Perception Condition of False Contour in JPEG

Tsutomu Shohdohji, Ken'ichiroh Murata and Yasushi Hoshino
Department of Systems Engineering
Faculty of Engineering
Nippon Institute of Technology
Gakuendai 4-1, Miyashiro-Machi, Saitama 345-8501, Japan

Abstract

When the JPEG (Joint Photographic Experts Group) compression algorithm compresses image with high compression rate, the false contour and mosquito noise that do not exist in an original image appear in a compression restoration image. It is well known that this trend is remarkable in artificial images (e.g. computer graphics) by comparison with natural images. A human being feels false contour to an eyesore. Also, false contour is influenced by the accuracy of the devices that outputs an image. False contour is conspicuous in the case that it used the high accuracy output devices, although it is not conspicuous in the case that it used the low accuracy noisy output devices.

In this research, we studied it from both sides of compression rate and the accuracy of output devices about the condition that false contour becomes eyesore.

Introduction

Many personal computer users nowadays started to deal with the pictorial images easily with the wide spread of high quality input devices (e.g. digital still cameras over 2 mega-pixels and scanners) and high quality output devices (e.g. laser beam printers and ink jet printers). Along with the diffusion of the high quality digital camera, we have come to be easily able to print the image data with various output devices.

As a restriction of memory capacity and network (even N-ISDN, N-ISDN is an acronym for "Narrow band Integrated Services Digital Network."), we need the JPEG[2,5] base line compression algorithm. The image quality of the input and output device is improved and we become to perceive the deterioration such as false contour and block distortion etc. that appear in the reconstructed image.

So we studied what kind of influence the resolution of the output devices exert on the perception of human being.

Experimental Approach

Test Images

Test images were pictorial image (ISO/JIS-SCID N3, "fruits basket" in "Japanese Industrial Standard, Graphic Technology -prepress digital data exchange- standard color image data (SCID)" published by Japanese Standard Association (1995), see Figure 1) and computer graphics. The image, "fruits basket" is used for the evaluation of the image processing result with the smooth feel of fruits. It is the part of the apple of this image that we used it for the experiment (Figure 2).

And CG image is used for the evaluation of the image processing result with gradual gradation.

Dependence of Output Devices

The display and printer are most general as the output devices of an image. The hope that we preserved an image as a hard copy is strong. Therefore, we have an interest in the quality of the output image. We know that the resolution of output devices rises in proportion to a rise in their price.

Thereupon, we research on the relation between the accuracy of the output devices and the noise of the image. Especially we choose the printer as the output devices.

We chose the laser beam printer and ink jet printer as the printer that uses it for the experiments. They are shown below.

(1) Laser Beam Printer: Canon LASER SHOT LBP-430
(2) Ink Jet Printer: Epson PM-750C

Resolution of Canon's laser beam printer is 300 dpi and 600 dpi. On the other hand, resolution of Epson's ink jet printer is 360 dpi and 720 dpi.

Results and Discussion

The output results by two kinds of printers are shown in Figures 3-6 and 8-11. As it is clear from these results we understood the following. Many combination of the printing mode and printing resolution exist in each printer. Some representative output results are shown here.

We can't perceive the noise (false contour) of image when resolution of the printer is low, but can perceive it when resolution of printer is high. Especially, this case is obvious in the CG image. When the noise of printer decreases, false contour becomes easily to be perceived. From the aforementioned result, we are thinking that dispersion of the dot diameter of toner and ink is influencing the quality of an output image.

The research regarding the improvement of the quantization table is reported, as such a method that the eyesore part (false contour) in an image is decreased.[3] As a

different method, the smoothing algorithm that we proposed can reduce the eyesore of false contour.[1,4] Our smoothing algorithm is using 3D surfaces. Therefore, the false contour that is easy to occur to a gradual gradation part can be improved.

Conclusions

As the increase of pixel number captured by digital still camera, the importance of data compression increases and the demand for image quality become high. One of eyesore deterioration by JPEG in quality is false contour, the condition of perceiving the contour on compression ratio of JPEG is obtained and it is found that when the noise of printer decreases, the threshold of perceiving false contour decreases. It is suggested that input/output devices improved to low noise and high resolution, false contour become problem in JPEG and to smooth its contour is effective. Because it is expected that the accuracy of the output devices improves increasingly in the near future, such a method that reduces false contour is important.

Studies in this field have been neglected. This promising field of research has just begun. The researchers should study investigate this problem sincerely.

Acknowledgment

This research was supported financially in part by the grant of Nippon Institute of Technology.

References

1. N. Iijima, T. Shohdohji, and Y. Hoshino, "Restoration of Image Deteriorated by JPEG Compression," *Proceed-ings of IS&T's NIP14: International Conference on Digital Printing Technologies*, pp.194-197, 1998.
2. W. B. Pennebaker and J. L. Mitchell, JPEG Still Image Data Compression Standard, Van Nostrand Reinhold, New York, 1993.
3. 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.
4. T. Shohdohji, N. Iijima, S. Kitakubo, and Y. Hoshino, "A Study on Improvement of JPEG Decoded Image Quality by False Contour Smoothing (in Japanese), " *Journal of the Imaging Society of Japan*, Vol. **38**, no. 2, pp.88-96, 1999.
5. J. K. Wallace, "The JPEG Still Picture Compression Standard," *Communications of the ACM*, Vol. **34**, No. 4, pp. 31-44, 1991.

Biography

Tsutomu Shohdohji is an Associate Professor of Operations Research at Nippon Institute of Technology, Japan. He received a BE and a ME degrees in Management Engineering from Aoyama Gakuin University, Japan, in 1973 and 1975 respectively. He is a member of the INFORMS (the Institute for Operations Research and the Management Sciences), the Imaging Society of Japan, the Information Processing Society of Japan and the Institute of Electronics, Information and Communication Engineers. His recent publications have appeared in international proceedings and journals. He is a coauthor of *Introduction to Operations Research* published by Maki-Shoten Inc, in 1993 and also has a publication plan of *Information Mathematics* in next spring. He is now interested in image processing and operations research.

Ken'ichiroh Murata is a graduate student of Prof. Hoshino, 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.

Hoshino Yasushi is a Professor of Nippon Institute of Technology, Japan. He gained BS, MS and Dr. Eng. degrees from the University of Tokyo, 1970, 1972, and 1984 respectively. After he gained Ms. degree, he joined Electrical Communication Laboratories of NTT and developed LED printer firstly, high speed laser printer, color laser printer by using ultra elliptical laser beam scanning, photo-induced toning technology and ion flow printing. He moved to Nippon Institute of Technology on 1994. He published more than 20 papers and several papers also in IS&T's journal. He attended almost NIP congresses.

Contact shodoji@nit.ac.jp

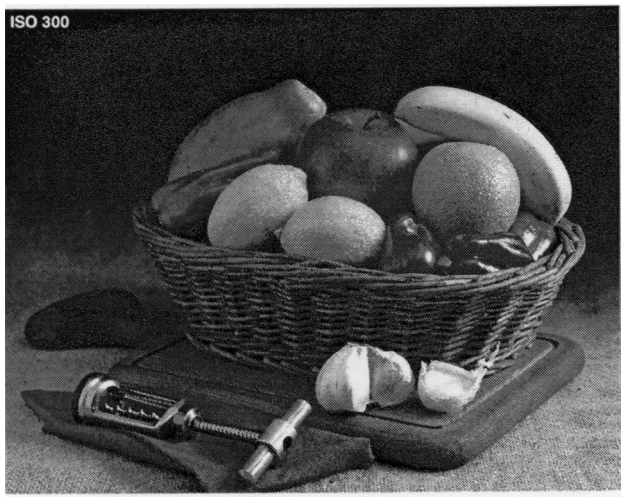

Figure 1. SCID Image (ISO/JIS N3, "fruits basket")

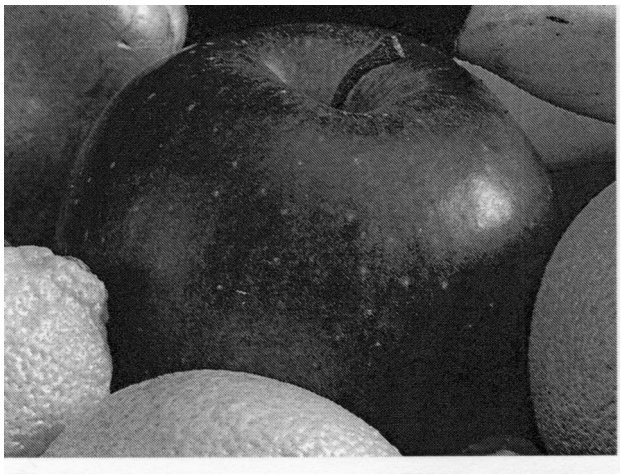

Figure 2. Original image #1 that we used for the experiment

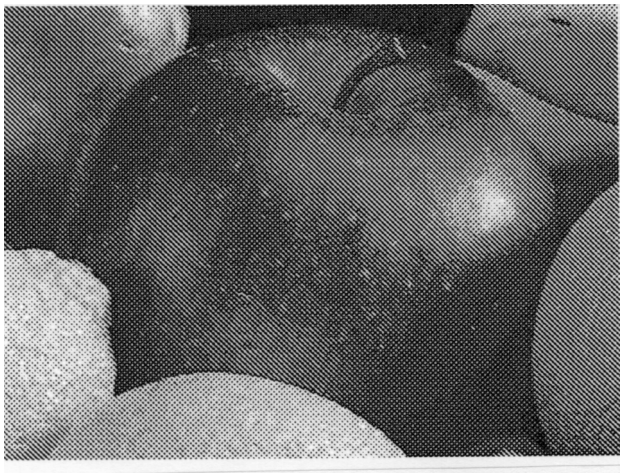

Figure 3. The output result of the JPEG image to the original image # 1 with laser beam printer (300 dpi)

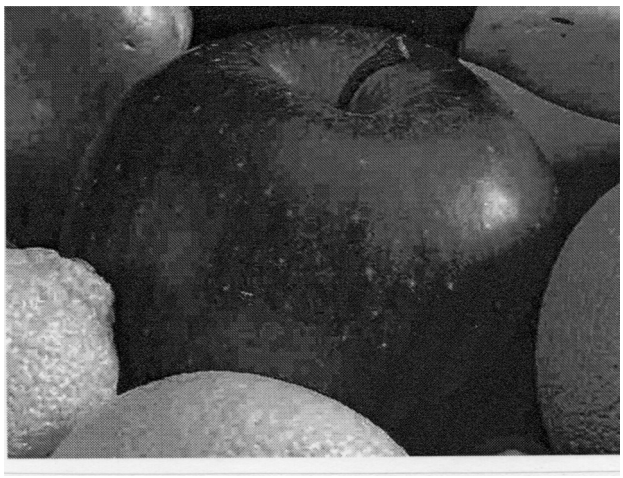

Figure 4. The output result of the JPEG image to the original image # 1 with laser beam printer (600 dpi)

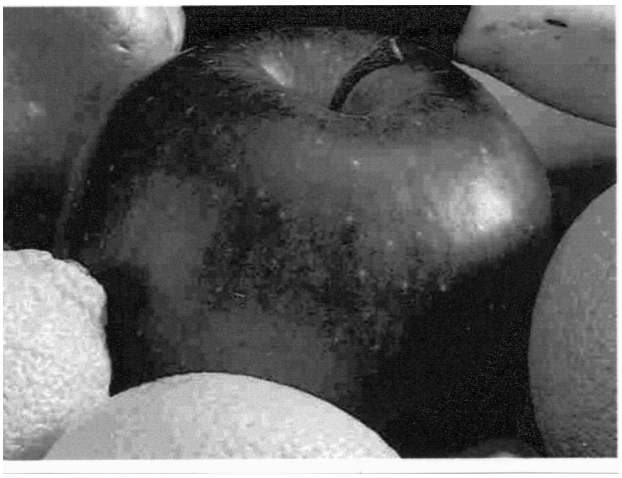

Figure 5. The output result of the JPEG image to the original image # 1 with ink jet printer (360 dpi)

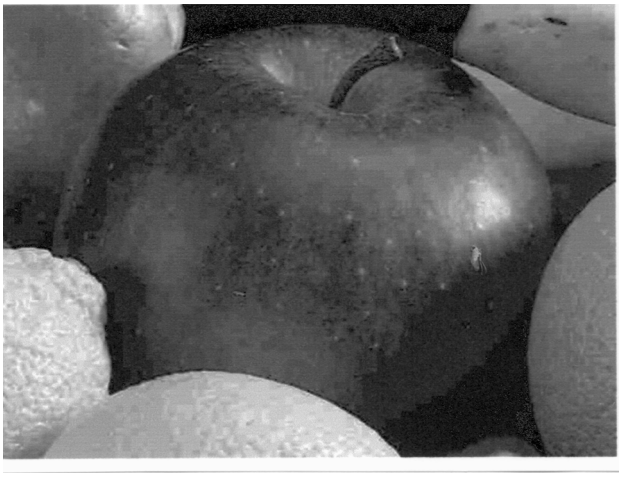

Figure 6. The output result of the JPEG image to the original image # 1 with ink jet printer (720 dpi)

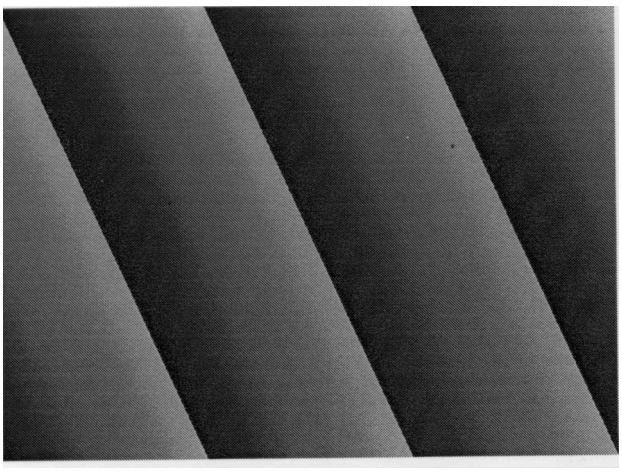

Figure 7. Original image #2 that we used for the experiment

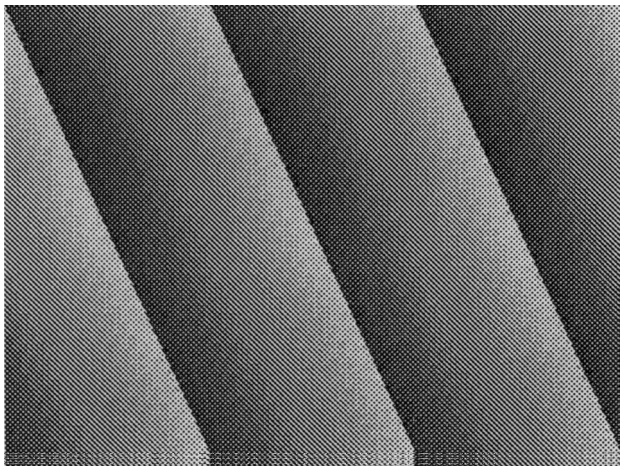

Figure 8. The output result of the JPEG image to the original image # 2 with laser beam printer (300 dpi)

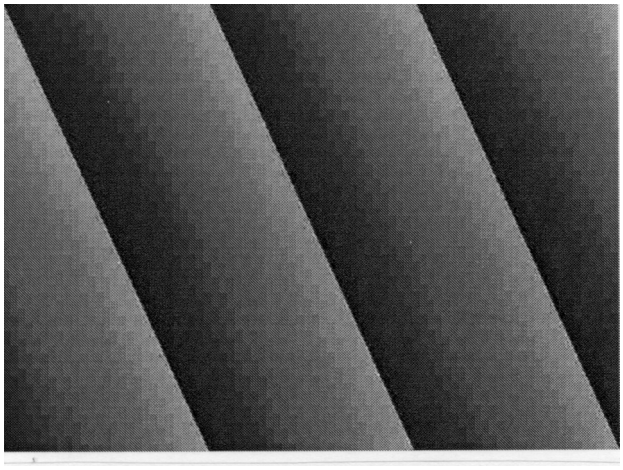

Figure 9. The output result of the JPEG image to the original image # 2 with laser beam printer (600 dpi)

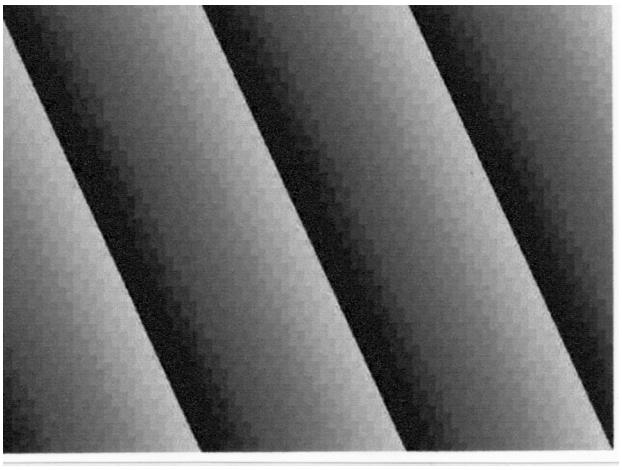

Figure 10. The output result of the JPEG image to the original image # 2 with ink jet printer (360 dpi)

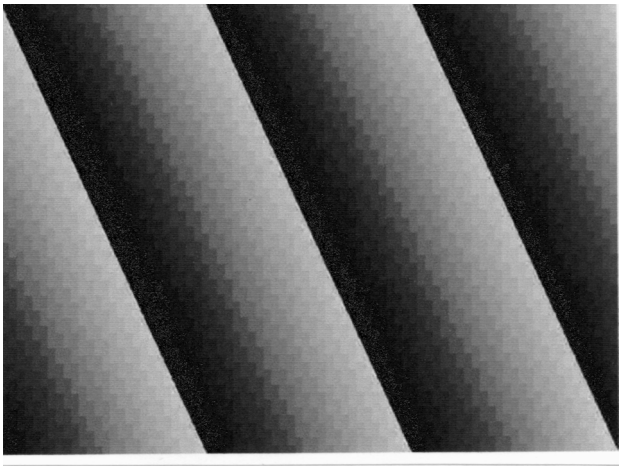

Figure 11. The output result of the JPEG image to the original image # 2 with ink jet printer (720 dpi)