Reading Assignment

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From the initial reduction of data redundancy to advanced encoding standards, and then to the expansion of dynamic range, each step in the development of image compression technology has been an exploration of the delicate balance between quality, efficiency, and storage space. With the rise of artificial intelligence and the evolution of computational models, deep learning has made the compression process more efficient and adaptive, optimizing compression quality and data processing efficiency.

1. Core Insights in Image Compression

Here are the key insights and principles extracted from Image compression technologies, along with their interconnections and universality:

- **Data Redundancy Reduction**:
    - **Fundamentals**: The essence of compression technology is reducing data redundancy, whether it's spatial redundancy (similarity between adjacent pixels), temporal redundancy (similarity between adjacent frames), or color redundancy (repetition of color information).
    - **Connectivity**: All compression methods revolve around effectively identifying and removing these redundancies.
- **Lossy vs. Lossless Compression(有損、無損)**:
    - **Principle**: Lossy compression achieves higher compression rates by sacrificing parts of the information (usually with minimal visual impact), while lossless compression retains all information.
    - **Universality**: Both methods are applied in image and video compression, with the specific choice depending on the need for quality and file size.

- **Color Space Optimization**:
  - **Basics**: Color spaces like YCbCr, which separate luminance and chrominance, leverage the human eye's greater sensitivity to luminance changes.
  - **Evolution**: The transition from RGB to YCbCr represents the evolution of compression technology, aiming to improve efficiency and quality.
- **Resolution and Scanning Methods**:
  - **Principle**: Resolution determines the level of detail in an image, while scanning methods (progressive or interlaced) affect the smoothness and clarity of video streams.
  - **Evolution**: The shift from interlaced to progressive scanning reflects technological advancement, catering to higher quality standards.

2. Technological Progress and Application

- **Evolution of Coding Standards**:
  - From MPEG-2 to H.264/MPEG-4 AVC, and then to H.265/HEVC, the progression of coding standards reflects a continual balance between compression efficiency and complexity.
  - These evolutions adapt to the needs for higher resolution and lower bandwidth.
- **Expansion of Dynamic Range**:
  - The emergence of HDR technology marks a shift from Standard Dynamic Range (SDR) to High Dynamic Range, enabling images and videos to display a richer and more realistic visual experience.
  - PQ curve and broader color spaces have driven this change, providing imagery closer to human visual perception.

3. Future-Oriented Thoughts and Ideas

- **AI in Image Compression**:

- Utilize machine learning and deep learning to optimize compression algorithms for smarter data redundancy identification and compression.
- Develop adaptive compression models that dynamically adjust compression strategies based on content and transmission conditions.

- **Combining Cloud Computing with Edge Computing**:
  - Combine the processing power of cloud computing with the real-time response of edge computing to optimize the storage and transmission of large-scale video content.
  - Use cloud resources for efficient video encoding, with edge devices handling personalized decoding and display.

- **Image Compression for AR and VR**:
  - Develop specialized compression technologies for AR and VR content to handle higher data volumes and more complex scenarios.
  - Explore efficient encoding methods for spatial audio and 360-degree videos for immersive experiences.

- **Environmental Sustainability and Efficiency**:
  - Develop low-energy consumption compression technologies to reduce energy usage in data centers and network devices.
  - Optimize algorithms to reduce computational resource needs while maintaining high-quality output, supporting environmental sustainability goals.

The development and application of image compression technology showcase a continual pursuit of storage and transmission efficiency while constantly adapting to and satisfying the need for high-quality visual experiences. From basic data redundancy reduction to advanced coding standards, and then to the expansion of the dynamic range, each step is an improvement and optimization of previous technologies. These advancements not only propel multimedia technology forward but also drive the evolution of related hardware and display technologies, bringing richer and more authentic visual experiences to users.