

Occurrence Condition of False Contour in JPEG and Its Improvement

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Abstract

The performance of recent digital cameras, printers, scanners and other input-output devices are wonderful. Therefore, the quality of a digital image is improved remarkably. As a result, the quality of the compressed image has come to be focused on. False contours may appear in the decoded image when a digital image is compressed with JPEG (Joint Photographic Expert Group) compression algorithm. There were many cases we are not able to perceive false contours when we used the input-output devices with certain noise level. We reported that false contours appear by the accuracy improvement of the output devices with the research in the IS&T's NIP15[8].

In this research, we studied the condition that false contours are seemed to the eyesore from both side of compressibility and the noise level of printer. We tried some experiments with various kinds of printer.

Introduction

JPEG[1,5,6,10] is a standardized image compression algorithm. JPEG is designed for compressing either full-color or gray-scale images of natural, real-world scenes. JPEG nowadays is one of the most popular still image data compression algorithm that is used widely with an internet communication and a digital camera.

JPEG is designed to exploit known limitations of the human eye, notably the fact that small color changes are perceived less accurately than small changes in brightness. Thus, JPEG is intended for compressing images that will be looked at by humans[3]. JPEG algorithm has a reversible coding method ("lossless") that is able to restore to a completely original image and a non-reversible coding method ("lossy") by using the visual characteristic of our human being.

In the case that an image is compressed with JPEG non-reversible coding method, false contour and mosquito noise and other noises that do not exist in an original image may appear in a decoded image. False contour is the outline that appears in the area of the intention where does not exist in an original image. It is well-known that these noises appear in the area of gradual change of brightness and color.

There are many cases that the image processing of non-reversible coding method in JPEG does it with the block units of 8×8 pixels. Because the correlation relation with the block of the surroundings has been disregarded, the difference happens to color components and brightness among each block. In the case that the difference between each block is intense, we human being be seen as there are some contour lines. We feel the noise of false contour and block distortion to an eyesore. From the aforementioned reason, our research group makes a study of an improvement of JPEG decoded image quality by using the 3-D smoothing method of the false contour area[2,9].

So we think that it is important to study the visual characteristic and to grasp the occurrence condition of false contour[4,7,8].

Experimental Approach

We research the condition that false contours are seemed to the eyesore from both side of compressibility and the noise level of output devices. Especially, we selected the printers of several different types as the output devices. These printers are two laser beam printers, two ink jet printers and a pictrography that use for the experiments. They are shown below.

(1) Laser Beam Printer:
Canon LASER SHOT LBP-470
Canon LASER SHOT LBP-430
(2) Ink Jet Printer:
Epson PM-2000C
Epson PM-750C
(3) Pictrography:
Fujix PICTROGRAPHY 3000

Resolution of Canon's laser beam printer is 300 dpi, 600 dpi and 1200 dpi. Resolution of Epson's ink jet printer is 360 dpi, 720 dpi and 1440dpi. And resolution of Fujix's Pictrography is 400dpi.

We experimented about the relationship between the accuracy of output devices and the noise of decoded image quality, to grasp the occurrence condition and the perception condition of false contour.

The procedure of our experiment is as follows.
Step 1: We compress the natural image and gradation image of the gray scale that are showed in Figs. 1 and 7 by using the JPEG compression algorithm with various compression rates (from 1/60 to 1/2).
Step 2: We output them with a laser beam printer, an ink jet printer and a pictrography.
Step 3: By changing the compression rate and the resolution of printer, we examine how false contour is recognized.

Results and Discussion

First of all, the natural image that showed in Fig. 1 as the experimental result was compressed in compression rate 1/30 by JPEG. The compressed image that was printed by the printer of various types (different dpi) shows in Figs. 2-6. When an image was printed with a high resolution, Figs. 2-4 were showing that false contour is conspicuous very much. The reason why we have come to be able to recognize the false contour clearly is that the resolution of the printer increases. We can not to recognize false contour conversely that the image is printed with the low resolution (see Figs. 5 and 6). However, it is because it is not able to express it to the details of the image in the resolution of the printer.

Printouts of the image that compressed the gradation image of Fig. 7 in compression rate 1/40 are showed in Figs. 8 and 9. We can easy to find false contour in this image, because the change of gradation is gradual. We understood the relationship between false contour recognition and the resolution of each printer. The images that showed in Figs. 10 and 11 were added random noise to the image that showed in Fig. 7.

We tried several opinion tests to these output results, and it evaluated to the score showed in Table 1. The 3-D graph showed in Fig. 12 shows the result of the opinion tests. It is nearly full mark as the image that false contour is not conspicuous. But, dirty image that include false contour became near the score 0. The opinion test was implemented under a regular distance interval by the sense of sight of a plural person without being caught by the compression rate, the resolution of a printer and other concept of each image. The more the resolution of a printer rises, the more evaluated values of the image drops. This fact is shown by the 3-D graph of Fig. 12.

Conclusions

It is clear that there is some relation in the resolution of a printer and the occurrence condition of false contour through our experiments. The image quality is influenced largely in the combination of compression rate and the resolution of a printer. It is conceivable that there is not the positive correlation between the quality of the image and the resolution of printer in the JPEG decoded image. As the input-output devices become high resolution and also, as the pixel number of the image is increasing the compression restoration of the high quality image is hoped.

Hereafter, we hope to do research the relationship between the perception conditions of these noises and the resolution of printer. We can not the exact comparison of the output result, because the matrix of a printer of each company differs. It needs further consideration. Therefor, we are scheduled to study that considered this point after this.

References

1. M. Bakshi, and D. R. Fuhrmann, "Improving the Visual Quality of JPEG-encoded Images via Companding," *Journal of Electronic Imaging*, Vol. 6, No. 2, pp. 189-197, 1997.
2. N. Iijima, T. Shohdohji, and Y. Hoshino, "Restoration of Image Deteriorated by JPEG Compression," *Proceedings of IS&T's NIP14: International Conference on Digital Printing Technologies*, pp.194-197, 1998.
3. T. Lane (organizer, Independent JPEG Group), "JPEG image compression FAQ, part 1/2, " http://www.faqs.org/faqs/jpeg-faq/part1/preamble.html
4. K. Murata, T. Shohdohji, and Y. Hoshino, "A Study on the Perception Condition of False Contour and Its Improvement (in Japanese), " *Proceedings of Imaging Society of Japan: Japan Hardcopy 2000*, pp.273-276, 2000.
5. W. B. Pennebaker, and J. L. Mitchell, *JPEG Still Image Data Compression Standard*, Van Nostrand Reinhold, 1993.
6. J. C. Russ, *The Image Processing Handbook, 2nd Edition*, CRC Press, Inc., 1995.
7. T. Shohdohji, Y. Hoshino, and N. Kutsuwada, "Optimization of Quantization Table based on Visual Characteristics in DCT Image Coding," *Computers & Mathematics with Applications*, Vol. 37, No. 11/12, pp. 225-232, 1999.
8. T. Shohdohji, K. Murata, and Y. Hoshino, "Perception Condition of False Contour in JPEG, " *Proceedings of IS&T's NIP15: International Conference on Digital Printing Technologies*, pp.378-381, 1999.
9. T. Shohdohji and Y. Hoshino, "Optimization of Image Quality for Decoded Images using Three-Dimensional Smoothing Method," *Applied Mathematics and Computation, to appear*, 2000.
10. G. K. Wallace, "The JPEG Still Picture Compression Standard, " *Communications of the ACM*, Vol. 34, No. 4, pp. 31-43, 1991.

Biography

Ken'ichiroh Murata is a graduate student of Prof. Hoshino and Associate Prof. Shohdohji, Nippon Institute of Technology, Japan. He received a BE degree in Systems Engineering from Nippon Institute of Technology in 1997. He is now studying image processing and chaos theory. Contact: kenitiro@aol.com

Figure 1. The original Image # 1 that we used for the experiment

Figure 2. The output result of the JPEG image to the original image # 1 with Pictrography (400 dpi)

Figure 3. The output result of the JPEG image to the original image # 1 with ink jet printer (1440 dpi)

Figure 4. The output result of the JPEG image to the original image # 1 with laser beam printer (1200 dpi)

Figure 5. The output result of the JPEG image to the original image # 1 with ink jet printer (360 dpi)

Figure 6. The output result of the JPEG image to the original image # 1 with laser beam printer (300 dpi)

Figure 7. Original image # 2 that we used for the experiment

Figure 8. The output result of the JPEG image to the original image # 2 with laser beam printer (1200 dpi)

Figure 9. The output result of the JPEG image to the original image # 2 with laser beam printer (300 dpi)

Figure 10. The output result of the random noise image to the original image # 2 with laser beam printer (1200 dpi)

Figure 11. The output result of the random noise image to the original image # 2 with laser beam printer (300 dpi)

Table 1. A Score of Opinion Test

Image Level	Score
Clear Image	100
|	|
Medium	50
|	|
Dirty Image	0

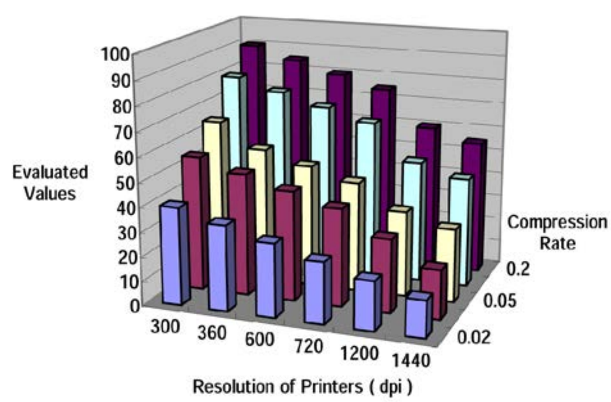

Figure 12. 3-D graph of the relationship compression rate and noise level.