CamouLED: Real-Time Generation of Pixel Pattern for Camouflage

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Abstract. This study has developed CamouLED, which is a real-time patterning technique for active camouflage, using light emitting diodes (LED). Once a CMOS camera receives a background image, camouflage patterns are generated real-time by the patterning program. The major strategies for color combination include Average, Main and Mosaic. Two arrangement types (Arrange, Random) control background properties and distribution of pixels to generate patterns. The generated patterns are then displayed on an 8 x 8 LED matrix. The system provides over 85% of color consistency between the inputted and outputted colors. Future researches should concentrate on improving the fine details of the real-time patterning program as well as the LED controlling technique for better adaptive camouflage.

Keywords: active camouflage, visual stealth, camouflage patterning algorithm, adaptive pattern, real-time patterning.

1 Introduction

Camouflage or concealment concerns avoiding detection and preventing recogni-tion. This is highly affected by various factors such as season and surrounding environment [2]. Especially in today's combats, there is a growing need for new combat uniforms, as well as military strategies and weapons that have effective camouflage ability, known as active visual stealth.

Therefore, this study has developed a real-time patterning technique named CamouLED. Given a real scene, the patterning program previously invented by the authors [1] could generate only one type of camouflage pattern. Since then, improvements have been made to the program, and it is now able to generate six types of camouflage patterns. CamouLED attempts to take one step further, by using light emitting diodes (LED). A camera attached to the system reads the surrounding environment and an LED display dynamically changes its color pattern accordingly. The patterning program controls the displayed color patterns.

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2 Development of an Automatic Patterning Program

2.1 Color Strategies for Camouflage

In order to develop an algorithm for generating camouflage patterns, we have reviewed visual camouflage researches and devised several color combination strategies. Their effectiveness was then assessed via a photo simulation experiment. Three color combination and two digital pattern arrangement strategies were selected. Each one of them is described below (Fig. 1):

2.1.1 Color Combination Strategies

- Average: The entire background image is divided into a 3 x 3 grid. The average color of the target grid that contains the camouflaged pattern is used to generate a suitable pattern. Once a reference color is selected, its tone is adjusted according to its luminance to produce four colors that constitute the camouflage pattern. The colors are assigned to a specific location according to their familiarity to the target area.
- Main: Main color is the color that has the highest frequency in the entire background. Four colors with the highest frequency are selected, and they are arranged according to their frequency and the proportion of the area they occupy within the target area.
- Mosaic: A selected area is divided into units and the average color of the target unit is allocated.

2.1.2 Pattern Arrangement Strategies

- Arranged distribution: Original location of the pixels is preserved when a camouflage pattern is applied. Thus the edges of the object in the scene are identifiable.
- Random distribution: Original location of the pixels is ignored; they are randomly distributed. Thus the edges are disrupted.

Fig. 1. Sample patterns for each strategy

2.2 Automatic Patterning Program

Based on the pattern algorithms, a program that automatically generates pattern-stimuli under dynamic backgrounds was created. This allows easier generation of pixel-dot patterns for various backgrounds based on quantitative descriptions of background features, including color information. The program contains total six strategies, as each color combination strategy (Average, Main, Mosaic) can adopt two pattern arrangement strategies (Arranged, Random).

Also included in the program are pattern strategy preset and parameter (target size, array size, number of colors, seed size, threshold) control functions. It also allows preloading a background image, defining a target area, extracting camouflage colors and creating and saving pattern strategies. Thus once an image is loaded and the pattern strategy is determined, the program extracts camouflage colors according to the selected strategy and distributes them to create a digital pattern.

3 CamouLED: Real-Time Patterning for Camouflage

The camouflage patterns generated from the program were implemented on an 8 x 8 LED display. Several studies have discussed the effectiveness of lights as a means of active stealth. For example, in the project codename Yehudi, the US Navy used lights instead of colors to blend their aircraft into the sky background. Camouflage color was not of a concern, as the airplane would be a black dot against the sky. However, adjusting the light intensity to match that of the sky succeeded in making it less visible [3]. It is from this point that the current study attempted to implement the camouflage pattern on the LED display (Fig. 2).

Fig. 2. Overview of CamouLED

As an input device, CamouLED uses a CMOS camera to read the background scene (Fig. 3). Once an image is received through the camera via a CCD image sensor, it is processed by the patterning algorithm. The processed digital signal is then converted into an analog signal and sent over to the LED display. A color comparison test showed that the system provides over 85% of color concordance between the inputted and outputted colors (Fig. 4).

Fig. 3. CamouLED hardware

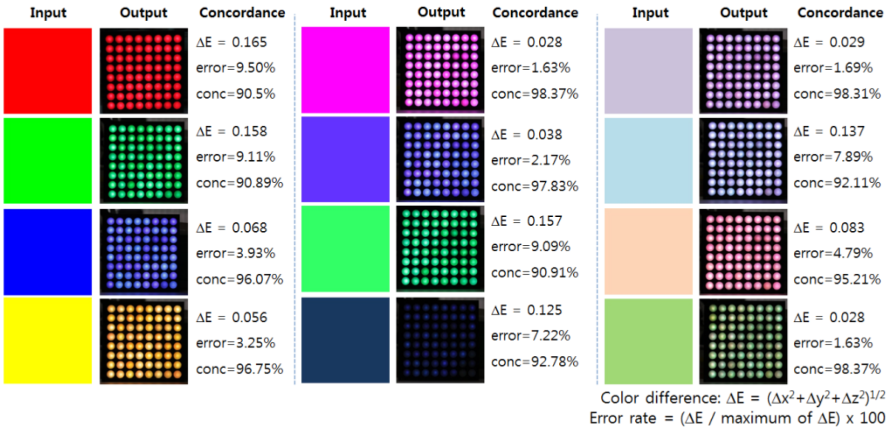

Fig. 4. Results from the color comparison test

4 Conclusion

The present study applied the patterning program to the real-time patterning system that uses an LED display. Future researches should concentrate on improving the fine details of the patterning program as well as the LED controlling technique for better adaptive camouflage. In addition, optical fibers are receiving much attention as a means of visual camouflage. Thus, the use of optical fibers instead of an LED display would broaden the system's application and use.

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