

EXPANDING INFORMATION HIDING SCHEME USING ARTIFICIAL FIBER (AF) PATTERN INTO KATAGAMI PATTERNS WITH A LOW-RESOLUTION WEB CAMERA

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ABSTRACT

We have proposed an artificial fiber pattern as a technique for embedding electrical information into the real world. In recent studies, we tried to extract embedded information in an artificial fiber pattern using a high-resolution digital camera instead of a scanner. In this paper, we attempted to use a relatively inexpensive and low-resolution web camera as an input device because one of the important applications of our technique is an augmented reality system. In addition, from a design perspective, we examined different colors (cyan, magenta, and yellow) instead of the grayscale, and a specific pattern (a traditional Japanese *katagami* pattern for a kimono (i.e., *Ise-katagami*)) instead of a paper fiber pattern.

1. INTRODUCTION

Powerful portable devices including smartphones and tablet PCs that integrate a high-definition display, a camera, and an advanced image-processing capability have rapidly become popular. Accordingly, an augmented reality (AR) technology for superimposing computer graphics (CG) through a display in the real world has been developed for not only the entertainment industry but also other areas. As a result, new services are beginning to emerge that utilize AR and smart devices. For example, a service enabling one to view additional photos and videos by holding a smartphone over a newspaper using a specific code such as a QR code has been developed.

In the previous study, we embedded information by using unevenness of paper fiber. But in this paper, we considered extension to a two-dimensional pattern by using *katagami*. In addition, extraction was performed with a low-resolution web camera.

2. ISE-KATAGAMI

Ise-katagami is a traditional Japanese stencil pattern and tool used in the process of dyeing patterns into a *kimono* or *yukata* fabric. *Katagami* has received significant attention owing to the novelty of its designs, and has

become widespread overseas as an example of a traditional style of Japan. If we can embed information while keeping original pattern, it can be said to be a method with less subjective discomfort. The reason for choosing *katagami* is because it has a pattern resembling paper fiber and it is easy to obtain and considering expansion to wallpaper and clothes.



Fig. 2-1 Examples of *katagami*.
(left: Three-dot constellations, right: Overlapping circle pattern)

3. AF PATTERN

There are basically two techniques for embedding information into a printed material. One involves the use of invisible digital watermarking, and the other involves the use of a special visible pattern such as a bar code. Digital watermarking has a low information capacity and low robustness against geometric conversion. The visual quality of visible method is bad. Our previously proposed information-hiding scheme for printed documents [1] overcomes these problems through the use of an AF pattern, which utilizes the features of the paper instead of those of the content. The proposed AF pattern utilizes the randomness of the paper fibers, which can be seen when the paper is inspected microscopically.

The procedure for generating an AF pattern is shown in Fig. 1 and described in detail below [2], [3].

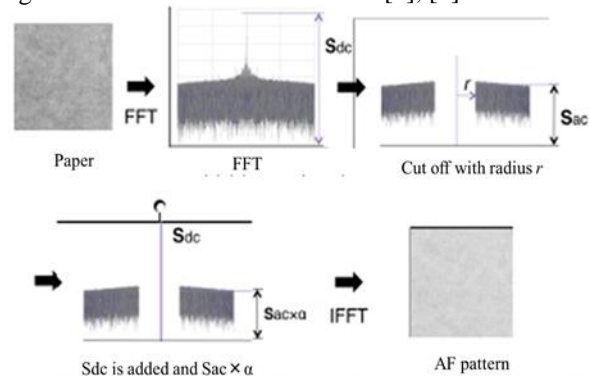


Fig.1 AF pattern generation procedure.

5. EVALUATION

The procedure for extraction from AF pattern described in detail below [2], [3]. To evaluate the reduction rate of the low-frequency component of adjacent AF patterns, P' and P'' , we define the intensity ratio $d(R)$ as

$$d(R) = \frac{\iint_0^R |P'(u, v)| dudv}{\iint_0^R |P''(u, v)| dudv} \quad (1)$$

4. PROPOSED METHOD

We studied embedding data for a print medium. Our proposed method uses an AF pattern. An AF pattern can be classified into three types, direct (geometric deformation) [5], superposition (dot pattern) [6], and indirection (use frequency) [1][2][5] types. For this paper, an AF pattern of an indirection type is applied.

We embedded the AF pattern wall cloth for use in everyday life (room walls or tablecloths etc.). We previously succeeded in an extraction using a digital camera with a high resolution. However, we need to be able to apply an extraction using a more low-resolution camera, and therefore, for the present study, we attempted to use a web camera.

In a previous study, we used the fiber of the paper to cut off the low-frequency pattern. For application under all types of situations, we used a color AF pattern in the grayscale, which we converted into cyan, magenta, and yellow through Photoshop [3]. In this paper, we propose the use of a *katagami* pattern, which has a low frequency, to generate an AF pattern. We chose parameters r_1 , r_0 , and R using a 2-D inverse Fourier transform of the *katagami* pattern. In order to parameters of AF pattern, we make different between “1” and “0”. In a previous study, we proved it is possible to apply the same scheme into a different color of AF pattern, such as gray, cyan and magenta. Therefore, as an AF pattern, we modified the color of a *katagami* pattern into gray, cyan, and magenta.

The flow of the extraction, shown in Fig. 2, is as follows:

- 1) Deploy 12 AF patterns (a pattern size is 5cm^2) onto an inkjet wall cloth of an A4 size.
- 2) Capture the patterns using a Web camera.
- 3) Cut out a part of each AF pattern.
- 4) Convert it into a grayscale and apply an auto level adjustment.
- 5) Calculate the intensity ratio in formula (1).

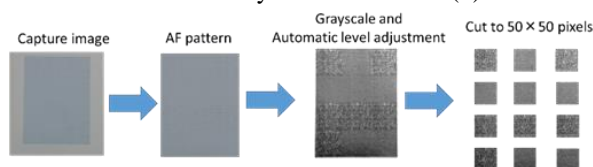


Fig.2 Extraction flow.

We chose 8 *katagamis* that similar to paper fiber pattern. We embed 11 bits information in A4 size. We photographed 10 times on 8 *katagamis* and conducted the extraction experiment.

5.1 Overview

We experimentally evaluated our proposed extraction method by conducting information embedding and extraction tests.

5.2 Equipment

- 1) Printer: Canon MG3530
- 2) Scanner: Kodak IQSmart2
- 3) Web camera: Logicool HD Pro Webcam (c920t, moving mode 1920 pixels×1080 pixels)
- 4) Pattern sizes:
Proposed pattern size: 5cm^2
- 5) Inkjet wall cloth: IP9000 (OHMI)
- 6) *Ise katagami* patterns:
Three dot constellations
Chrysanthemum arabesques
Overlapping circle pattern
Whirling beetles on streams
Tortoise shell with folding fans
Plum blossoms and bamboo
Paulownia
Grains of rice
Geometric pattern
- 7) Software used:
MATLAB R2015a
Adobe Photoshop CC

The basic parameters were set as $r_1 = 2$, $r_0 = 30$, $\alpha = 0.65$, and $R = 15$ in accordance with the values given elsewhere.

6. RESULT

We also showed that it is possible to extract an information from AF pattern using a low resolution Web camera. We choose a *katagami* pattern because it is a low-frequency pattern similar to paper. For parameters r_1 , r_0 , and R , we chose values between 0 and 1. We chose nine *Ise-katagami* patterns [4], as shown in Fig. 3. The basic parameters of the *katagami* patterns are shown in Table 1.

Table 1 Basic parameter.

	r_1	r_0	R	color
Three dot constellations	2	30	20	Magenta
Chrysanthemum arabesques	2	20	10	Cyan
Overlapping circle pattern	2	20	10	Gray
Whirling beetles on streams	2	20	15	Magenta
Tortoise shell with folding fans	2	10	10	Cyan
Plum blossoms and bamboo	2	15	10	Gray
Paulownia	2	20	15	Magenta
Geometric pattern	2	20	10	Cyan

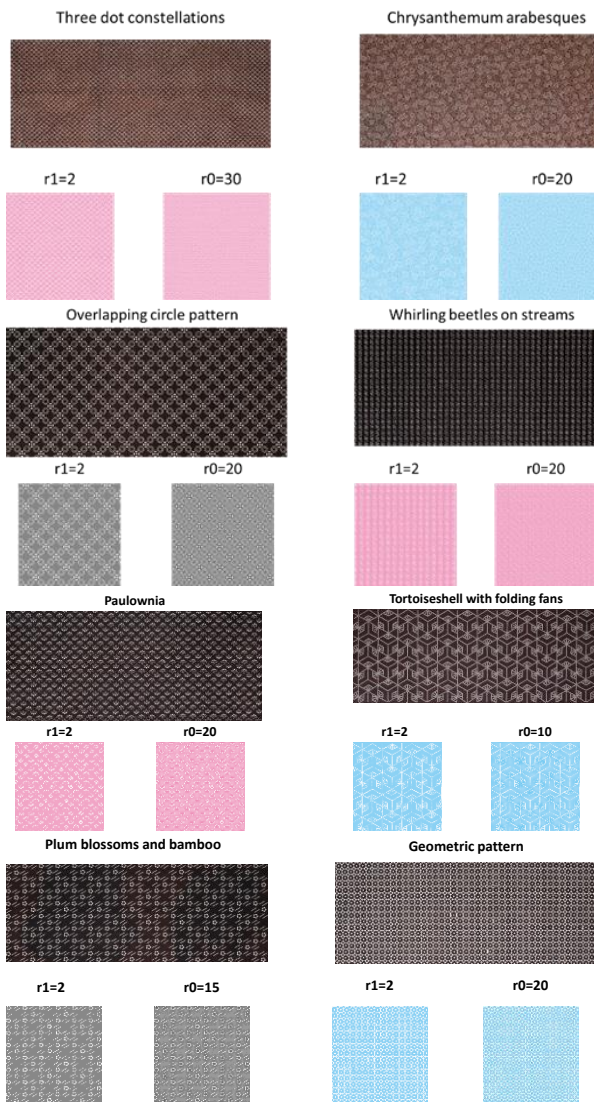


Fig.3 Images of *katagami* and AF patterns.

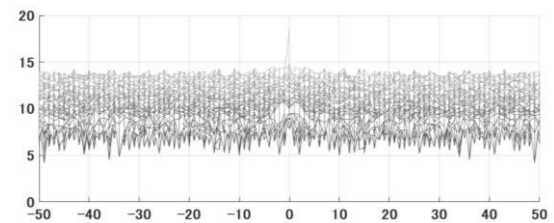
The experimental results are listed in Table 7-2. The experiment was conducted 10 times for each pattern. That is, the extracted information amount is 110 bits per pattern.

Table 2 Experimental results. [

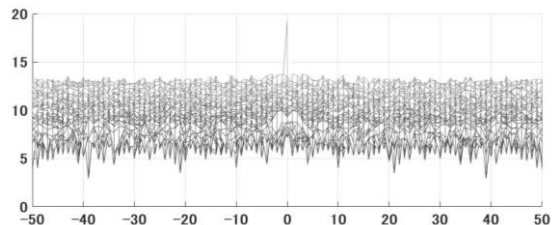
	Number of error	Extraction rate [%]
Three-dot constellations	1	99.1
Chrysanthemum arabesques	0	100
Overlapping circle pattern	10	91.0
Whirling beetles on streams	10	91.0
Tortoise shell with folding fans	1	99.1
Plum blossoms and bamboo	31	71.8
Paulownia	1	99.1
Geometric pattern	0	100

As a result, the 7 patterns excluding "Plum blossoms and bamboo" have a high extraction rate, and it was possible to obtain results similar to those of conventional paper or inkjet cloth paper.

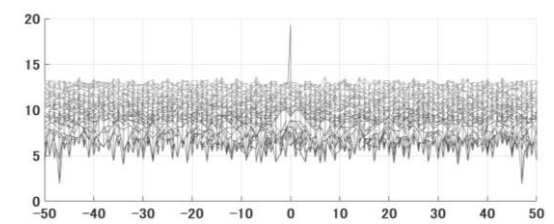
The spatial frequency distribution of "Chrysanthemum arabesques" is shown in Fig.4 and "Plum blossoms and bamboo" is shown in Fig.5. As can be seen from the comparison with the spatial frequency distribution of "Chrysanthemum arabesques" in Fig. 4, the peak of the spatial frequency distribution of "Plum blossoms and bamboo" extends to high frequency components. If it extends to the high frequency component, even if the low frequency component is cut, the difference between "1" and "0" is unlikely to occur, and it seems that information extraction was difficult. From the above, it was found that information can be embedded / extracted if the peak exists only in the low frequency component, but it is found that it is difficult to extract the information if the peak is extended to the high frequency component.



(a) original



(b) r=2



(c) r=20

Fig.4. Chrysanthemum arabesques

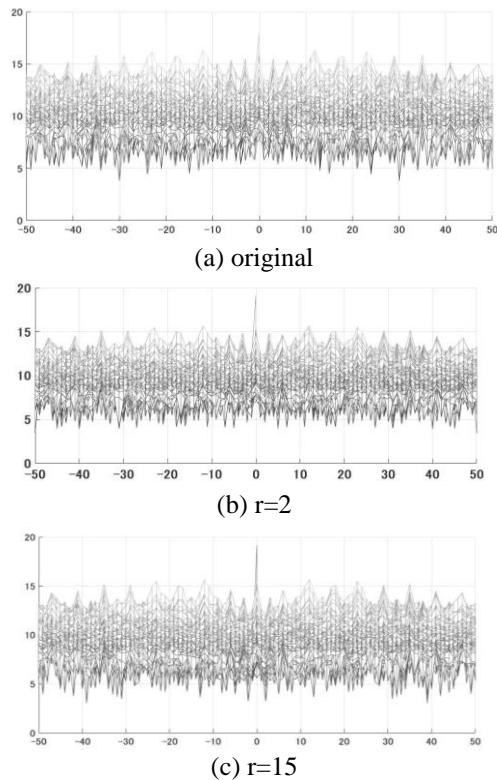


Fig.9. Plum blossoms and bamboo

7. CONCLUSION

This experiment was carried out using the conversion of a *katagami* pattern into an AF pattern. Generating an AF pattern from nine different *katagami* patterns resulted in three types of results. We assumed that a *katagami* pattern can be used for an AF pattern by optimizing its parameters. By using a pattern that can be extracted 100%, it is possible to use it for a new AR marker etc. by printing and pasting it on the room. In this experiment, since information was extracted from the image shot from the front in the short distance, angle shooting etc. must be taken into consideration. When used as a marker, automatic detection is also necessary, which is a future task.

8. REFERENCES

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