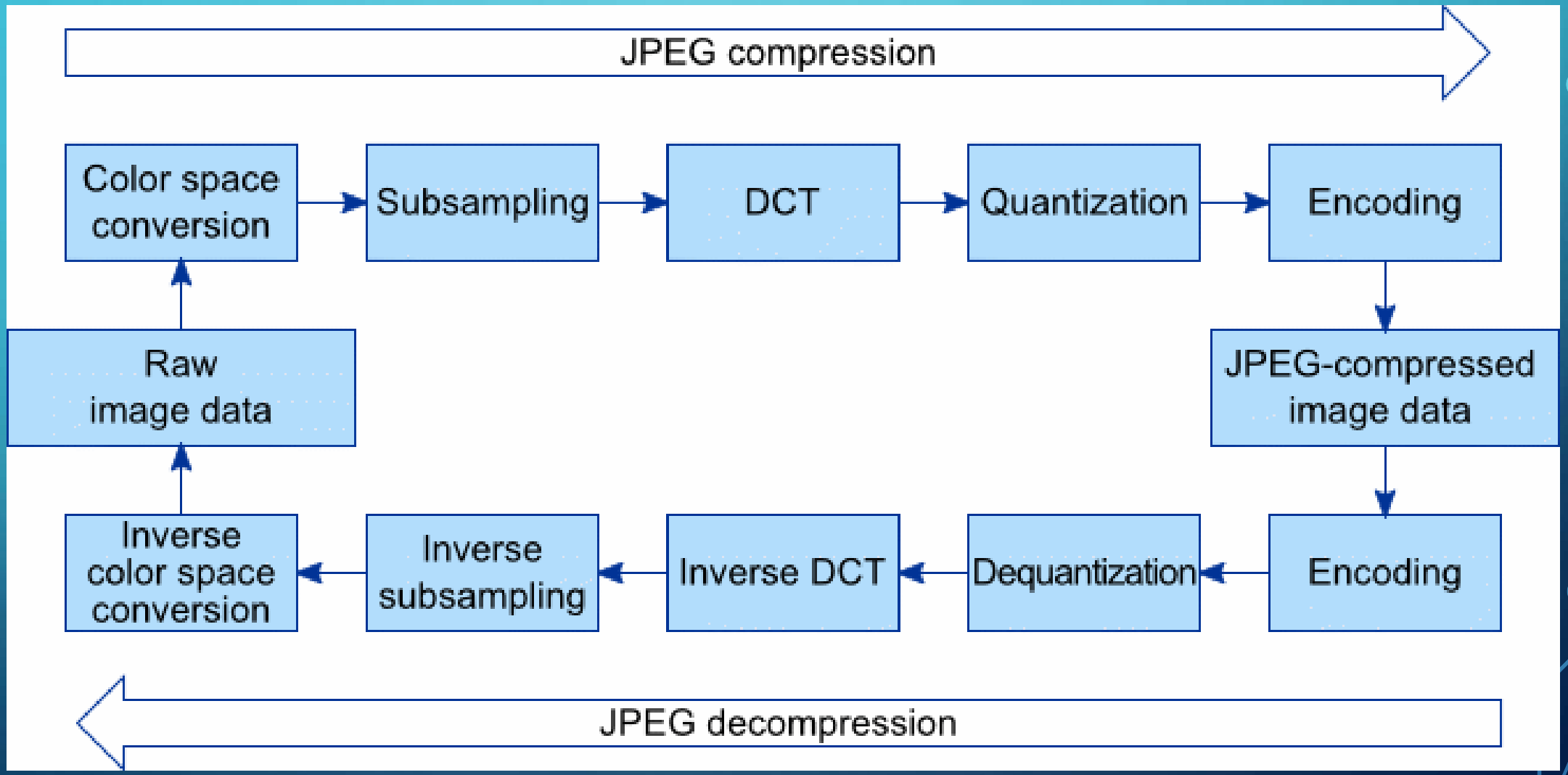
UNIT 7

MULTIMEDIA COMPRESSION TECHNIQUE

JPEG COMPRESSION

- JPEG (Joint Photographic Experts Group) compression is a widely used method for compressing digital images, particularly for those images produced by digital photography. It is a lossy compression technique, meaning that some amount of original image data is lost and cannot be recovered, but it is designed to reduce file size while maintaining acceptable image quality. Here's a breakdown of how JPEG compression works:


JPEG compression
Color space conversion
Subsampling
DCT
Quantization
Encoding
JPEG-compressed image data
Encoding
Dequantization
Inverse DCT
Inverse subsampling
Inverse color space conversion
Raw image data
JPEG decompression

1. COLOR SPACE TRANSFORMATION

- JPEG compression typically starts by converting the image from the RGB color space to the YCbCr color space. This separates the image into one luminance component (Y) and two chrominance components (Cb and Cr). Human vision is more sensitive to luminance changes than to chrominance changes, which allows more compression on the chrominance components.

2. **DOWNSAMPLING**

- The chrominance components (Cb and Cr) are often downsampled. Common ratios are 4:2:2 or 4:2:0, meaning that the chrominance information is stored at a lower resolution than the luminance information. This step reduces the amount of data without significantly affecting perceived image quality.

3. **BLOCK SPLITTING**

- The image is divided into 8x8 blocks of pixels. Each block is processed independently, which allows for localized compression and helps in managing the complexity of the calculations.

4. DISCRETE COSINE TRANSFORM (DCT)

- Each 8x8 block is transformed from the spatial domain to the frequency domain using the Discrete Cosine Transform (DCT). This step converts pixel values into sets of coefficients that represent the image's spatial frequencies. The DCT tends to concentrate most of the block's information into a few coefficients, particularly the low-frequency ones.

5. **QUANTIZATION**

- The DCT coefficients are then quantized. This means dividing each coefficient by a quantization factor and rounding the result. The quantization step is where most of the compression happens, as it reduces the precision of the DCT coefficients, leading to loss of some image data. Quantization is controlled by a quantization matrix, and adjusting this matrix allows control over the trade-off between image quality and file size.

6. **ENTROPY CODING**

- After quantization, the coefficients are ordered in a zigzag sequence to group the zero values together. This sequence is then subjected to entropy coding (typically Huffman coding or arithmetic coding), which further reduces the file size by encoding the data more efficiently.

7. FILE FORMATTING

- The compressed data is then formatted into a JPEG file, which includes headers and metadata necessary for decoding the image.

DECODING PROCESS

1. **Entropy decoding** to retrieve the quantized DCT coefficients.
2. **Inverse Quantization** to multiply the coefficients back by the quantization factors.
3. **Inverse DCT** to convert the coefficients back to spatial domain pixel values.
4. **Recombination** of the blocks into the full image.
5. **Color space conversion** from YCbCr back to RGB.

QUALITY AND COMPRESSION RATIO

- JPEG allows users to adjust the compression level, typically through a quality setting (usually ranging from 0 to 100). Lower quality settings increase compression (resulting in smaller file sizes) but reduce image quality. Higher quality settings reduce compression (resulting in larger file sizes) but maintain better image quality.

LIMITATIONS

- **Lossy Compression**: Some data loss occurs, which can result in visible artifacts, especially at high compression ratios.**Not Ideal for Line Art or Text:** JPEG is not well-suited for images with sharp edges or text, as it can introduce blurring and artifacts.

LOSSY AUDIO COMPRESSION

- Lossy audio compression is a technique used to reduce the file size of audio data by removing parts of the audio signal that are deemed less important or imperceptible to human hearing. This type of compression results in some loss of audio quality, but it is designed to be minimal and often unnoticeable to the average listener. The goal is to achieve a significant reduction in file size while maintaining an acceptable level of audio quality.

PSYCHOACOUSTICS

Psychoacoustics

Psychoacoustics is the study of how humans perceive sound. Lossy audio compression algorithms use psychoacoustic models to identify and remove audio data that is unlikely to be perceived by the human ear. For example, sounds that are masked by louder sounds nearby in frequency or time can be discarded.

MP3 (MPEG-1 AUDIO LAYER 3):

- MP3 is one of the most widely used lossy audio compression formats. It uses a psychoacoustic model to remove inaudible parts of the audio and compresses the remaining data using transform coding and quantization.

OVERVIEW

- **Development:** MP3 was developed by the Fraunhofer Society in the early 1990s and became a standard in 1993.
- **Compression Method:** Uses psychoacoustic models to remove inaudible parts of the audio, then applies transform coding (MDCT) and quantization to compress the data.

KEY FEATURES

- **Bit Rates:** Typically ranges from 32 kbps to 320 kbps. Common bit rates for music are 128 kbps, 192 kbps, and 256 kbps.
- **Compatibility:** Widely supported across almost all digital audio players, smartphones, and media software.
- **File Extension:** .mp3

ADVANTAGES

- **Ubiquity:** MP3 is one of the most universally accepted audio formats.
- **Compatibility:** Nearly all audio playback devices and software support MP3.
- **Decent Quality at High Bit Rates:** Provides good audio quality at higher bit rates (192 kbps and above).

AAC (ADVANCED AUDIO CODING):

- AAC is considered the successor to MP3 and offers better sound quality at similar bit rates. It is used in various applications, including streaming services, video platforms, and digital radio.

OVERVIEW

- **Development:** AAC was developed as part of the MPEG-2 and MPEG-4 standards by a consortium including companies like Dolby Laboratories, AT&T, Sony, and Nokia. It became a standard in 1997.
- **Compression Method**: Uses more advanced psychoacoustic models and coding techniques than MP3, such as temporal noise shaping, prediction, and better handling of frequencies.

KEY FEATURES

- **Bit Rates:** Typically ranges from 8 kbps to 512 kbps. Common bit rates for music are 128 kbps, 192 kbps, and 256 kbps.
- **Compatibility:** Supported by most modern devices and software, including smartphones, media players, and streaming services.
- **File Extension:** .aac or .m4a (commonly used in iTunes and Apple devices).

ADVANTAGES

- **Better Quality at Lower Bit Rates:** Offers better audio quality than MP3 at the same or even lower bit rates.
- **Efficiency:** More efficient compression results in smaller file sizes for the same quality.
- **Versatility:** Supports more audio channels and higher resolution audio.

DISADVANTAGES

- **Less Ubiquity**: While widely supported, it is not as universally compatible as MP3, particularly on older devices.**Licensing**: Some proprietary aspects might complicate usage in certain open-source or free software projects.

MP3 VS AAC

- **Compression & Size**

AAC & MP3: Both are lossy formats. They compress audio data to reduce file size, leading to some loss in quality. However, AAC typically offers better quality at similar bit rates than MP3.

- **Compatibility**
  - MP3’s longevity ensures broad compatibility across devices, old and new. However, AAC is widely accepted in modern devices, especially thanks to endorsements from big players like Apple.

- **Sound Quality**

When comparing AAC vs MP3, AAC is generally superior to MP3, especially at lower bit rates where MP3 can sound less clear. Yet MP3 still offers decent quality, especially at higher bit rates, but might not be as crisp as AAC.

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