Design & Implementation of JPEG baseline coder model

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Our Motivation

- **Increasing Volume Of Data**

  Around 3.7m new videos are uploaded to YouTube every day - that's around 271,330 hours of video content based on an average length of 4.4 minutes.

- **Increasing Quality Of Data**

  In past times we talk about 260p video data but increasing demands of people and day by day technology leads to 720p, 1080p, 2K, 4K & even 8K now these days.

- **Increasing Storage Capacity For Data**

  Storing a low quality image is easy but when we go on increasing quality of the image we have to compromise with the space.

Now here comes the idea of Data Compression!

Introduction to Data Compression.

What is compression?

Data compression is a reduction in the number of bits needed to represent data. Compressing data can save storage capacity, speed up file transfer, and decrease costs for storage hardware and network bandwidth.

Types of Compression.

T

- **Lossless** - the original image or video data can be recovered exactly.
- **Lossy** - there is always a loss of some information about the original data.

Basic Data Redundancies

Coding Redundancy

- It is associated with the representation of information.
- The information is represented in the form of codes.
- If the gray levels of an image are coded in a way that uses more code symbols than absolutely necessary to represent each gray level then the resulting image is said to contain coding redundancy.

Interpixel Redundancy

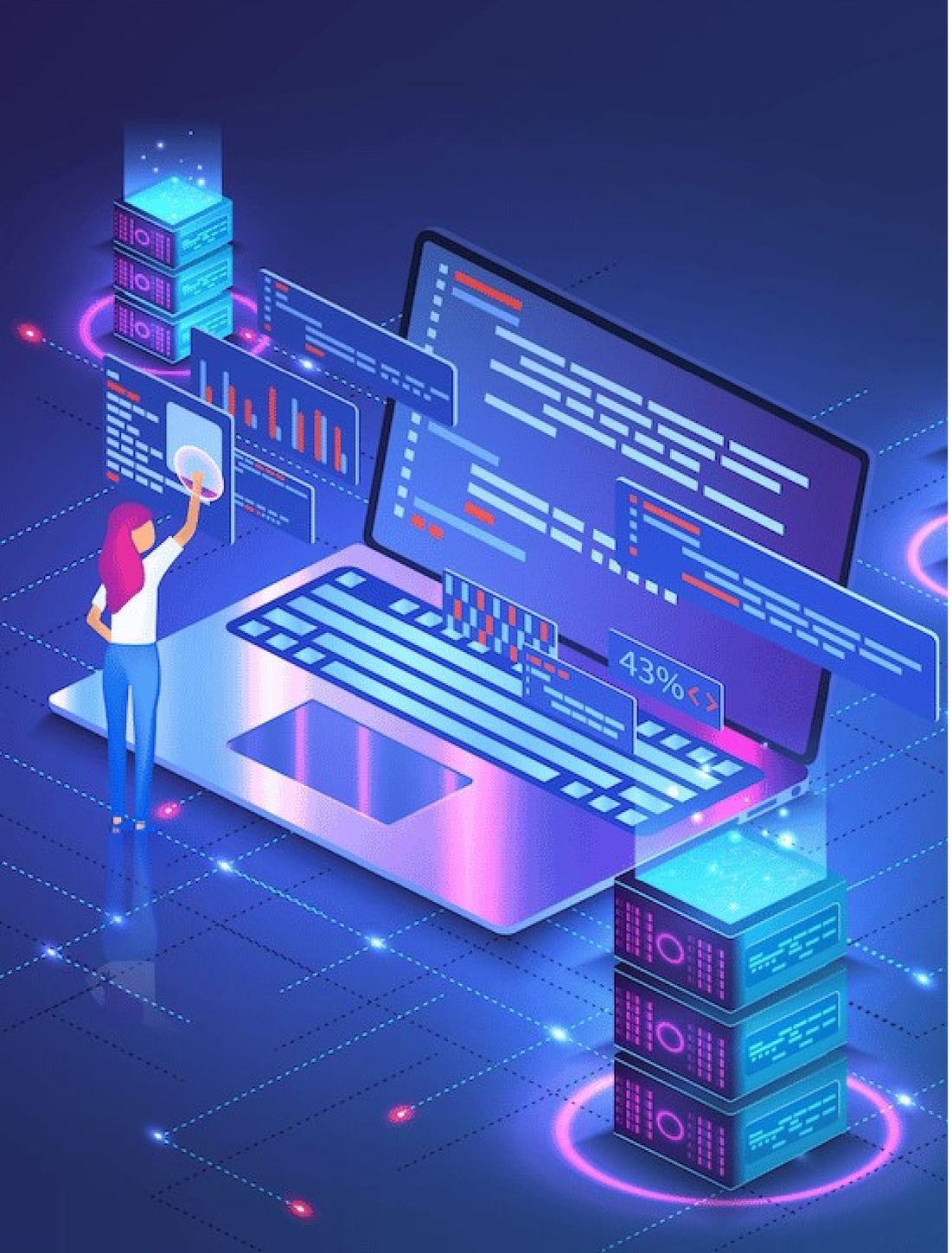
- It is due to the correlation between the neighboring pixels in an image.
- That means neighboring pixels are not statistically independent. The gray levels are not equally probable.
- The value of any given pixel can be predicated from the value of its neighbors that is they are highly correlated.

Psychovisual Redundancy

- It exist because human perception does not involve quantitative analysis of every pixel or luminance value in the image.
- It’s elimination is real visual information is possible only because the information itself is not essential for normal visual processing.

Performance Parameter's of Data Compression

- **Compression ratio** - size of original data to that of compressed one.
- **Distortion** - difference between the original and reconstructed data.
- **Compression rate** - the average number of bits required to represent a single sample.
- **Fidelity & Quality** - difference between the reconstruction and the original are fidelity and quality.



Literature Survey of Data Compression.

Data Compression Techniques (DCT) is the most widely used in lossy compression method, and is used in multimedia formats for images (such as **JPEG** and **HEIF**), video (such as **MPEG**, **AVC** and **HEVC**) and audio (such as **MP3**, **AAC** and **Vorbis**). **Lossy image compression** is used in digital cameras, to increase storage capacities.

Comparison of different compression techniques

FACTORS	DATA COMPRESSION	
	LOSSLESS COMPRESSION	LOSSY COMPRESSION
Definition	Lossless compression is a class of data compression algorithms that allow the original data to be perfectly reconstructed from the compressed data[7].	Lossy compression is the class of data encoding methods that uses inexact approximations to represent the content. These techniques are used to reduce the data size for storage, handling, and transmitting content[8].
Algorithm	RLW, LZW, Arithmetic encoding, Huffman coding, Shannon-Fano coding	Transform coding, DCT,DWT, Fractal compression, Rectangle Segmentation and Sparse Matrix Storage (RSSMS).
Uses	Text or programs, images and sound	Images, audio and video.
Images	RAW, BMP, and PNG are all Lossless formats.	JPEG and GUI are lossy image formats.
Audio	WAV, FLAC, and ALAC are all Lossless formats.	MP3, MP4, and OGG are lossy audio formats.
Video	Few lossless video formats are in common consumer use, they would result in video files taking up a huge amount of space.	Common formats like H-264, MKV, and WMV are all lossy. H-264 can provides smaller files with higher qualities than previous generation of video codec because it has a “smaller” algorithm that’s better at choosing the data to throw out.

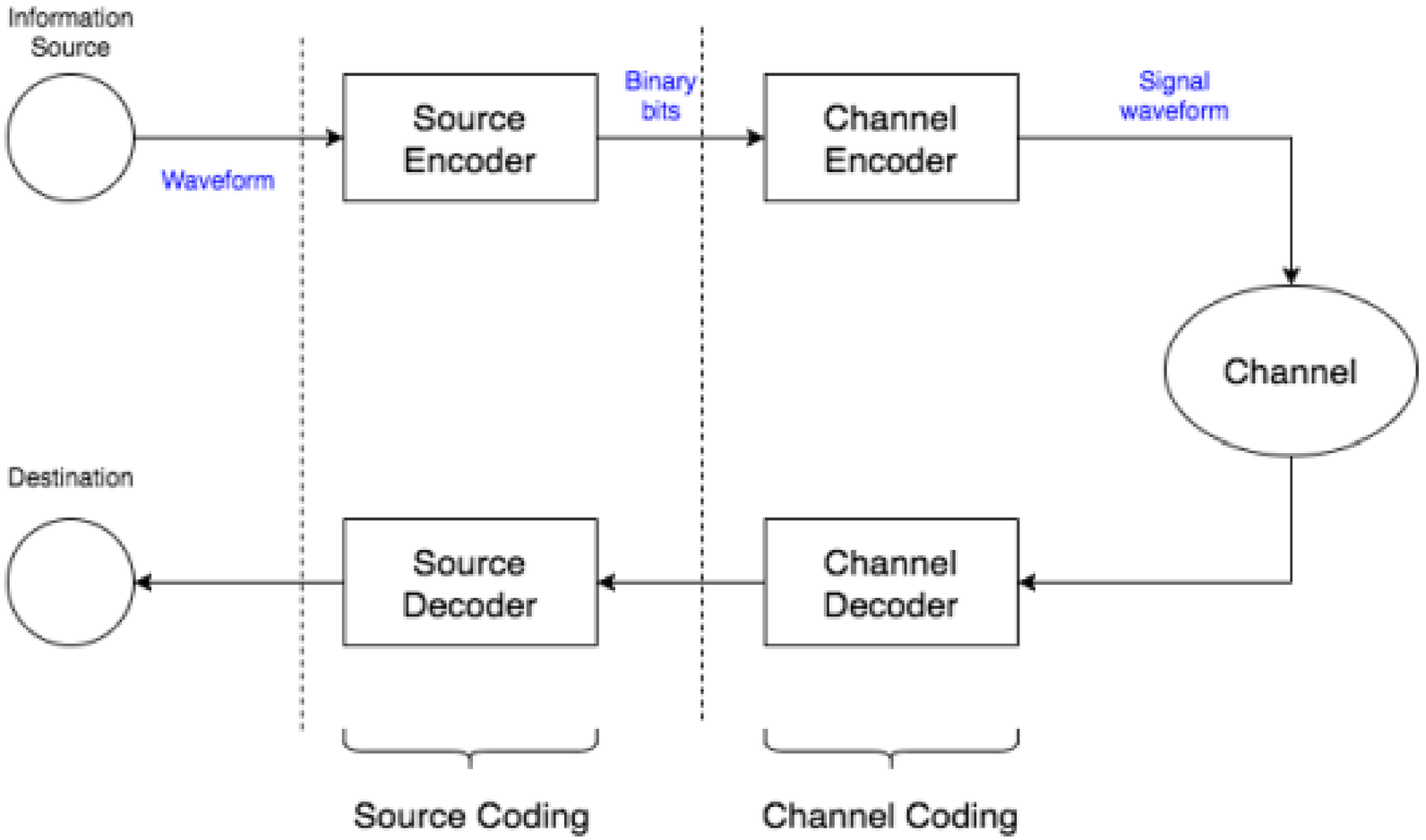
Lossless compression techniques

FACTORS	Lossless Compression Techniques		
	RLE	**LZW**	**HUFFMAN CODING**
Advantages	It is easy to implement. It is a good alternative for a complex compression algorithm.	It is simple and good compression. Dynamic code word table built for each file. Decompression creates the code word table so it does not need to be passed.	It is easy to implement. Produce a lossless compression of images.
Speed	Fast to execute.	Fast compression	Fast to execute.
Application	TIFF, PDF, BMP	TIFF, GIF, PDF	ZIP, ARJ, JPEG, MPEG
Drawback	It cannot achieve the high compression ratios as compared to another advanced compression methods.	Management of string table is difficult. Only works for English text. Everyone needs a dictionary.	Relatively slow. Depends upon statistical model of data. Decoding is difficult due to different code lengths. Overhead due to Huffman tree.

Lossy compression technique

FACTORS	Lossy Compression Techniques		
	Transform coding	**DCT**	**DWT**
Advantages	It produce very good image quality. Increased encoding with adaptive bit assignment (ATC), an encoding complexity comparable to that of fully adaptive predictive coding (APC).	It is real valued. Better energy compaction. Coefficients are nearly correlated. Experimentally observed to work well.	It offer a simultaneous location of time and frequencies. It can be used to decompose a signal into component wavelet. Very small wavelet can be used to isolate fine details in a signal, while very large wavelet can identify coarse details.
Computation	It is computationall y intensive.	It is a fast computational approach.	It is computationally very fast.
Application	JPEG, MPEG	JPEG, MPEG, MJPEG	JPEG, MPEG
Drawback	Transform matrix cannot be factored into sparse matrix. High computational complexity.	Truncation of higher spectral coefficients results in blurring of the images, especially wherever the details are high. Coarse quantization of some of the low spectral coefficient introduces graininess in the smooth portions of the images.	DWT is shift sensitive because input signal shifts generate unpredictable changes in DWT coefficients. It suffers from poor directionality because DWT coefficients reveal only three spatial orientations.

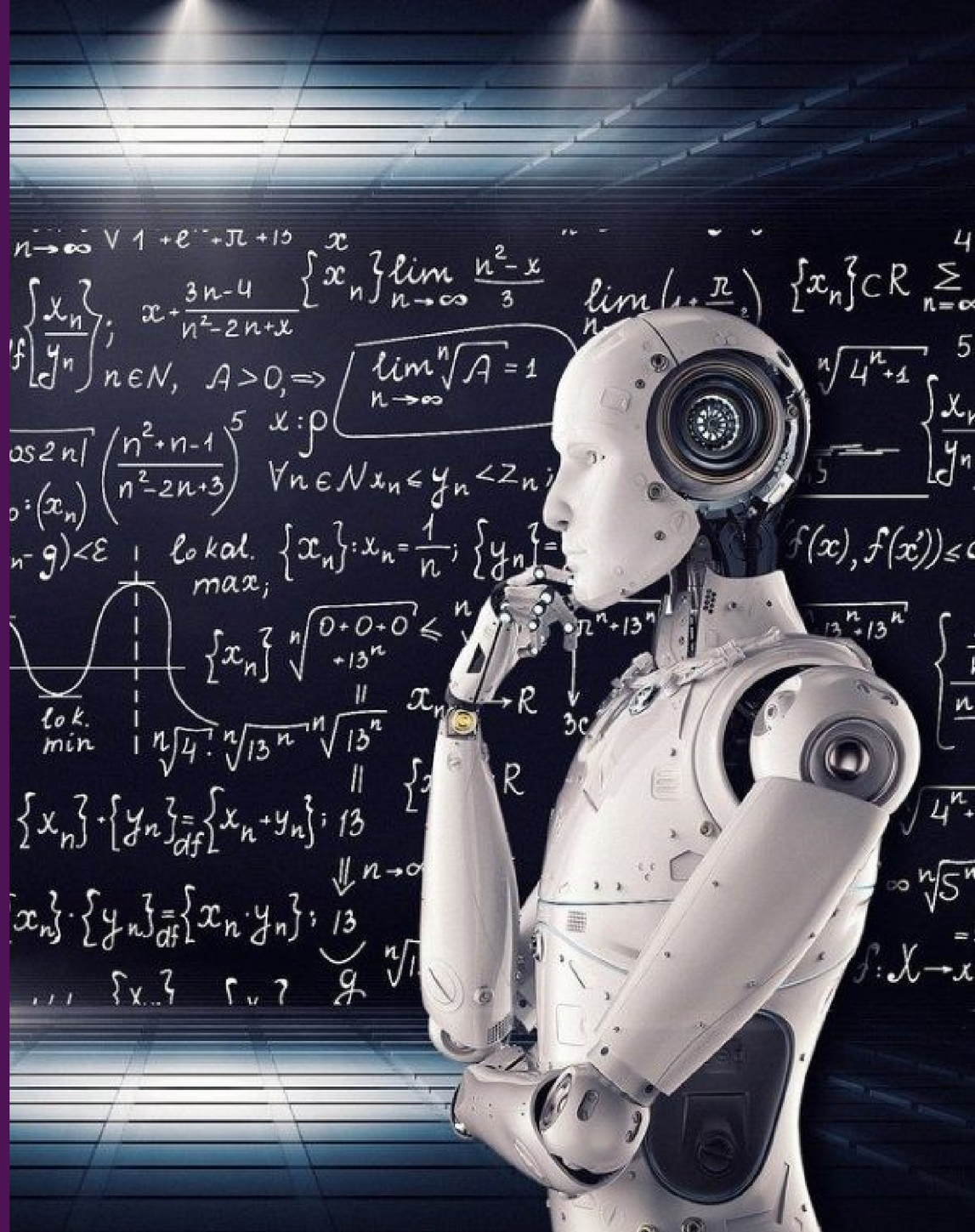
Basic model for Data Compression.



- **Source coding** - process of reducing the image and video data so that it fits into the available limited bandwidth or storage space.
- **Channel coding** - process of adding additional data bits to the compressed data stream before transmission is called channel coding

JPEG 2000

JPEG 2000 is an image coding system that uses state-of-the-art compression techniques based on wavelet technology and offers an extremely high level of scalability and accessibility. Content can be coded once at any quality, up to lossless, but accessed and decoded at a potentially very large number of other qualities and resolutions and/or by region of interest, with no significant penalty in coding efficiency.



JPEG *Vs* JPEG 2000

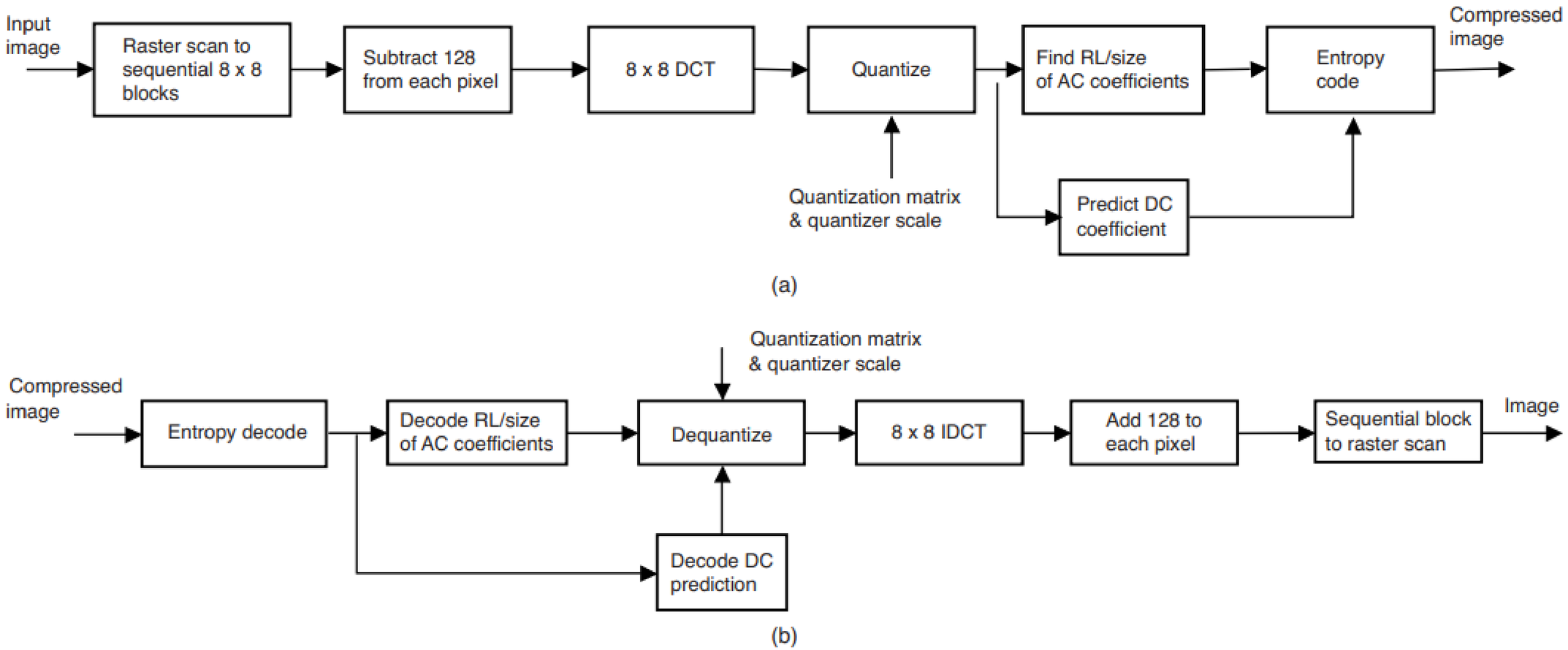
JPEG

1. DCT (Discrete Cosine Transform)
2. Block based segmentation of source image.
3. Less computational Complexity.
4. Less compression ratio.
5. The quality of image is less at low bit rate.
6. PSNR is low.

JPEG 2000

1. DWT (Discrete Wavelet Transform)
2. Tile based.
3. High computational Complexity.
4. More compression ratio (20% to 50% more)
5. Improvement in Image quality at low bit rate.
6. PSNR is high.

Design & Implementation of JPEG baseline coder model



Block diagram of JPEG baseline coder (a) encoder (b) decoder

Planning for further Progress

Topics covered till now

- Our motivation towards data compression.
- Introduction to Data Compression.
- Why Data compression is necessary.
- Design & Implementation of the JPEG 2000 model for further progress.

Topics to be covered next

- Evaluating proposed model.
- Application of JPEG 2000.
- Algorithm & Code description.
- Brief intro to the state-of-the-art compression technique.

Finalizing project

- Implementation of project using matlab.
- Comparison between our model and other models.
- Discussion based on the final code and modifications.

References & Bibliography

- **Books we referred**
  - Still Image and Video Compression with MATLAB by K. S. Thyagarajan
  - Course on Digital Image Processing with MATLAB by P K Thiruvikraman
  - Digital Signal and Image Processing Using MATLAB by Maurice Charbit
- **Research papers we referred**
  - A survey : Various techniques of image compression
  - A survey paper on different Data Compression Techniques

Thank You