24. Cognitive Information Processing

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24.1 Picture Coding

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 on a wide variety of pre–sampling 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 not valid 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, non–statistical, 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 quantizer.[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 abovementioned 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]

24.2 Graphic Arts Applications

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 focused 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 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.

24.3 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.[6]

The differences between this system and other existing pre-press 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.

24.4 Computer Graphics Architectures

International Business Machines Corporation (Grant)
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We are investigating architectures suitable for high resolution, high speed interactive graphics displays. We consider cost-performance trade-offs both for today's costs and those projected for the future. Both memory and processing costs are expected to decrease dramatically. However, reduced cost of special purpose computation suitable for high speed graphics displays by means of custom VLSI circuits may well be achievable only with volume production. The primary focus of our research has been to investigate appropriate trade-offs for a hierarchically-structured graphics memory architecture consisting of a combination of disk, bulk random-access memory, and high

speed image refresh memory. The overall aim is to provide a cost–effective architecture which will still permit rapid access to very large images. We are aiming to provide windowing, zooming, and roaming capabilities for images of arbitrary size, where these images are generated from a combination of data structures appropriate to scanned–in continuous tone images (contones), scanned–in line art, and algorithmically generated images, e.g., from a vector display list and/or a text file.

There has been considerable literature and increasing use of anti–aliasing in order to generate more pleasing displays for a given spatial sampling grid. This, of course, impacts architectural considerations as the size of the required image refresh memory can be reduced, thus altering the trade–offs. An interesting question concerns the trade–off between the spatial and gray scale resolution, i.e., how available memory should be allocated to optimize quality. Another area of research concerns the computation required to produce an anti–aliased display as pertaining to the benefits to be derived from anti–aliasing. When roaming or zooming quickly through an image, it is more important to give fast response than to optimize quality. When motion ceases, then the highest quality is desired.

A thesis project completed this year involved the simulation of three different hierarchical memory structures.[7]

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