Camouflage Assessment of Color Pattern Strategies in Different Environmental Contexts

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Abstract. This study examined the effectiveness of adaptive camouflage patterns according to environmental contexts. We performed visual search tasks using photo simulation to evaluate the effectiveness of camouflage strategies. Pattern combination strategies from a previous study were used. Each one of the 4 strategies (Average [A], AverageRandom [AR], Main [M], and MainRandom [MR]) were presented in 3 environmental contexts (Woodland, Rural, and Urban), and performance (Error Rate) was measured. An analysis of performance revealed the main effect of strategy and a significant interaction between strategy and the context. Strategy A appeared to be more effective than the others. The A and AR strategies were better in the Woodland context, and strategies A and M appeared to be superior to the others in the Urban and Rural contexts. This study can be the foundation for determining optimal adaptive camouflage patterns in different environmental contexts and provide a theoretical basis for future military uniforms.

Keywords: Active camouflage · Camouflage assessment · Dynamic environmental contexts · Adaptive pattern strategy

1 Introduction

Evaluating a camouflage's effectiveness is a fundamental step in determining the optimal camouflage pattern [3, 4]. Because the effectiveness of active camouflage technologies varies with the environmental contexts, continuing evaluations of the effect of pattern combination strategies, combat-contextual changes, and the camouflage's reflection are needed. Assessing camouflage strategies with a prototype is an ideal way to evaluate the camouflage's effectiveness and reflect the results on the development process of a camouflage pattern. However, it is not practically simple to evaluate a camouflage's effectiveness with a prototype in various contexts. This is the reason why researchers use the photo simulation method. Photo simulation is performed on a controlled experimental situation, which makes it possible to produce rich statistical data from different groups of observers with the same image sets. Photo simulation is used to design or evaluate a developed pattern for dynamic and various military contexts because it is implemented in digital environments [4]. In this study, we performed visual search tasks using photo

C. Stephanidis (Ed.): HCII 2015 Posters, Part I, CCIS 528, pp. 170–173, 2015.
DOI: 10.1007/978-3-319-21380-4_30

simulation and evaluated the effectiveness of the pattern strategies for adaptive camouflage according to environmental contexts.

2 Method

2.1 Stimuli

If dynamic environments are essential for designing adaptive patterns, controlling digital images and making patterns automatically with a computer can be efficient alternatives during the development and evaluation design processes [1]. The researchers generated camouflage patterns using an automatic patterning program [2] to evaluate the effectiveness of camouflage strategies. The stimuli included four total strategies (Average [A], Main [M], AverageRandom [AR], and MainRandom [MR]), using 2 color combination strategies (average, main) X 2 pattern arrangement strategies (arranged, random) of stimulus matrices. A total of 18 images (6 images of 3 contexts—Woodland, Rural, and Urban) were used, and each of the four strategies appeared in all 18 images.

2.2 Participants and Procedure

Thirty participants were recruited. Each of the 4 strategies (Average, Main, Average-Random, MainRandom) were presented in three environmental contexts (Woodland, Rural, Urban), and the participants were ask to evaluate the camouflage abilities. The experiment involved five practice trials to make certain that the participants understood the task. A total of 216 trials were presented to each participant in random order, and the participants were asked to detect the camouflaged targets. The targets were located in one of nine positions within each image, in random order. The participants were asked to find the camouflaged targets and click the left mouse button. Also, they were required to click the right button of the mouse when there were no camouflaged targets in the images (Fig. 1).

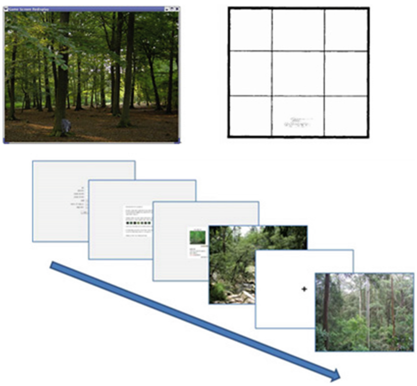

Fig. 1. Visual search task

The participants performed a total of 216 trials (environmental contexts (3)) X number of images (6) X pattern strategies (4) X target existence (3). All of the trials were randomly displayed on the monitor, and the participants received a brief rest every 36 trials. The camouflage abilities were measured by the participants' performance (error rate) on the visual search tasks (Fig. 2).

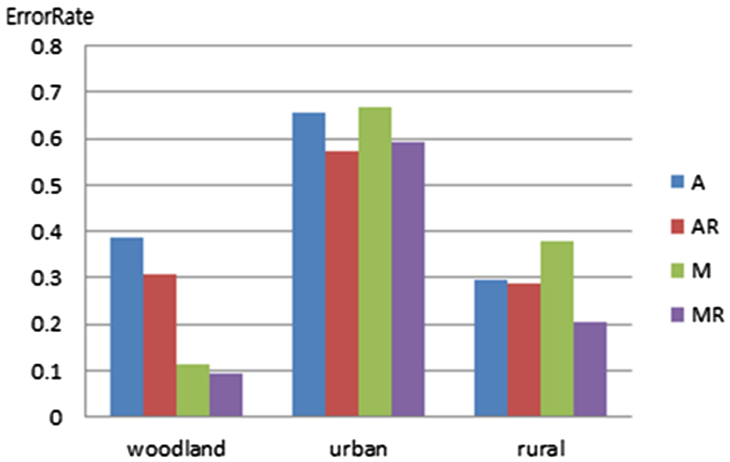

Fig. 2. Error rate

3 Results

The performance (error rate) of 4 strategies (Average, AverageRandom, Main, and MainRandom) in 3 environmental contexts (Woodland, Rural, and Urban) was analyzed with repeated measure analysis. Higher error rates were evaluated as better camouflage patterns. An analysis of performance (error rate) revealed the main effect of color pattern strategy, $F\ (3,93) = 15.66$, $p < .05$. Strategy A ($M = .45$, $SD = .04$) had a higher error rate than strategy M ($M = .39$, $SD = .02$), and strategy AR ($M = .39$, $SD = .03$) revealed a higher error rate than strategy MR ($M = .30$, $SD = .03$), $p < .05$. In other words, strategy A appeared to be the most effective color pattern, compared to the others, among the overall environmental context (Table 1).

There was a significant interaction between color pattern strategy and environmental contexts, F (6,186) = 12.49, $p < .05$. We conducted a planned contrast to

Table 1. Comparison of camouflage performance

	Overall	Woodland	Urban	Rural
Strategy A	**0.45** (0.04)	**0.39** (0.27)	**0.66** (0.21)	0.30 (0.23)
Strategy M	0.39 (0.02)	0.11 (0.14)	**0.67** (0.17)	**0.38** (0.17)
Strategy AR	0.39 (0.03)	0.31 (0.19)	0.57 (0.19)	0.29 (0.21)
Strategy MR	0.30 (0.03)	0.09 (0.15)	0.59 (0.26)	0.20 (0.21)

*Mean of Error rate (SD)

investigate which camouflage strategy was more effective in each context. The results of the planned contrast revealed that strategy A (M = .39, SD = .27) had a higher error rate (better camouflage) than the others in the Woodland context, p < .05. Strategies M (M = .67, SD = .17) and A (M = .66, SD = .21) had higher error rates than the others in the Urban context. Finally, strategy M (M = .38, SD = .17) had a higher error rate than the other strategies in the Rural context, p < .05. In other words, strategies A and AR were better in the Woodland context, and strategies A and M appeared to be superior to the others in the Urban and Rural contexts.

4 Conclusion

This study examined the effectiveness of adaptive camouflage patterns according to environmental contexts. For this purpose, we administered visual search tasks, which detect camouflaged targets using photo simulation. The findings of our camouflage analysis are below.

The result demonstrated that strategy A is least affected by the environmental contexts, so strategy A could be more likely to be applicable as Universal pattern. In addition, the camouflage effectiveness of the pattern strategy differed on the background context. In Woodland conditions, strategies A and AR were better than the other strategies. In Urban and Rural conditions, strategies M appeared to be superior to the others.

Researchers need to improve the camouflage strategies to match optimal adaptive camouflage patterns for different environmental contexts for future studies. The present study is significant for analyzing the effectiveness of camouflage patterns in varied environmental contexts. The present study can be the foundation for optimal adaptive camouflage patterns in different environmental contexts and provide a theoretical basis for future military uniforms.

Acknowledgement. This work has been supported by the Low Observable Technology Research Center program of Defense Acquisition Administration and Agency for Defense Development.

References

1. Cho, W.J., Ahn, W., Kim, M.S., Park, J., Kim, S., Han, K.-H.: Making pixel patterns automatically for camouflage – using color information from their background. In: Stephanidis, C. (ed.) Posters, Part II, HCII 2011. CCIS, vol. 174, pp. 98–101. Springer, Heidelberg (2011)
2. Cho, W.J., Seo, H.-K., Kim, H., Lee, J., Kang, D.-H., Kim, M.-K., Han, K.-H.: CamouLED: real-time generation of pixel pattern for camouflage. In: Stephanidis, C. (ed.) HCII 2013, Part II. CCIS, vol. 374, pp. 699–703. Springer, Heidelberg (2013)
3. Friskovec, M., Gabrijelcic, H., Simoncic, B.: Design and evaluation of a camouflage pattern for the Slovenian urban environment. J. Imaging Sci. Technol. **54**(2), 020507–020511 (2010)
4. Peak, J.: Guidelines for Camouflage Assessment Using Observers. NATO Research & Technology Organization Neuilly-Sur-Seine. RTO-AG-SCI-095 (2006)