DEVELOPMENT OF DIGITAL WATERMARKING APPLICATION TECHNOLOGIES FOR NEWSPAPERS

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ABSTRACT
Newspapers, no different from other copyrighted works, are protected by the copyright laws. However, as the duplication itself is technically executable without any license agreement, in cases where users are ignorant of the copyright laws or have no intent to honor them, copies of newspapers end up to be illegally produced. In this paper, we report experiments for applying digital watermarking to newspapers. Digital watermarking is utilized to realize copyright management system that prevents illegal duplications while offering great convenience. Watermarking application is achieved in which the embedding artifacts are hardly noticeable and the embedded information extraction is stable.

Index Terms— Copyright protection, Digital watermarking, Desktop publishing, Newspaper, Binary image

1. INTRODUCTION
The widespread use of copying machines, together with the advance in technologies related to digitalizing and communication, has facilitated duplication and distribution of copyrighted works. Due to unauthorized copying and distribution of copyrighted works, problems such as nonpayment of usage fee typically occur. In response to this situation, we have studied copyright management system applying digital watermarking that realizes control on unauthorized use of newspapers. Digital watermarking technics are suitable for copyright management, since they have advantages like the following: they create no change in the appearance of the pages, and additional data are difficult to separate from page content.

In this paper, we present copyright management system applying digital watermarking technologies [1, 2], and report experiments for applying digital watermarking to newspapers.

2. NEWSPAPER COPYRIGHT MANAGEMENT

2.1. Application overview of digital watermarking technology
We can associate additional data with printed material by digital watermarking, and using the additional data, we can construct different kinds of systems with various functionalities [1]. As an example, basic concept of copyright management system applying digital watermarking technologies is shown in Fig.1. Copyright data is embedded in the pages by digital watermarking technics during the newspaper publishing process. At copying devices, the copyright data is read out from the digital watermark embedded in the pages to be duplicated. The read-out copyright data includes information such as copyright holder identification and copy allowed/not-allowed information. Copying devices are controlled according to the information. For example, the number of copies for every right holder may be stored and used for charging usage fee, or copy process may be canceled when the read-out copyright data indicates copy-not-allowed. The copyright management system has the following advantages:

- It enables unified right management according to the copyright data attached to the newspaper.
- It reflects the actual copy usage to collection and distribution of copy usage fee.
- It helps corporation ensure compliance with copyright laws.

![Fig. 1. Concept of copyright management system](image)

2.2. Established digital watermarking technology
Digital watermarking is a technology to embed information into digital medium such as image, audio, and video [3, 4].
The embedded information is imperceptible to human eyes as-is, and is extractable by dedicated software.

Many algorithms for digital watermarking are proposed [3, 4]. Recently, digital watermarking methods are developed with which the embedded data resides not only on digital contents but also on their analog converted form such as printed black-and-white documents [5, 6, 7].

As the watermarking technics to apply to newspaper pages, we adopt the technics described in the literatures [7, 8], which realize watermark embedding suppressing the degradation of image quality. The feature of the technic in [7] is that it prevents degradation caused by watermark embedding especially for black-and-white images, which was difficult to realize by traditional technics. In order to realize a more image-quality-maintaining watermark embedding to newspapers, we also adopt the technic in [8] to prevent image degradations caused by combination of pixel modifications, which are impossible to cover just by considering the visual effects of every single pixel alterations.

3. PROPOSAL OF DIGITAL WATERMARKING TECHNIC FOR NEWSPAPERS

3.1. Output flow of newspapers

The output flow of newspapers is sketched in Fig.2. The pages are output as follows:

1. Editors use their articles and images to create page layout data in the page layout terminal. Page layout data are vector data such as PS/EPS/PDF.

2. Page layout data are input into RIP devices (Raster image processor) and TIFF data are output. TIFF data are raster data which are divided into colors corresponding to the printing plates such as CMYK.

3. TIFF data are input into printing devices and newspaper pages are printed.

Fig. 2. Output flow of newspapers

3.2. Developments for newspaper application

The adopted digital watermarking technics are mainly intended for application to general documents used in offices. In order to apply the technics to newspapers, we have developed the following two methods. They are namely, method to adapt to high-resolution image and method to adapt to halftone dots.

The output resolution of newspapers is higher than that of general documents in offices. While digital watermarks are detected from the digital scans of the printed materials, there are not much difference in the effect of print and scan (noise addition, contrast decrease, distortion, etc.) between newspapers and general documents. Thus, in order to embed to high-resolution newspaper data the digital watermarks that have equivalent detection stability as in the general documents’ case, the size of the watermark patterns printed on to the physical newspaper surfaces must be adjusted. We have developed methods to enlarge the watermark patterns while maintaining stability of watermark detection and not spoiling the advantages of high-resolution images.

After page layout data are converted to raster data in the RIP devices, color tones in the multi-level region are to be represented by halftone dots. Halftone dots consist of patterns of small dots, and it is possible to represent continuous color tones with restricted number of ink colors by changing the density and the size of the dots. On the other hand, in the adopted digital watermarking technics, the embedded information is represented by pixel modification forming a certain watermark pattern. Through some experiments, it was found that the watermark pattern interferes with the halftone dot patterns. The interference results in problems such as, creating difficulties in detecting the watermark, and degrading the image quality in the halftone region. Thus, when embedding digital watermark to raster data created by RIP devices, it is preferable to evade the halftone-dotted region. We have developed a method to automatically detect the halftone-dotted regions and embed digital watermark evading them.

4. EXPERIMENTS AND EVALUATION

4.1. Experimental procedure

The experiment flow is sketched in Fig.3. As the adopted digital watermarking technics take raster data as the target of embedding, there are two candidates for the timing of embedding, as shown in Fig.3: embedding into TIFF data created by RIP devices (embed-timing A), and embedding into images used in the page layout step (embed-timing B).

In the experiments for binary pages embedding is done at embed-timing A, and in experiments for multi-level pages embedding is done at both embed-timing A and B.

4.2. Experiment result and evaluation

In the experiment for binary pages, the target images for digital watermark embedding are black-and-white TIFF data output by RIP devices. Small regions of an image before and after the watermark embedding are shown in Fig.4, 5, and 6.

Fig.4 are magnified images that show an example of the embedding on the characters existing in the binary pages. The irregularities along the contours of the characters are slightly modified by the embedding. In the figure, modifications are
distinguishable since a certain region of the image is magnified, but it was confirmed that the watermark embedding was hardly noticeable on the actual printed pages.

Fig. 3. Experiment flow

evade the halftone-dotted region. Similar to Fig.4, slight modifications are seen in the irregularities along the contours of the characters, but embedding on the halftone-dotted region as in Fig.5 do not exist. That is, automatic detection and evasion of the halftone-dotted region is certainly working effectively.

Fig. 4. Example of embedding on characters in binary pages. (Left) Original image. (Right) Watermarked image.

Fig.5 are magnified images that show an example of the embedding on the halftone-dotted region in the binary pages. Interference of the watermark patterns with the halftone patterns can be seen in the image. Degradation of the image quality owing to the pattern interference is also apparent on the actual printed pages. It is believed to be better to evade watermark embedding on the halftone-dotted region.

Fig. 5. Example of embedding on halftone-dotted region in binary pages. (Left) Original image. (Right) Watermarked image.

Fig.6 are magnified images that show an example of the embedding using the method to automatically detect and evade the halftone-dotted region. (Left) Original image. (Right) Watermarked image.

Effects on the appearance of the binary pages caused by digital watermarking are summarized as follows:

- Watermark embedding on the character regions is hardly noticeable.
- Watermark embedding on the halftone-dotted regions causes degradation in image quality.
- Image quality degradation can be circumvented by automatically detecting the halftone-dotted region.

As for the detection of the embedded information, we obtained good results for all the pages used in the experiment. There were no pages with the embedded information difficult to detect.

Experiments for multi-level pages were conducted changing the timing of embedding in two ways.

In the first experiment, embedding is done at the same timing as in the binary page case (Fig.3: embed-timing A). The target images for digital watermark embedding are TIFF data output by RIP devices, which consist of four binary images corresponding to CMYK inks respectively. For all four images, halftone dots are used in large areas. Watermarks are embedded to all four CMYK images, and the watermarked images are input into the printing devices.

Fig.7 are magnified images of the scan of the printed page. In the color photograph area, interference pattern between the watermark and the halftone dots appears (Fig.7: right). The interference results from each of the four CMYK binary image watermarking interference. As for the detection of the embedded information, we obtained good results for all the pages used in the experiment.
Next, we changed the timing of the watermark embedding. In the second experiment, watermarks are embedded in images used in the page layout step (Fig.3: embed-timing B). The target images are multi-level image data expressed in the CMYK color space.

Fig.8 are magnified images of the scan of the printed page created in the experiment. In the image Fig.8: right, watermark patterns may slightly be seen, but strong interference pattern that are generated in Fig.7: right cannot be located. It was confirmed that the watermark embedding was hardly noticeable on the actual printed pages. This is because, digital watermark was embedded directly to the multi-level image, where there are high degrees of freedom for alteration, and because, after the page layout, halftone dots with natural appearance were generated by RIP devices. In this experiment, same with other experiments, the embedded information was correctly detected for all the pages printed in the experiment.

Effects on the appearance of the multi-level pages caused by digital watermarking are summarized as follows:

- Embedding watermark to TIFF data which are output by RIP devices, results in great degradation of image quality.
- In the case of embedding watermark to images before layout, embedding is hardly perceptible.

5. CONCLUSIONS

We realized watermark embedding for binary and multi-level newspaper pages with embedding artifacts hardly perceptible, while the watermark extraction is stable. Challenges for the future include: technical challenges to add the proposed watermarking functionalities to the newspaper publishing system, technical challenges to add watermark extracting and copy controlling functionalities to copying devices, and institutional and operational challenges to introduce copyright management system shown in Fig.1.

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6. REFERENCES


