion	40	40	40	40
	Homemade green pigment	35	30	28	15
	Iron yellow	/	5	7	/
	Iron red	/	/	/	/
	Iron black	/	/	/	20
	Additive	8	8	8	8
	Water	17	17	17	17

V. PAINT PRINTING OF CAMOUFLAGE TENT CLOTH

After preparing the four-color camouflage coatings mentioned above, the camouflage coatings are printed on the surface of the cloth with polyester base cloth and circular screen printing technology[5]. The camouflage coatings are printed on the surface of the cloth by the coating printing process, and then baked to make the camouflage patterns firmly fixed on the cloth and become camouflage coated cloth, i.e. camouflage tent cloth. This completes the printing of Digital Camouflage Patterns on the tent cloth. The process is shown in Figure 2. Finally, the tent cloth is made into field military tents and placed in the original natural background.



Figure 2. Paint printing of tent cloth

VI. CAMOUFLAGE PERFORMANCE EVALUATION OF CAMOUFLAGE TENT CLOTH

A. Camouflage performance evaluation of tent cloth

The main camouflage performance indicators of camouflage tent cloth include: color difference, spectral reflectance.

Digital camouflage tent cloth produced with inorganic pigments is compared with standard color. The color difference of each color patch is less than $3L^*a^*b^*$ unit, which meets the color difference requirement.

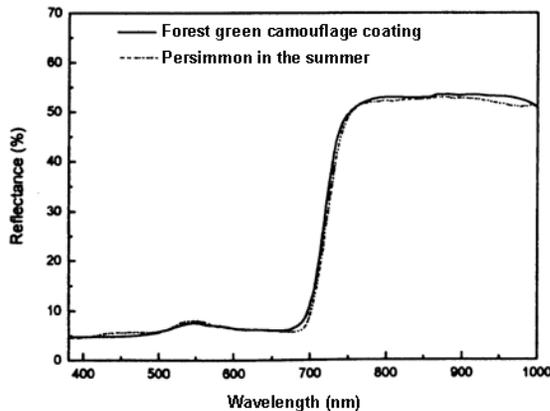
The Digital Camouflage tent cloth produced with inorganic pigments is consistent with the spectral reflectance characteristics of the corresponding natural background, which meets the limited requirements of spectral reflectance.

In terms of weatherability of tent cloth, after 400 hours of artificial climate aging, the color difference of each color patch is $2-3L^*a^*b^*$ unit, and the spectral reflectance of each color patch is basically unchanged.

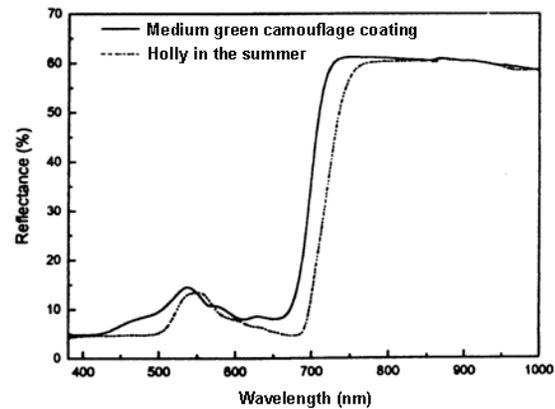
For example, in Figure 3, pictures (a) and (b) show the spectral reflection characteristics of dark green and

medium green coatings, respectively. It can be seen that the spectral reflectance characteristics of the two

green patches are consistent with those of the corresponding vegetation.



(a) forest green coating and persimmon tree;



(b) medium green coating and holly tree.

Figure 3. Spectral reflectance of forest/medium green coatings and plants.

B. Actual camouflage effect

In order to observe the actual camouflage effect of the tent cloth, the Digital Camouflage tent cloth produced in front of it was made into a tent and placed in the forest background in the field. As shown in Figure 4. Picture (a) is the original woodland

background. Picture (b) is our Digital Camouflage design. Figure (c) shows the camouflage effect of woodland tents. The red pane represents the target. Obviously, the Digital Camouflage of woodland tents is almost integrated with the natural background.



(a) woodland background; (b) designed digital camouflage; (c) camouflaged effect

Figure 4. Woodland type camouflage effect

VII. CONCLUSION

In this paper, camouflage design, camouflage material development and production in camouflage camouflage have carried out a series of research. Aiming at the problem of texture distortion in camouflage design, a design method of Digital

Camouflage based on background features is proposed. Aiming at the problems of poor camouflage performance, fast fading and short life of tent cloth, camouflage coatings with good weather resistance, color difference and spectral reflectance satisfying the limited requirements are developed, and Digital

Camouflage tent cloth is produced by coating printing process. After testing, the camouflage performance of tent cloth meets the requirements and the camouflage effect is good. It is of great significance to improve the level of camouflage design and technology implementation of Digital Camouflage in China, and to promote the development of camouflage materials and camouflage technology.

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