23. Cognitive Information Processing

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23.1 Picture Coding

Donald E. Troxel, William F. Schreiber

a. Sampling and Reconstruction

Most present-day picture coding is digital; virtually all input and output images are analog. Thus the conversion from one form to the other is everpresent and important to the quality and efficiency of the overall process. To elucidate the phenomena involved, a systematic study was carried out of a wide variety of presampling and interpolation filters. It was found that, as suspected, the "ideal" low-pass filter was far from best, subjectively, since the least-rms-error criterion is invalid for human observers. Aliasing resulting from "violation" of the sampling theorem is visually traded off against sharpness and visibility of the sampling structure which occurs with other filters. Several filters studied performed substantially better than the ILPF. The best combination of performance and computational simplicity was found in the "sharpened Gaussian" filter, which has an impulse response not unlike that of human vision.[1]

b. Differential Pulse Code Modulation

This most common of image data compression systems has been widely studied. Its performance depends in marked degree on the characteristics of the signal source, since the presence of very sharp transitions requires an unfavorable trade-off between slope overload and the granular noise which occurs in blank areas. Nevertheless, when this factor is carefully taken into account, we have gotten good results with a form of DPCM in which the companding characteristic is adaptively adjusted to local image properties. In speech coding effective adaptation is possible based only on the coded signal. Because of the isotropic character of vision and images, this is not possible - extra data must be transmitted. Even including this extra data, we have obtained nearly "original" quality at 2.2 bits/pel, nonstatistical, and 1.5 bits/pel statistical.[2]

c. Two-Channel Coding System

For a number of years we have studied a picture transmission system in which the signal is divided into two channels, a two-dimensional low-pass signal ("lows") which is coarsely sampled and finely quantized, plus the remainder ("highs") which is finely sampled and coarsely quantized with the aid of a tapered randomized quanitizer.[3] While this can be thought of as a crude form of transform coding, the two- or three-channel approach permits tailoring the separate channel coding parameters to well-known human visual properties. While the performance of the non-adaptive version of this system is not as good as the adaptive DPCM system mentioned above, it does feature rather simple implementation and excellent (PCM-like) performance in the presence of channel errors. Under a grant from the Sony Corporation, a real-time hardware system was implemented.[4]

d. Adaptive Two-Channel Color Coding System

The above-mentioned system can be substantially improved by adapting the highs quantization to the local signal properties. Blank-area signal-to-noise ratio of 50 db at about 3 bits/pel is possible in most cases. The system is extended to color coding by transmitting a three-color lows signal plus an adaptively-companded achromatic highs signal. The color lows signal is further compressed by mapping to a perceptually uniform color space, akin to the Munsell system of subjective color notation. Excellent quality full color images are possible at four bits/pel, compared with 24 for the uncoded signal. Further compression is possible by statistical (entropy) coding of the two-channel coder output.[5]

e. Randomized DPCM

We have also studied the application of pseudorandom (PRN) noise to the DPCM quantizer. Unlike previous efforts to apply PRN to DPCM we chose to apply the noise directly to the quantizer inside the feedback loop. The application of PRN greatly reduces the most prominent artifacts of DPCM and allows greater freedom in the choice on the nonlinear quantizer so that slope overload can be reduced.[6]

References

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23.2 Digital Wirephoto[19] System

Associated Press (Grant)

Donald Troxel, William F. Schreiber

In previous reports, we have discussed the system we developed for the Associated Press for transmitting pictures to newspapers. This comprises cost-effective Laserphoto* facsimile transmitters and receivers and a computer-based image processing system (Electronic Darkroom) which permits automatic transmission and reception of pictures over many different channels, conversion between different Wirephoto scanning standards, and simultaneous editing (enlargement, reduction, cropping, combining, filtering, tone scale transformation, caption writing, etc.) of stored images. In this last year of the project, we have continued to improve the system reliability and performance. The major project has been the development of a device which automatically overprints the computer file name onto facsimile pictures as they are simultaneously received by the computer and a local facsimile receiver. This greatly reduces the load on the computer system by eliminating the need to automatically retransmit ID or identification copies to enable the photographic editors to easily associate pictures with their computer file names.

23.3 Graphic Arts Applications

William F. Schreiber, Donald E. Troxel

The vast majority of pictures produced every day are made on printing presses. The printing industry is one of the largest in the country - five times as large as radio and TV broadcasting, and three times as large as the semiconductor industry. This industry is undergoing a true revolution in technology based on electronics and computers. For this and other reasons, our activities in recent years have been focussed on understanding and improving the complicated chain of processes used to translate images of natural scenes, or man-made graphics, into printed pages. This orientation affects our activities in a number of ways:

1. Our sponsors generally plan to use the products of our research and development in daily production. Thus, the systems must be practical, reliable, and cost-effective.

2. Graphic arts images are of very high quality compared to those usually used by computer image

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[19] Trademark of the A.P.

processors. This requires careful attention to certain factors, such as tone reproduction, not always considered of great importance. High quality also implies very large amounts of data to be processed.

3. The images we deal with are intended for human viewing, and the systems we design are always operated by people. Human perceptual and operational capabilities are central to our work.

The principal operations which must be performed are the scanning and editing of individual page components, the selection and arrangement of elements on the page (composition, often erroneously called pagination), the arrangement of pages on the sheet (imposition), and the control of machines which make printing plates for letterpress, offset, and gravure printing.

We have undertaken two sizeable projects in this field with the main purpose of reducing the time and cost of preparation of printing surfaces by means of computer control of the process. Page elements are scanned by a high resolution laser scanner, digitized, and temporarily stored. Pages are assembled and displayed on a TV screen, the quality enhanced and editorial corrections made. The information is then efficiently coded (differently for text and pictures), stored, and finally output for the purpose of plate making.

23.4 Graphics Processing for Yearbook Production

Taylor Publishing Company (Grant)
Donald E. Troxel, William F. Schreiber

This is the image processing portion of a complete system for producing printing plates for yearbooks and similar publications which use a very large number of pictures. Compared to conventional techniques, the new system is to feature lower cost, higher speed, and no reduction in quality. The work done at MIT consists of the design of a scanner station and its operating system. Physically, the station, which itself is a satellite of the Taylor Publishing Company's publishing system, comprises a small computer with associated peripherals. These include a picture display, full-frame memory, disk memory, tablet and Autokon scanner. The operating system permits the station operator, sitting in front of the computer console, to perform, interactively, the following operations:

1. Receive layout instructions for each page, from the central system, including location and size of graphical elements.

2. Scan pictures into the system using parameters derived from the layout information.

3. View scanned pictures on the display and perform aesthetic corrections, if required. View entire page on display to verify layout.

4. Organize graphical data in local memory as required by page layout and initiate data transfer to the central system.

The novel features of this system revolve around the use of a small computer, in combination with a graphic arts quality laser scanner and some special-purpose digital hardware, to permit input and graphic elements, aesthetic corrections, and the organization of data for each page according to layout information, all on an interactive basis, and in a cost-effective manner.

23.5 Automated Engraving of Gravure Printing

Providence Gravure, Inc. (Grant)
William F. Schreiber, Donald E. Troxel

Gravure printing is characterized by high platemaking costs but inexpensive and very stable operation of the printing press. Thus it is suited primarily to long runs, particularly of color work, of both high and low quality. Substantial economic benefit would accrue from reducing the cost and time required to prepare printing cylinders, perhaps even making it practical to extend gravure printing to certain very significant applications such as daily newspapers.

In the system under development, all photographic steps between the original copy and the cylinder are eliminated by scanning into a computer system. Pictures are interactively edited, and then all components for each page are assembled into a single disk file. Cylinders are engraved directly from computer storage. (In other forms of printing, four color separation films would be made for each page instead.) Imposition and correction for ink and paper are performed in "real" time simultaneously with engraving.

The differences between this system and other existing prepress systems include substantially reduced storage requirements due to data compression, high cost-effectiveness, the elimination of the need for the operators to have long experience in color printing, a high-speed page composition system, and the ability to perform multiple tasks at the same time. The monochrome version of the sytem is in regular daily production, while the color system is under development.[1]

References

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