CNND Unit II

Application Layer and Presentation Layer - Part 2

Presentation Layer:

Compression: Lossless Compression, Lossy Compression,

Multimedia data: Text, Image, Video , Audio ,

Multimedia in the Internet: Streaming Stored Audio/Video, Streaming Live Audio/Video, Real-Time Interactive Audio/Video,

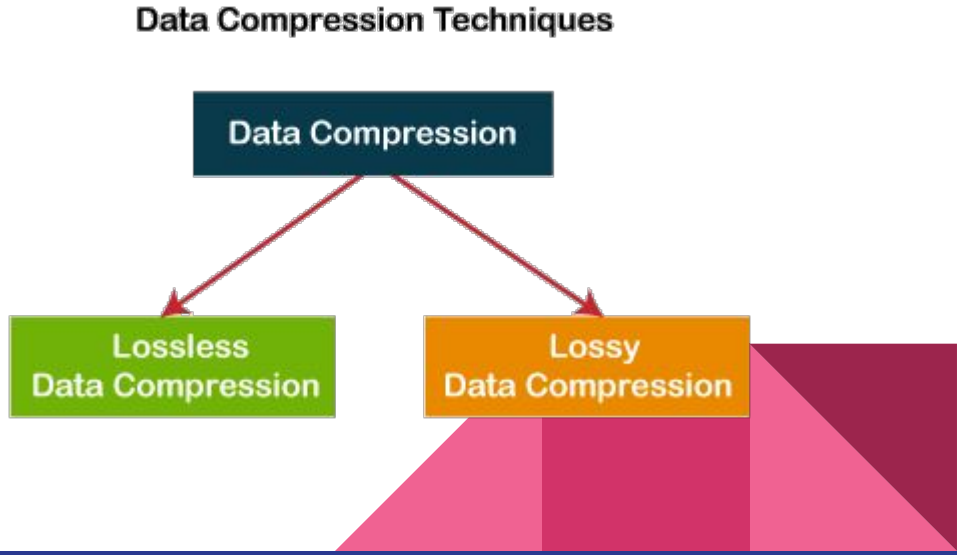
Optimal Compression Algorithms, Huffman Coding, Adaptive Huffman Compression, Dictionary Based Compression,

Speech Compression, LZW, RLE,

Image Compression – GIF,JPEG.

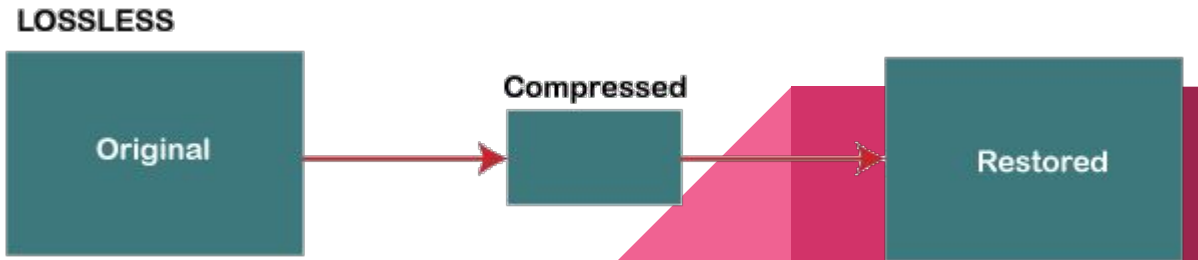
Compression:

- Data Compression is also referred to as **bit-rate reduction** or **source coding**. This technique is used to reduce the size of large files.
- The advantage of data compression is that it helps us save our disk space and time in the data transmission.
- There are mainly two types of data compression techniques -
  - Lossless Compression
  - Lossy Compression



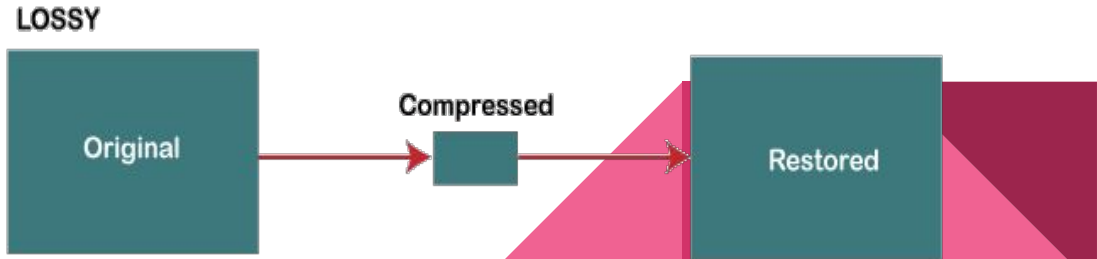
What is Lossless data compression

- Lossless data compression is used to compress the files **without losing an original file's quality and data**.
- In lossless data compression, file size is reduced, but the quality of data remains the same.
- The main advantage of lossless data compression is that we can restore the original data in its original form after the decompression.
- Lossless data compression mainly used in the sensitive documents, confidential information, and PNG, RAW, GIF, BMP file formats.
- Some most important Lossless data compression techniques are -
    - Run Length Encoding (RLE)
    - Lempel Ziv - Welch (LZW)
    - Huffman Coding
    - Arithmetic Coding



What is Lossy data compression

- Lossy data compression is used to compress larger files into smaller files.
- In this compression technique, some specific amount of **data and quality are removed (loss) from the original file**.
- It takes less memory space from the original file due to the loss of original data and quality.
- This technique is generally useful for us when the quality of data is not our first priority.
- Lossy data compression is most widely used in JPEG images, MPEG video, and MP3 audio formats.
- Some important Lossy data compression techniques are -
- Transform coding
- Discrete Cosine Transform (DCT)
- Discrete Wavelet Transform (DWT)



Multimedia data: Text, Image, Video , Audio ,

Multimedia

- Multimedia is a representation of information in an attractive and interactive manner with the use of a combination of text, audio, video, graphics and animation.
- Multimedia is a computerized method of presenting information combining textual data, audio, visuals (video), graphics and animations.
- For examples: E-Mail, Yahoo Messenger, Video Conferencing, and Multimedia Message Service (MMS).
- Multimedia as name suggests is the combination of Multi and Media that is many types of media (hardware/software) used for communication of information.

Components of Multimedia

- Text
- Image
- Video
- Audio

Multimedia in the Internet:

We can divide audio and video services into three broad categories:

Streaming Stored Audio/Video,

Streaming Live Audio/Video,

Real-Time Interactive Audio/Video,

Figure 5.17 Internet audio/video

Multimedia in the Internet:

Streaming Stored Audio/Video:

Streaming of videos involve, storing of prerecorded videos on servers.

- Users send request to those servers.
- Users may watch the video from the start till the end, and may pause it anytime, do a forward or reverse skip, or stop the video whenever they want to do so.

There are 3 video streaming categories:

1. UDP Streaming
2. HTTP Streaming
3. Adaptive HTTP Streaming

Streaming Stored Audio/Video

Advantages of Streaming Stored Video

- **Convenience:** Streaming stored video allows users to access content at any time, without the need for a physical media or download.
- **Increased Accessibility:** Streaming stored video makes it easier for users to access content, as it eliminates the need for physical storage and retrieval of media.
- **On-demand Content:** Streaming stored video allows users to choose what they want to watch, and when they want to watch it, rather than having to conform to a schedule.
- **Increased User Experience:** Streaming stored video provides a better viewing experience compared to traditional broadcast, as it allows for higher quality video and improved interactivity.
- **Scalability:** Streaming stored video can be scaled to meet the demands of large numbers of users, making it a reliable solution for large-scale video distribution.

Streaming Stored Audio/Video

Applications of Streaming Stored Video

- **Online Entertainment:** Streaming stored video is commonly used for online entertainment, allowing users to access movies, TV shows, and other content from the internet.
- **Video Conferencing:** Streaming stored video is used for video conferencing, allowing for real-time communication between participants.
- **Education:** Streaming stored video is used in education to facilitate online classes and lectures.
- **Corporate Communications:** Streaming stored video is used in corporate communications to share important information with employees and stakeholders.
- **Advertising:** Streaming stored video is used for advertising, allowing businesses to reach target audiences with video content.

Multimedia in the Internet:

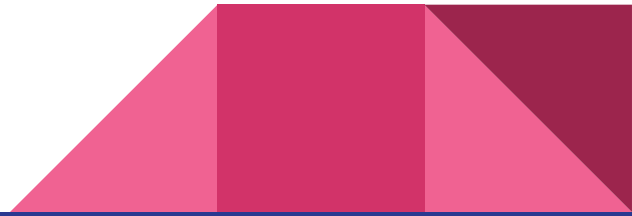
Streaming Live Audio/Video :

- Streaming live audio/video is similar to the broadcasting of audio and video by radio and TV stations.
- Instead of broadcasting to the air, the stations broadcast through the Internet.
- There are several similarities between streaming stored audio/video and streaming live audio/video.
- They are both sensitive to delay; neither can accept retransmission.
- However, there is a difference.
- In the first application, the communication is unicast and on-demand.
- In the second, the communication is multicast and live.
- Live streaming is better suited to the multicast services of IP and the use of protocols such as UDP and RTP.
- Examples: Internet Radio, Internet Television (ITV), Internet protocol television (IPTV)

Multimedia in the Internet:

Real-Time Interactive Audio/Video

- In real-time interactive audio/video, people communicate with one another in real time.
- The Internet phone or voice over IP is an example of this type of application.
- Video conferencing is another example that allows people to communicate visually and orally.



Optimal Compression Algorithms,

Huffman Coding,

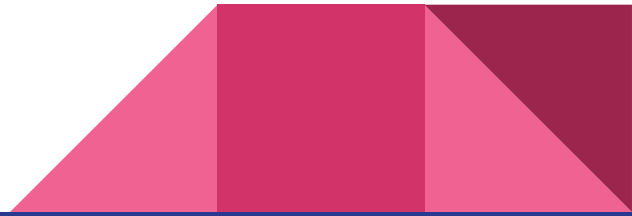
Adaptive Huffman Compression,

Dictionary Based Compression,

Speech Compression,

LZW, RLE,

Image Compression – GIF,JPEG.



Huffman Coding

- Data may be compressed using the Huffman Coding technique to become smaller without losing any of its information.
- Data that contains frequently repeated characters is typically compressed using Huffman coding.
- A well-known Greedy algorithm is Huffman Coding.
- The size of code allocated to a character relies on the frequency of the character, which is why it is referred to be a greedy algorithm.
- The short-length variable code is assigned to the character with the highest frequency, and vice versa for characters with lower frequencies.
- It employs a variable-length encoding, which means that it gives each character in the provided data stream a different variable-length code.

Huffman Coding

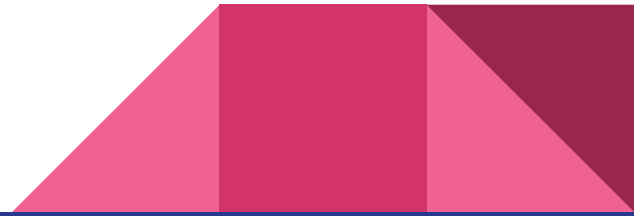
Prefix Rule

- Essentially, this rule states that the code that is allocated to a character shall not be another code's prefix. If this rule is broken, various ambiguities may appear when decoding the Huffman tree that has been created.
- Let's look at an illustration of this rule to better comprehend it: For each character, a code is provided, such as:
  - a - 0
  - b - 1
  - c - 01
- Assuming that the produced bit stream is 001, the code may be expressed as follows when decoded:
  - 0 0 1 = aab
  - 0 01 = ac

Huffman Coding

The Huffman Code is obtained for each distinct character in primarily two steps:

- Create a Huffman Tree first using only the unique characters in the data stream provided.
- Second, we must proceed through the constructed Huffman Tree, assign codes to the characters, and then use those codes to decode the provided text.



Huffman Coding

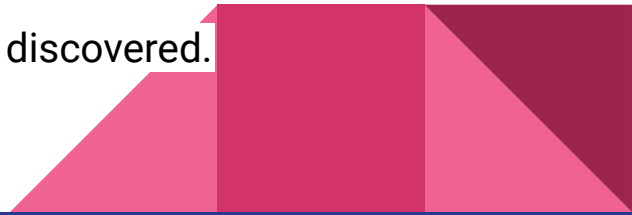
Steps to Take in Huffman Coding

The steps used to construct the Huffman tree using the characters provided

1. Input:
2. string str = "abbcdbccdaabbeeebeab"

If Huffman Coding is employed in this case for data compression, the following information must be determined for decoding:

- For each character, the Huffman Code
- Huffman-encoded message length (in bits), average code length
- Utilizing the formulas covered below, the final two of them are discovered.



Huffman Coding

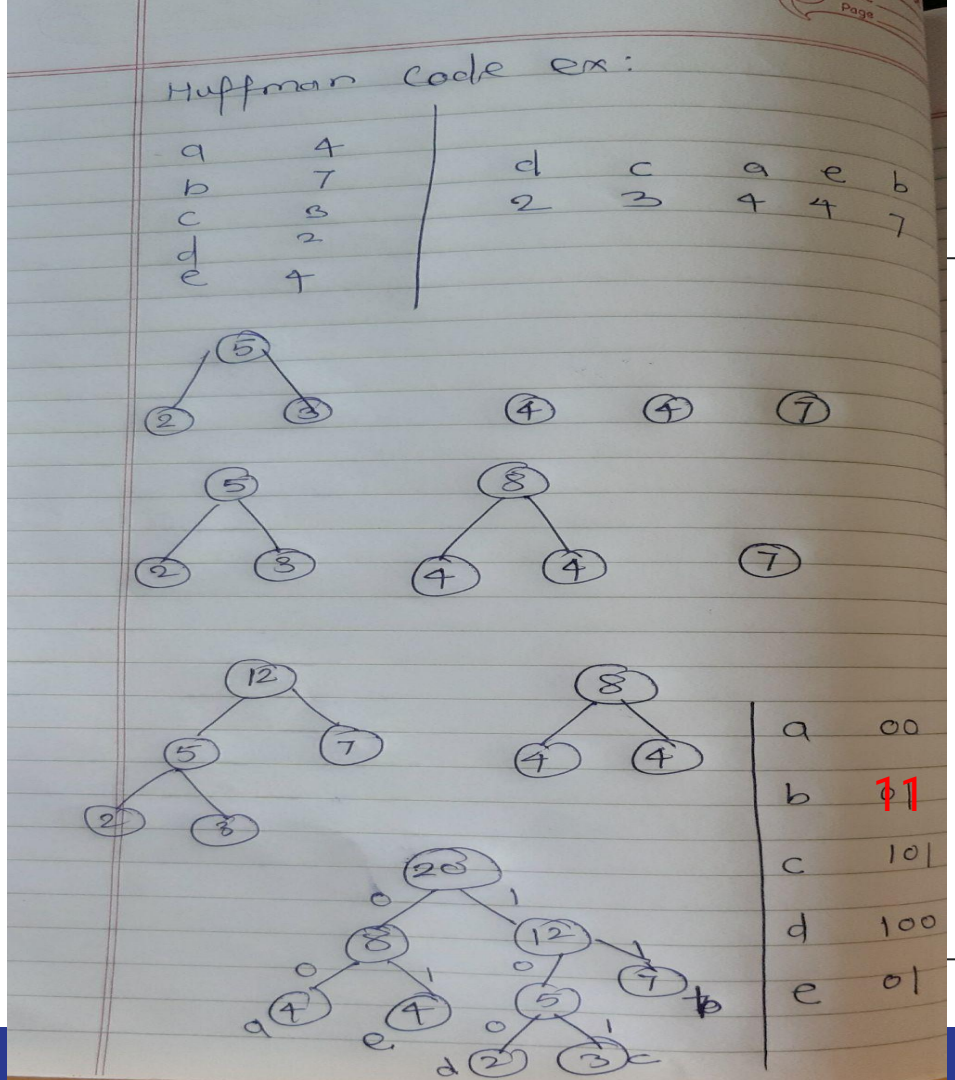
How Can a Huffman Tree Be Constructed from Input Characters?

The frequency of each character in the provided string must first be determined.

Character	Frequency
a	4
b	7
c	3
d	2
e	4

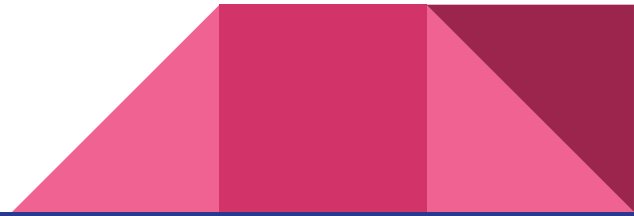
Huffman Coding

1. Sort the characters by frequency, ascending. These are kept in a Q/min-heap priority queue.
2. For each distinct character and its frequency in the data stream, create a leaf node.
3. Remove the two nodes with the two lowest frequencies from the nodes, and the new root of the tree is created using the sum of these frequencies.
    - Make the first extracted node its left child and the second extracted node its right child while extracting the nodes with the lowest frequency from the min-heap.
    - To the min-heap, add this node.
    - Since the left side of the root should always contain the minimum frequency.
4. Repeat steps 3 and 4 until there is only one node left on the heap, or all characters are represented by nodes in the tree. The tree is finished when just the root node remains.


Huffman code ex:
a 4
b 7
c 3
d 2
e 4
d c a e b
2 3 4 4 7
a 00
b 11
c 101
d 100
e 01

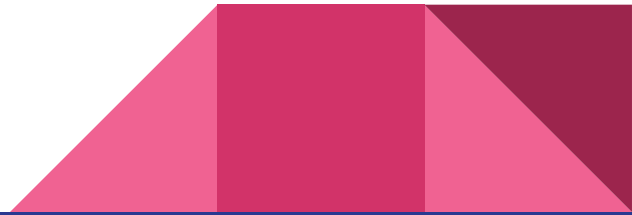
Adaptive Huffman coding

- **Adaptive Huffman coding** (also called **Dynamic Huffman coding**) is an adaptive coding technique based on Huffman coding.
- It permits building the code as the symbols are being transmitted, having no initial knowledge of source distribution, that allows one-pass encoding and adaptation to changing conditions in data.
- The benefit of one-pass procedure is that the source can be encoded in real time, though it becomes more sensitive to transmission errors, since just a single loss ruins the whole code, requiring error detection and correction.



Dictionary Based Compression

- The compression algorithms we studied so far use a statistical model to encode single symbols
  - Compression: Encode symbols into bit strings that use fewer bits.
- Dictionary-based algorithms do not encode single symbols as variable-length bit strings; they encode variable-length strings of symbols as single tokens
  - The tokens form an index into a phrase dictionary.
  - If the tokens are smaller than the phrases they replace, compression occurs.
- Dictionary-based compression is easier to understand because it uses a strategy that programmers are familiar with-> using indexes into databases to retrieve information from large amounts of storage.
  - Telephone numbers
  - Postal codes



Dictionary Based Compression

- Consider the Random House Dictionary of the English Language, Second edition, Unabridged. Using this dictionary, the string:
  - A good example of how dictionary based compression works
- can be coded as:
  - 1/1 822/3 674/4 1343/60 928/75 550/32 173/46 421/2
- Coding:
  - Uses the dictionary as a simple lookup table
  - Each word is coded as x/y, where, x gives the page in the dictionary and y gives the number of the word on that page.
  - The dictionary has 2,200 pages with less than 256 entries per page: Therefore x requires 12 bits and y requires 8 bits, i.e., 20 bits per word (2.5 bytes per word).
  - Using ASCII coding the above string requires 48 bytes, whereas our encoding requires only 20 (<-2.5 * 8) bytes: 50% compression.

Speech compression

Speech compression may refer to:

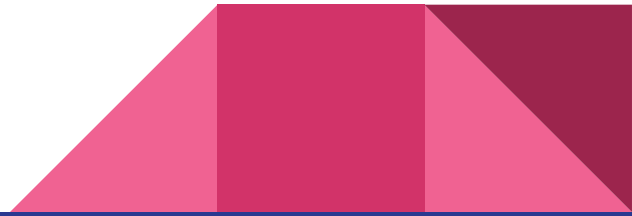
- Speech encoding, compression for transmission or storage, possibly to an unintelligible state, with decompression used prior to playback.
  - **Speech coding** is an application of data compression to digital audio signals containing speech.
  - Speech coding uses speech-specific parameter estimation using audio signal processing techniques to model the speech signal, combined with generic data compression algorithms to represent the resulting modeled parameters in a compact bitstream.
  - Common applications of speech coding are mobile telephony and voice over IP (VoIP).
  - The most widely used speech coding technique in mobile telephony is linear predictive coding (LPC), while the most widely used in VoIP applications are the LPC and modified discrete cosine transform (MDCT) techniques.

Speech compression

- Time-compressed speech, voice compression for immediate playback, without any decompression (so that the final speech sounds faster to the listener).
- **Time-compressed speech** refers to an audio recording of verbal text in which the text is presented in a much shorter time interval than it would through normally-paced real time speech.
- The basic purpose is to make recorded speech contain more words in a given time, yet still be understandable.
- For example: a paragraph that might normally be expected to take 20 seconds to read, might instead be presented in 15 seconds, which would represent a time-compression of 25% (5 seconds out of 20).

LZW (Lempel–Ziv–Welch)

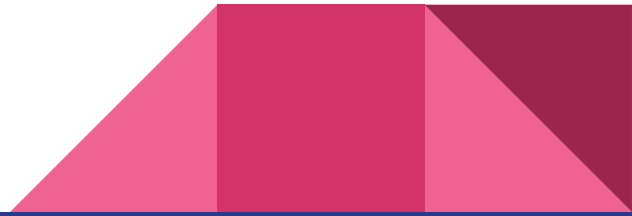
- LZW (Lempel–Ziv–Welch) is a universal lossless data compression technique.
- This compression algorithm was developed by Abraham Lempel, Jakob Ziv, and Terry Welch.
- In hardware implementations, the algorithm is simple and has the potential for very high throughput.
- It is the algorithm used in the GIF image format and is part of the widely used Unix file compression utility compress.



LZW (Lempel–Ziv–Welch)

How does it work?

- LZW compression works by **reading a sequence of symbols, grouping the symbols into strings, and converting the strings into codes.**
- Because the codes take up less space than the strings they replace, we get compression.



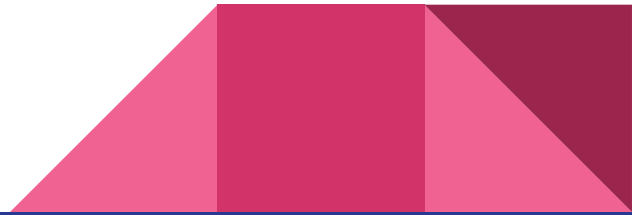
LZW (Lempel–Ziv–Welch)

Characteristic features of LZW includes,

- LZW compression uses a code table, with 4096 as a common choice for the number of table entries. Codes 0-255 in the code table are always assigned to represent single bytes from the input file.
- When encoding begins the code table contains only the first 256 entries, with the remainder of the table being blanks. Compression is achieved by using codes 256 through 4095 to represent sequences of bytes.
- As the encoding continues, LZW identifies repeated sequences in the data and adds them to the code table.
- Decoding is achieved by taking each code from the compressed file and translating it through the code table to find what character or characters it represents.

Run-length encoding (RLE)

- RLE is a simple method of compressing data by specifying the number of times a character or pixel colour repeats followed by the value of the character or pixel.
- The aim is to reduce the number of bits used to represent a set of data. Reducing the number of bits used means that it will take up less storage space and be quicker to transfer.
- This is most efficient on data that contains many such runs, for example, simple graphic images such as icons, line drawings and animations.
- For files that do not have many runs, RLE could increase the file size.



Run-length encoding (RLE)

Follow the steps below to solve this problem:

1. Pick the first character from the source string.
2. Append the picked character to the destination string.
3. Count the number of subsequent occurrences of the picked character and append the count to the destination string.
4. Pick the next character and repeat steps 2, 3 and 4 if the end of the string is NOT reached.

Given an input string, write a function that returns the Run Length Encoded string for the input string.
For example,

- if the input string is “wwwwaaadexxxxxx”,
- then the function should return “w4a3d1e1x6”

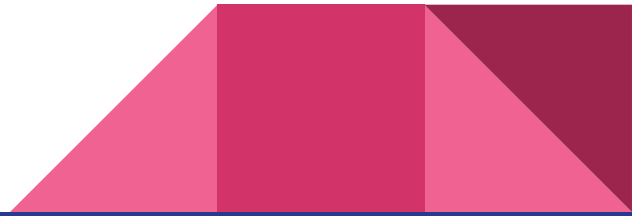


Image Compression

- GIF
- JPEG

Image Compression

- Image compression is an effect that makes image files smaller
- It is an important part of image optimization.
- … information
- … ensure that the image loads quickly

Why is image compression important?

- Compressed images load faster than uncompressed images [illegible]
- [illegible] load even faster. [illegible] can allow the most important content of a webpage to [illegible]

Lossless vs. lossy compression

	Lossless	Lossy
WHAT IT DOES	▪ Restores, rebuilds compressed file data in original form.	▪ File data removed during compression and not restorable to original form.
USED TO COMPRESS	▪ Files where data loss is unacceptable or information loss could pose a problem (e.g., finaicial data).	▪ When file information loss is acceptable.
APPLICATIONS	▪ Images, audio, text	▪ Images, audio, video
FORMAT EXAMPLES	▪ Image: GIF, RAW, BMP, PNG ▪ Audio: WAV, FLAC ▪ General: ZIP	▪ Image: JPEG ▪ Audio: MP3, AAC ▪ Video: AVC, HEVC, MPEG
ALGORITHMS USED	▪ Run Length Encoding ▪ Lempel-Ziv-Welch ▪ Huffman Coding ▪ Arithmetic Encoding	▪ Transform Coding ▪ Discrete Cosine Transform ▪ Discrete Wavelet Transform ▪ Fractal Compression
ADVANTAGES	▪ Retains file quality in smaller size	▪ Significantly reduced file size ▪ Supported by many tools, plugins, software ▪ Can choose preferred degree of compression
DRAWBACKS	▪ Larger compressed file sizes	▪ Result in file quality loss, degradation ▪ Original file quality cannot be recovered with decompression

JPEG

- JPEG stands for Joint Photographic Experts Group.
- We perform such type of compression to reduce the size of the file without damaging its quality.
- By reducing the size we can store it in a huge amount which was not possible earlier.
- Reducing the size of images will also improve the efficiency of the system as it will give less load on it.

Process Of JPEG Compression :

1. **Splitting** –
   We split our image into the blocks of 8*8 blocks. It forms 64 blocks in which each block is referred to as 1 pixel.
2. **Color Space Transform** –
   In this phase, we convert R, G, B to Y, Cb, Cr model. Here Y is for brightness, Cb is color blueness and Cr stands for Color redness. We transform it into chromium colors as these are less sensitive to human eyes thus can be removed.
3. **Apply DCT** –
   We apply Direct cosine transform on each block. The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies.

Process Of JPEG Compression :

4. **Quantization** –
   In the Quantization process, we quantize our data using the quantization table.
5. **Serialization** –
   In serialization, we perform the zig-zag scanning pattern to exploit redundancy.
6. **Vectoring** –
   We apply DPCM (differential pulse code modeling) on DC elements. DC elements are used to define the strength of colors.
7. **Encoding** –
   In the last stage, we apply to encode either run-length encoding or Huffman encoding. The main aim is to convert the image into text and by applying any encoding we convert it into binary form (0, 1) to compress the data.

GIF (Graphics Interchange Format)

- GIF (Graphics Interchange Format) is not a data compression method.
- The original version of GIF is known as GIF87a.
- It is graphical image format that uses variant of LZW to compress the graphical data and allows to send image between different computers.
- It scans the image row by row and discovers pixel correlated within row not between rows.
- GIF uses growing and dynamic dictionary for compressing data.
- GIF images uses 8 bit format which supports 256 colors.
- These colors cannot be mixed to make new colors.
- It is very popular on internet due to its small size and portability feature.
- It is considered best for line art with limited colors, images with large flat areas of color and for images that need to be animated.

GIF (Graphics Interchange Format)

Versions of GIF

GIF has only two versions:

- The first version was introduced in 1987 as GIF87a.
- The second version was an extended version and came in existence in 1989. It was called GIF89a and it is used until today as the standard format.