DATA COMPRESSION APPLICATIONS

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Abstract

The application of data compression in graphic arts is usually used for the storage of digitized image data or transmission of digitized image data. In the first case, data compression is applied to conserve storage capacity of the storage media, in the second case, transmission time. Data compression can be achieved by using techniques derived from information theory (images are information), by dividing the information into four parts. These four parts are components of known (redundant) or unknown (non-redundant) or relevant (of interest) and irrelevant (of no interest) information. From this can be deduced that only those information components, which are, non-redundant and of interest to the recipient have to be stored or transmitted. Therefore, in the application of data compression, the best results are derived by removing all redundant components and as many irrelevant components as possible.

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Introduction

The technology which is presently used for digitization of color images results in large quantities of binary data information. Each pixel of the image is represented in binary data in the form of 1 Byte for each of the four colors. These four Bytes per pixel translate into almost 34 M Bytes for an 8 1/2 X 11 image at a resolution of 150 lines per inch. This value increases for larger sizes with the square of the linear size changes and if a higher resolution is required also with the square of the resolution. In order to process or store these data quantities, high data rate links and high capacity storage media are required. Similarly, the transmission of these data quantities requires high speed T1 transmission lines. Even with these high speed lines, the transmission time without overhead is still approximately three minutes for a 34 M Byte page. Both the large capacity of storage media and the transmission time translate into cost. The application of data compression will reduce this cost by the same factor (excluding overhead) by which the data quantity is reduced. In other words, if the data quantity is compressed by a factor of 10, the linear cost is also reduced by ten.

Data Compression

Images are information and as such information theory can be applied in considering the content of images. By these means the image content can be divided into four parts as shown in Figure 1.

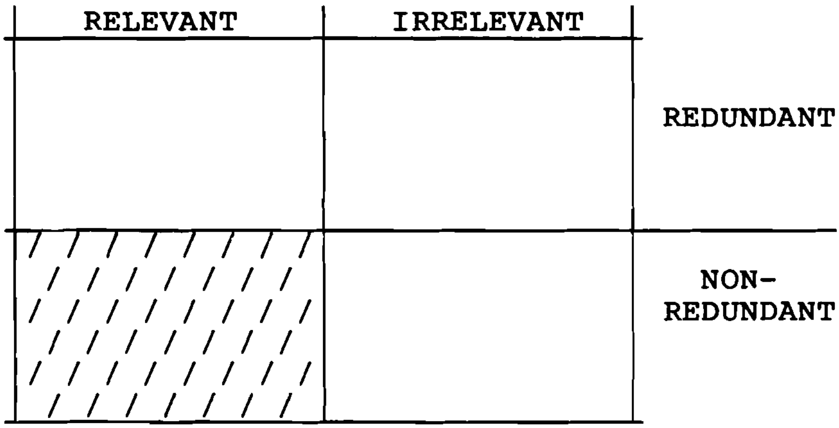

Figure 1

Only those parts of the information which are "NON-REDUNDANT" and "RELEVANT," of interest to the recipient have to be stored or transmitted. Such optimum data compression is achieved if all redundancy is eliminated and as many irrelevant components as possible are removed from the information.

<u>Redundancy</u>

If points of information are already known by the receiver, they do not provide any additional information and become redundant. By comparing an image, one will notice a similarity between adjacent picture elements (pixel). This means some of the information is contained in the neighboring pixel. Through this similarity of information only this part of the information not contained in the previous pixel needs to be transmitted.

Irrelevance

While redundancy can be determined accurately, irrelevance is also a function of the receiver. In other words, the receiver has to decide whether part of the information is important (relevant) or unimportant (irrelevant) to him. This question of importance depends to a large extent on the intelligence of the receiver which makes it difficult to govern this property by mathematical or logical rules. For this reason, in case of an image, data reduction derives its limits from the physical perception of the human eye, which means, whenever one can see differences between compressed/uncompressed images, non-redundant and/or relevant reduction has been performed.

Data Compression Methods

For the compression of natural color images, two methods for data compression have become popular--the predictive method and the transformation method. A third method, run-length encoding, is used for text and line art. The feature common to both the predictive and transformation methods, is the need to continuously change their parameters which can be influenced. This influence on their parameters is controlled by the current image content in order to obtain a maximum reduction factor while continuously ensuring that no loss in predefined quality occurs.

A simple example for the reduction factor as a function of the image content can be demonstrated by a tint in a page. This part of the page can be simply described by storing its geometric dimensions and the tint color.

Predictive Methods

The data compression methods covered by this concept follow the principle of calculating an estimated value for the image dot which is currently processed. Only the difference between the actual value and the estimated value is stored or transferred. The best-known method is Differential Pulse Code Modulation (DPCM), as shown in Figure 2.

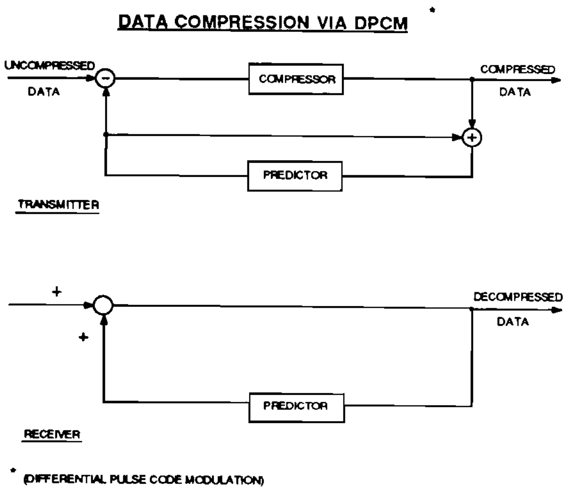

Figure 2-Differential Pulse Code Modulation

In calculating the estimated value for the processed image dot, the neighboring image dot is utilized, since generally similar information is contained in this dot. This similarly signifies "knowledge overlap" or redundancy. The result is a differential signal which, because of this similarity, represents less data and consequently fewer Bytes. During decompression the differences are added back to the estimated value in order to reconstruct the original image dots. Compression factors of 2 to 10 can be achieved using DPCM. Hell has been using this method for a long time in the telephoto transmission links. If a direct connection between the telephoto transmitter to a Chromacom System via telephone lines exist, then the decompression is done on the fly in the Chromacom Station.

Transformation Methods

Transformation methods are based on converting the image into a different representation which makes data compression easier to handle. As an example from printing, similar to reproducing the whole palette of colors by printing four colors (YMCK) over each other, it is also possible to regenerate brightness and fine structure by superimposing a series of basic structures. In order to keep the number of basic structures required for this process as small as possible, the image is broken down into small blocks of a few image dots, e.g. 4 X 4 or 8 X 8, before being transformed into 16 or 64 basic structures (see Figure 3). The transformation calculation is performed by calculating a weighting factor for each block and each basic structure. This calculation results in approximately 132,000 blocks for an image of 8.5 X 11 inches at a resolution of 300 L/inch and 8 X 8 image dots.

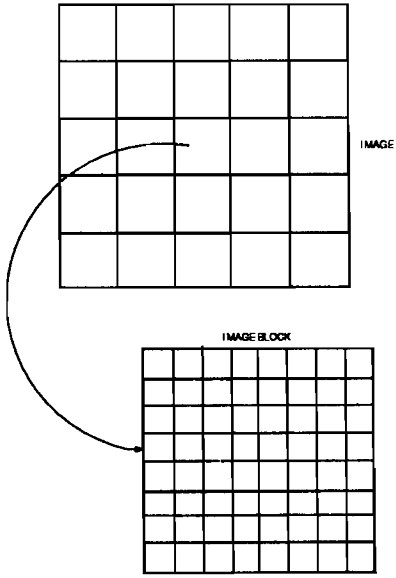

Figure 3

For data compression, the weighting factors of the basic structures are analyzed for each block to determine which basic structures are of importance for reconstructing the image contents. After this analysis, only the number and weighting factors of the selected basic structures have to be stored or transferred for each block.

Supposed that the correct selection is made and a certain degree of image degradation is allowed, this method allows data compression factors to be attained ranging from two and up to higher two-digit figures or even more. Taking into account the premises mentioned above (e.g. no visible degradation), the average factor is in the region of ten and probably somewhat higher. It is also essential to note that when archiving data each data stock can be compressed and decompressed several times without image quality being noticeably impaired.

Run-Length Encoding Methods

Run-length encoding in graphic arts is usually utilized for line art and text. Most systems supply this type of encoding on the basis of two Bytes. The first Byte usually contains the color number (0 to 255) and the second Byte contains the run-length also 0 to 255. If necessary, the number of colors can be increased by using pointers and color tables. The data compression that can be achieved is very much a function of the image and the judgement of the operator in which direction the image is scanned. If both are favorable (image and scanning in the best direction) then compression rations of 15 or better can be achieved with the two Byte configuration.

Monotone systems for text and facsimile transmission provide for short and long run encoding. They also provide for two-dimensional encoding, meaning if the next line repeats, then only the code for identical line is transmitted. This type of encoding results in much larger compression ratios. However, color variations and detail of line art make it uneconomical for graphic arts applications. A natural image rarely has either a long run-length, nor do lines repeat.

Using Compressed Data

The principle of an image processing system is shown in Figure 4, to its principle functions are added the transmission of compressed data and archiving of compressed data. The functions of the work station are performed on decompression data either from the archive or stored and decompressed data from the transmission. The use of compressed data for both, transmission and storage, will reduce cost either for transmission line or storage media.

PRINCIPLE OF IMAGE PROCESSING SYSTEM

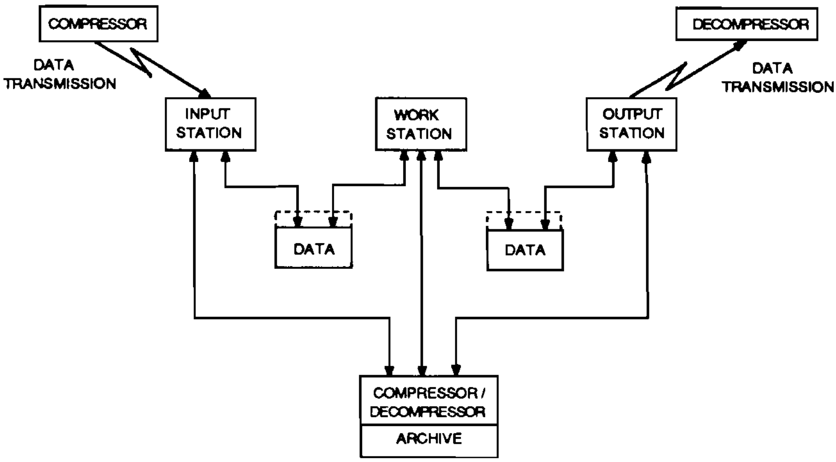

Figure 4

If, during a processing sequence data is created only temporarily and can be disregarded when the page has been completed, the quantity of data is only of secondary importance. This is especially true in the future when physically smaller storage media of decreasing cost will hold larger quantities of data. For this reason the first step in data compression will be for data transmission and archiving. One exception is a future Helio Data Processing (HDP) system using the Electron Beam Gravure (EBG) machine. For this it is absolutely necessary to utilize data reduction methods to feed the EBG at a high data transfer rate.

As a first hardware/software solution, Hell has a software package REDU which works in conjunction with the well proven array processor BSP-II. This processor is available as one or three CPU version.

The calculation time to compress image data with the aid of the BSP-II is approximately in the range of transmitting time for a 56 or 64 kbit/sec. digital transmission line, see Figure 5. This means the compression and transmission time for a 8.5 X 11 inch page at 150 lines/inch is reduced from 1.5 hours without data compression to an economically justifiable 4-12 minutes with data compression.

DATA COMPRESSION WITH BSP 11 AND SOFTWARE REDU

AMOUNT OF DATA	PROCESSING TIME FOR COMPRESSION / DECOMPRESSION		TRANSMISSION TIMES COMPRESSION RATIO 1:10 AND 20% OVERHEAD FOR ERROR PROTECTION	
	1 CPU	3 CPU	56 KBIT/S	1,544 KBIT/S (T1)
10 MBYTE	3.3 MIN	1.25 MIN	2.8 MIN	8.2 SEC
36 MBYTE (8.5 X 11")	11.8 MIN	4.5 MIN	10.3 MIN	22.4 SEC

Figure 5

Applications of Data Compression and Transmission

A transmission link between Essen and Ahrensburg near Hamburg on the basis of 64 Kbit/s digital channels exists for the newspaper "Die Welt". This system uses up to 4 X 64 Kbit/s dedicated lines in parallel resulting in a transmission time of approximately three minutes for one page of compressed data. The microcomputer controlled system uses a High Level Data Link Control (HDLC) procedure and has been in operation since April, 1985. This link includes a two-dimensional encoder for data compression as high speed hardware.

The linking of Chromacom systems has been accomplished for installations located in the cities of Nuernberg to Stuttgart and Nuernberg to Munich. Near completion is a link from Stuttgart to Barcelona. These links are established using up to 3 X 64 Kbit/s dedicated lines in parallel. Transmission and reception functions including data protection is performed by a standard minicomputer in the Chromacom system. For high speed data transmission, Hell will install a special computer controlled transmission system capable of transmitting up to 6 Mbit/s via terrestrial and satellite units. Special actions have been incorporated to ensure high quality data transmission at high speeds and long loop delays of the satellite links which are not covered by standard procedures for protected data transmission.

The first installation in the United States will be for remote gravure printing plants via T1 channel with 1.544 Mbit/s.

Reference:

Data Compression, by Dr. J. Klie of Dr.-Ing. Rudolf Hell GmbH