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Data Compression in Multimedia (Text,Image,Audio and Video)

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Abstracts

- Multimedia files are large and consume lots of hard disk space. The files size makes it time-consuming to move them from place to place over school networks or to distribute over the Internet.
- Compression shrinks files, making them smaller and more practical to store and share.
- Compression works by removing repetitious or redundant information, effectively summarizing the contents of a file in a way that preserves as much of the original meaning as possible.

Keywords: data compression algorithm, text, image, audio and video.

Introduction

Beginning in the 1980s, the capacity and speed of storage devices have been tremendously improving. Today, new kinds of cheaper and more efficient memory devices are constantly emerging. Nevertheless, as files become too large, it is helpful if we could somehow encode them into a smaller size and restore them back when needed later. That way, we can avail more of our storage media like diskettes, hard disks, CDs, USB Flash Disks, and tapes. Most data that we store in our computer devices are digital each unit of information packed in binary form. This binary nature of the source is how much information it really contains, and which better way to represent that information in a smaller number of binary digits, or bits. The compressed file is ultimately a concatenation of thousands or even millions of bit strings. Clearly, the cost of sending data over communications networks is minimized if the files are highly compressed.

Data compression

Data compression is the process of encoding data using a representation that reduces the overall size of data. This reduction is possible when the original dataset contains some type of redundancy. Data compression, also called compaction, the process of reducing the amount of data needed for the storage or transmission of a given piece of information, typically by the use of encoding techniques. Multimedia compression is employing tools and techniques in order to reduce the file size of various media formats. With the development of World Wide Web the importance of compress algorithm was highlighted because it performs faster in networks due to its highly reduced file size. Furthermore with the popularity of voice and video conferencing over the internet, compression method for multimedia has reached it next generation to provide smooth service even in unreliable network infrastructure.

Data Compression shrinks down a file so that it takes up less space. This is desirable for data storage and data communication. Storage space on disks is expensive so a file which occupies less disk space is cheaper than an uncompressed file. Smaller files are also desirable for data communication, because the smaller a file the faster it can be transferred.

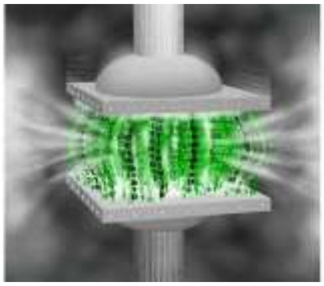

Figure 1: Examples of data compressed as digital like 1's and 0.s to reduce the space

. A compressed file appears to increase the speed of data transfer over an uncompressed file. Data compression involves a certain amount of raw data being processed and stored in a much more compact form. The processing is done by computer applications that use specific compression algorithms. There are many of these, each with its own strengths and weaknesses and particular areas where they are used.

Compression and decompression

Compressing a file is the process by which a large file is converted to a smaller file, such as a 10 KB (Kilobyte or 1000 bytes) file converted to a 1 KB file.

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Decompressing a file is the process by which a compressed file is converted back to its standard state, such as if our 1 KB file were converted back to a 10 KB file. The process by which files are compressed and decompressed are defined in algorithms, of which there are many. These algorithms are programmed into codecs (**CO**mpression/**DEC**ompression) and used by your operating system or software programs to access these files. The block diagram of compression and decompression as show below.

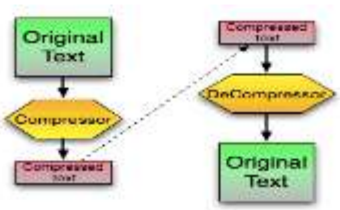

Figure 2: Structure of compression and decompression

Compression is the reduction in size of data in order to save space or transmission time. For data transmission, compression can be performed on just the data content or on the entire transmission unit depending on a number of factors. Content compression can be as simple as removing all extra space characters, inserting a single repeat character to indicate a string of repeated characters, and substituting smaller bit strings for frequently occurring characters. This kind of compression can reduce a text file to 50% of its original size. Compression is performed by a program that uses a formula or algorithm to determine how to compress or decompress data.

A simple characterization of data compression is that it involves transforming a string of characters in some representation such as ASCII into a new string of bits, which contains the same information but whose length is as small as possible. Data compression has important application in the areas of data transmission and data storage. Many data processing applications require storage of large volumes of data, and the number of such applications is constantly increasing as the use of computers extends to new disciplines. At the same time, the proliferation of computer communication networks is resulting in massive transfer of data over communication links. Compressing data to be stored or transmitted reduces storage and/or communication costs. When the amount of data to be transmitted is reduced, the effect is that of increasing the capacity of the communication channel. Similarly, compressing a file to half of its original size is equivalent to doubling the capacity of the storage medium. It may then become feasible to store the data at a higher, thus faster, level of the storage hierarchy and reduce the load on the input/output channels of the computer system.

Data compression algorithms

The compression methods can be classified broadly into lossy or lossless compression. Lossy compression can achieve a high compression ratio, 50:1 or higher, since it allows some acceptable degradation. Yet it cannot completely recover the original data. On the other hand, lossless compression can completely recover the original data but this reduces the compression ratio to around 2:1.Lossy compression is most commonly used to compress multimedia data (audio, video, and still images), especially in applications such as streaming media and internet telephony. By contrast, lossless compression is typically required for text and data files, such as bank records and text articles.

A. Lossless Compression

Lossless compression is a class of data compression algorithms that allows the exact original data to be reconstructed from the compressed data. The term lossless is in contrast to lossy data compression, which only allows an approximation of the original data to be reconstructed, in exchange for better compression rates. Most lossless compression programs do two things in sequence: the first step generates a statistical model for the input data, and the second step uses this model to map input data to bit sequences in such a way that "probable" data will produce shorter output than "improbable" data. Refers to data compression techniques in which no data is lost.

B. Lossy compression.

Lossy compression technologies attempt to eliminate redundant or unnecessary information. Most video compression technologies, such as MPEG, use a lossy technique. Is a data encoding method which discards some of the data, in order to achieve its goal, with the result that decompressing the data yields content that is different from the original, though similar enough to be useful in some way. Lossy compression is most commonly used to compress multimedia data (audio, video, still images), especially in applications such as streaming media and internet telephony. Lossy compression formats suffer from generation loss: repeatedly compressing and decompressing the file will cause it to progressively lose quality. This is in contrast with lossless data compression.

C. Lossless Compression Algorithms

There will be no data loss in this type of compression as it is defined by the name. Both original data and the compressed data are the same in this compression. The algorithms for the compression and decompression are exact inverse of each other in the Lossless Compression. The main mechanism in this compression is removing the redundant data in the compression and adding them in the decompression. The methods are

- Run Length Encoding
- Huffman Coding
- Lempel Ziv Encoding

Advantages: The original format of the data remains even it is compressed.

Disadvantages: Reduction of the size of the data is a small. Sometimes the size can increase instead of decrease.

i. Run-length Encoding

Run-length encoding can be named as the simplest method of encoding. Any combination of symbols can be compressed by this encoding technique. The concept of this algorithm is removing continuous sequence of symbols using another shorten symbol which represent it. Practically what is does is to replace the number of occurrences with the numeric value and the symbol itself. For example, a text like 'AAAACBBBBB' is replace by 'A04C01B05'. This method is very much efficient when there are only two symbols.

ii. Huffman Coding

This is a little bit complicated than the previous one. First, the frequency of each appearing character is taken. Then the characters that have least frequencies being taken to give values '1' for the higher one and '0' for the lower one and there wise it is continued. Then the each available character is represented by a separated code included with 1s and 0s.

iii. Lempel Ziv Encoding

This system does the encoding as two processes. They are indexing and compressing a string of symbols. When there is a set of characters, first step is to check whether an index have the minimum available character combination that appears. If available then put the index number in the string. If not, it will be added to the index. This compression technique is more effective as it has a two way compression method.

D. Lossy Compression Algorithms

It is the compression technique which will lose data in the original source while trying to keep the visible quality at the almost same amount. The compression ratio will be very high. Most probably the ratio will be a value near 10. It reduces non sensitive information to the human eyes and the compressed media will not be the media that was available before compression. The methods of Lossy compressions are

- Mathematical and Wavelet Transformation
- JPEG Encoding
- H.x

Advantages: Can reduce the file size more than in the Lossless Compression

Disadvantages: The original file cannot be taken after the decompression

i. Mathematical And Wavelet Transformation

In this process, images are converted to the mathematical functions. Discreet Cosine Transformation uses series of cosine functions to approximate image. This technique is used with JPEG, MPEG1 and MPEG 2 formats. A wavelet function is used to approximate the image. This can be used with the JPEG 2000 and MPEG 4 formats.

ii. JPEG Encoding

In this encoding, an image is represented by a two dimensional array of pixels. A Grayscale picture of 307*200 pixels is represented by 2,457,600 bits and a color picture is represented by 7,372,800 bits. Due to the number of calculations to be had in a JPEG format of a grayscale picture, it is divided into blocks of 8*8 pixels. The number of the units' id equal to the number of mathematical equations of each picture. The whole idea of JPEG is to change the picture into a linear set of numbers that reveals the redundancies. In addition to those techniques, MPEG is also a Lossy Compression technique. It is a way to encode the moving images and audio included in it. It supports many video formats from mobile phone to HD TV.

iii. H.261, H.263, H.264

H.261 is designed for video telephony and video conferencing applications. It was developed in 1988-1990. Data rate is a multiplication of a 64 kb/s. H.263 is a video coding technique for low bit rate communication. In addition, a 30% of bit saving can be done by this technique when it is compared to the MPEG-1. H.264 is a joint project of ITU-Ts Video Experts Group and the ISO/IEC MPEG group. All those three methods use different methods of reducing redundant data. There for the output differs from bit rate, quality and latency.

Text compression

Text is a very big part of most files that digital technology users create. For example, these files could be: Word or PDF documents, emails, cell phone texts SMS format or web pages. Therefore being able to compress text for storage or transmission is extremely important. Fortunately files containing mainly text can be significantly compressed. Like image compression there are many algorithms or methods that have been devised to do this. There is one important point to note about text compression and that is it needs to use a lossless method. This means the method must not discard any data when it compresses the data. If this was so, the data when it is uncompressed would be incomplete. Some techniques used by general purpose compressors such as zip, gzip, bzip2, 7zip, etc, and some types of models of text compression are,

- Static
- Semiadaptive or Semistatic

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- Adaptive.

A *static model* is a fixed model that is known by both the compressor and the decompressor and does not depend on the data that is being compressed. For example, the frequencies of symbols in English language computed from a large corpus of English texts could be used as the model.

A *semiadaptive or semistatic model* is a fixed model that is constructed from the data to be compressed. or example, the symbol frequencies computed from the text to be compressed can be used as the model. This model has to be included as a part of the compressed data.

An *adaptive model* changes during the compression. At a given point in compression, the model is a function of the previously compressed part of the data. Since that part of the data is available to the decompressor at the corresponding point in decompression, there is no need to store the model. For example, we could start compressing using a uniform distribution of symbols but then adjust that distribution towards the symbol frequencies in the already processed part of the text.

- Text compression predates most work on general data compression.
- Text compression is a kind of data compression optimized for text (i.e., based on a language and a language model).
- Text compression can be faster or simpler than general data compression, because of assumptions made about the data.
- Text compression assumes a language and language model
- Text compression is effective when the assumptions are met;

Example 1:
Uncompressed text:
"I am dumb and because I am dumb, I can't even tell you that I am dumb.
"
Compressed text:
"$1 and because $1, I can't even tell you that $1. $1=[I am dumb]"

Image compression

Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form. Images make up a very big part of the (web page traffic) data. The image contains a lot of information compared to text. Even a small image sized 200 by 200 (pixels) saved in the bitmap format (using a 24 bits per pixel storage system) can take up 200x200x24 = 960,000 bits or 960,000/8 = 120,000Bytes = 117.1975Kilobytes (120000/1024 = 117.1875). Most of compression techniques are,

- JPEG
- GIF
- PNG

Joint Photographic Experts Group created the standard. The standard specifies the algorithm used for compression and decompression (codec). Lossy compression - some visual quality is lost. The jpg format is good with photographs. It is not so good with high contrast pictures like screenshots or computer art. It relies on the eye not being sensitive to tiny changes of color. Compression can be varied when the image is saved. This format recompresses each time it is saved and repeated saving may lose quality. You should always work with uncompressed formats before saving in the target format.

The *Graphics Interchange Format* is based on limiting the colors used in the image. Typically up to 256 colors are used to make the palette - a table assigning up to 256 colors to the number 0 - 255. The pixel data for the image is then stored using the 8 bit number that represents the color's position in the table.

Portable Network Graphics uses lossless data compression. PNG is an open-source format that was created to improve upon the GIF. GIF was not open source and there were licensing costs to developers using the format. This was also a motivating factor in the uptake of the PNG

Bitmap (118KB)	**Jpeg (8KB)**	**Gif (27KB)**	**Png (25KB)**
			

Figure 3: various format of image

The above figure of image is saved in the bitmap, gif, png and jpeg formats. The last three are popular web page formats. As can be seen the most efficient format is jpeg at 8KB file size because it is designed to store information on millions of colours that may blend into each other e.g. a photograph or complexly coloured image. The least efficient is bitmap, and that is why this type of image is not commonly found on web pages . Both gif and png are designed to store images that have relatively distinct areas of plain colours.

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Example 2:

Figure 4 : Compression of image at 20%

The original size of the image is 3.09MB, it compress at the level of 20% to reduce the file size as 1.30MB. in this to save and share 1.78MB space. It compress at the level of 100% to reduce the file size as 119.45KB. in this to save 2.97MB space.

Figure 5: Compression of image at 100%

Audio compression

Audio compression the amount of data in a recorded waveform is reduced for transmission. This is used in CD and MP3 encoding, internet radio, and the like. Audio level compression is the dynamic range difference between loud and quiet of an audio waveform is reduced. This is used in guitar effects racks, recording studios, etc. Audio compression is a form of data compression designed to reduce the size of audio files. Audio compression algorithms are implemented in computer software as audio codecs. Generic data compression algorithms work with audio data but the compression ratios are low (around 50-60% of original size) and they do not work in real time and are therefore not practical. Specific audio "lossless" and "lossy" algorithms have been created. Lossy algorithms provide far greater compression ratios and are used in mainstream consumer audio devices.

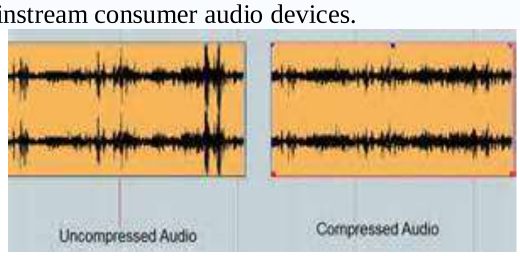

Figure 6: Audio compression wave

Audio compression is a companion to video compression, but the techniques are very different. First, the audio signal requires much less bandwidth than the video signal. For example, a stereo audio pair sampled at 48 KHz and using 16-bit samples requires 1.536 Mbps. It would be quite possible to send uncompressed audio. Moreover, audio compression cannot achieve the same compression ratio as video; a typical rate for the stereo audio pair is 192 Kbps, an 8:1 compression ratio. There are two leading audio compression,

- MPEG
- Dolby AC-3

MPEG-1 Layer 2 audio compression, also known as Musicam, is specified in ISO/IEC IS 13818-3. MPEG audio compression delivers near–CD quality audio using a technique called sub-band encoding. MPEG audio compression is used mainly in Europe and is used by most direct-to-home satellite providers in the United States. MPEG audio compression is a two-channel system, but it can encode a Dolby Pro-Logic signal, which includes two additional channels for rear and center speakers. (This is analogous to the way in which a Dolby Pro-Logic signal is carried by a BTSC [Broadcast Television System Committee] signal as part of an NTSC transmission).

Dolby AC-3 is a more advanced system than MPEG audio compression. AC-3 was selected as the audio compression system for digital television in North America and is specified by ATSC Standard A/52. AC-3 encodes up to six discrete channels: left, right, center, and left-rear, right-rear, and sub-woofer speakers. The sub-woofer channel carries only low frequencies and is commonly referred to as a 0.1 channel because it has such a limited frequency range. Thus, AC-3 5.1 gets its name from five full channels and a 0.1 channel. In addition, AC-3 has a two-channel mode that can be used to carry stereo and Dolby Pro-Logic encoded signals.

Video compression

Video compression refers to reducing the quantity of data used to represent video images. Compressed video can effectively reduce the bandwidth required to transmit digital video via terrestrial broadcast, via cable, or via satellite services. It is the process of converting digital video into a format that takes up less storage space or transmission bandwidth. It is an essential technology for applications such as digital television (terrestrial, cable or satellite transmission), optical storage/reproduction, mobile television, videoconferencing, and Internet video streaming. Video compression standards make it possible for products from different manufacturers (e.g. encoders, decoders, and storage media) to interoperate. An encoder converts video into a compressed format and a decoder convert's

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compressed video back into an uncompressed format. One of the big advantages of digital video is that it can be compressed for reduced bandwidth applications including transmission over satellite, cable TV and Internet-based networks. Compressed video is particularly useful for reducing storage requirements especially in the broadcast and government markets.

Figure 7: Various format of video

Uncompressed video that we record from a video camera(e.g. movies) occupies huge amount of data. For example, a video clip recorded with a resolution of 720x576(PAL), with a refresh rate of 25fps and 8-bit color depth takes:

720 x 576 x 25 x 8 + 2 x (360 x 576 x 25 x 8) = 1.66 Mb/s (luminance + chrominance)

If we take HDTV(High definition television) which uses a resolution of 1920x1080

1920 x 1080 x 60 x 8 + 2 x (960 x 1080 x 60 x 8) = 1.99 Gb/s

(Note: In YUV color space, each pixel has one brightness(luminance) value and two color(chrominance)
Values)

If no compression was used, a video with dimensions of 640 x 480 pixels (with each pixel using 24bits to store its color information) would need 640x480x24 = 7,372,800bits of memory storage per frame. If the video was played at a frame rate of 24fps then one second's playback would consume 7,372,800x24 = 176,947,200bits or 22,118,400Bytes or 21,600KB. One minute's playback would need 21,600x60 = 1,296,000KB or 1,265.625MB or 1.27GB. This is about 25% the size of a standard DVD disc. So, a standard DVD disc could hold about 4 minutes of uncompressed 640x480 video. Note: this example video contains no audio track. If it did more storage would be required. So, storing video in an uncompressed format is plainly impractical. The most popular internet video compression standards are,

- **MPEG-1**
- **MPEG-4**
- **DV**
- **H.261 AND H.263**
- **DIVX**
- **FLASH VIDEO**

MPEG-1 **is** a compression standard for audio and moving pictures, with support for bit rates up to 1.5 Mbit/sec. This is a popular standard for streaming videos as .mpg files over the internet. The ubiquitous MP3 format, standing for MPEG 1 Audio Layer 3, is a famed standard for audio compression.

MPEG-4 is a popular object-based compression standard for multimedia compression. Objects in a frame are tracked independently and compressed together to form an MPEG4 stream. The result is an efficient compression standard flexible over a vast range of bit rates. Its interactivity provides developers to control independent objects in a scene with ease.

DV is a high-resolution digital video format which employs lossy compression where certain redundant information in a file is permanently deleted, so that even when the file is uncompressed, only a part of the original information is still there.

H.261 is standard for duplex communication over ISDN lines and supports data rates in multiples of 64Kbit/s. The algorithm uses intraframe and interframe compression. H.263 is an enhanced version of the H.261 codec that improves quality of video streaming over modems.

DivX Compression is an application that employs MPEG-4 compression standards to facilitate fast downloads over DSL/cable modem, without compromising on video quality.

The most popular compression format for videos on the internet is .flv or *Flash Video*. FLV and F4V are container file formats which play videos on the internet through Adobe Flash Player. Encoding of audio and video data for FLV files are same as those for SWF files. This format is the favorite choice for embedded video on the web as it compresses video to low bitrates and maintains optimum quality.

Conclusion

Data compression is the art of finding short descriptions for long strings. Every compression algorithm can be decomposed into zero or more transforms, a model, and a coder. Lossless compressors ignore meaningless data in selecting contexts. Meaningless or random data has no predictive value and is itself not compressible. A lossy compressor not only

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ignores the meaningless data, but also discards it completely. Data compression is most consideration thing of the recent world with multimedia. We have to send a huge amount of data like text file, image audio and video are in a limited bandwidth. That is why data has to be compressed using the standard models and its related techniques. Each and every data gets some type and different compression ratio(file size).

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