H.264 (AVC): Core concepts

Information and Encoding

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01

Introduction

Introduction

Figure 1: Video Encoder for H.264

H.264 (AVC):

- Most common video compression standard in use today.
- Can encode high-quality video at lower bit rates than older compression standards
- Used in Blu-ray and a wide variety of streaming services, including on-demand and live TV.
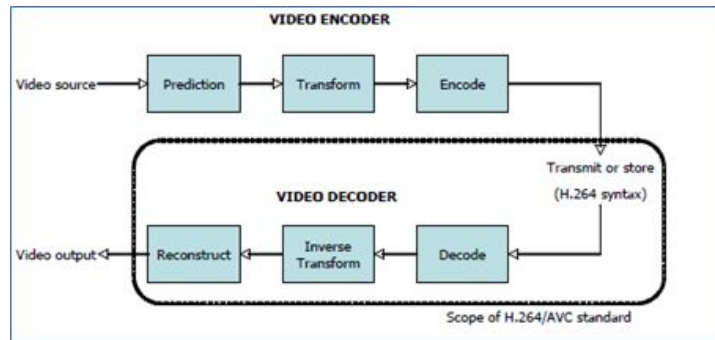

Figure 2: H.264 macroblocks with 16 * 16 pixels

H.264 Bitstream Structure

Section A: Group of Pictures (GOP)

What is a GOP?

- A sequence of frames starting with a key picture, such as an Instantaneous Decoding Refresh (IDR) picture.
- Independent decoding.

Hierarchical-P Coding:

- Frames encoded hierarchically
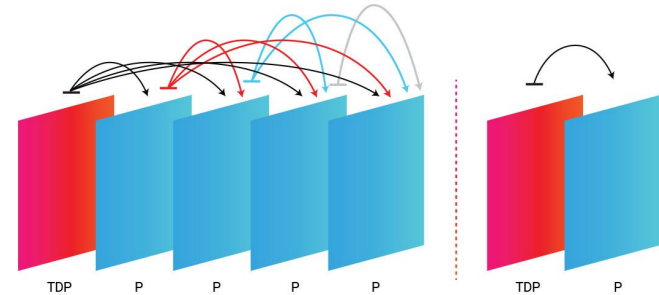- P-frames predicted
- Efficient prediction while reducing delay.

Figure 3: Hierarchical-P coding structure example

H.264 Bitstream Structure

Section B: Network Abstraction Layer Unit (NALU)

What is a NALU?

- Network Abstraction Layer Units
- Each carrying specific types of data
- Each NALU has a 1-byte header with three fields:
  - **Forbidden Zero Bit (F):** Signals data loss; error handling.
  - **NAL Reference Indicator (NRI):** Importance of the NALU for decoding.
  - **NAL Unit Type (NUT):** Type of data in the payload.

Preventing Data Conflicts:

- Emulation prevention byte (0x03) is inserted when necessary.

Nut	Nalu content	NRI	NALU class
1	non-IDR picture	2	VCL
5	IDR picture	3	VCL
6	Supplermental Enhancement Information	0	non-VCL
7	Sequence Parameter Set	3	non-VCL
8	Picture Parameter Set	3	non-VCL

Figure 4: Most common NALUs

H.264 Bitstream Structure

Section C: Macroblock Layer

What is a Macroblock?

- Basic unit of video encoding in H.264

Macroblock in VCL NALU:

- Core of coding.
- Each macroblock's data is stored in a string of data bits (SODB). Later transformed into a byte-aligned payload (RBSP) to meet bitstream requirements.

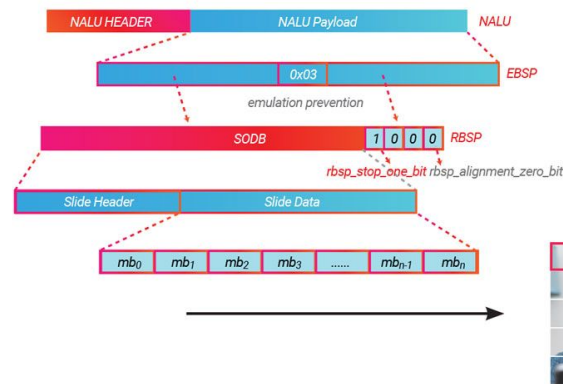**Preventing Patterns** `0x0000` or `0x000001`:

- Insertion of special bytes.

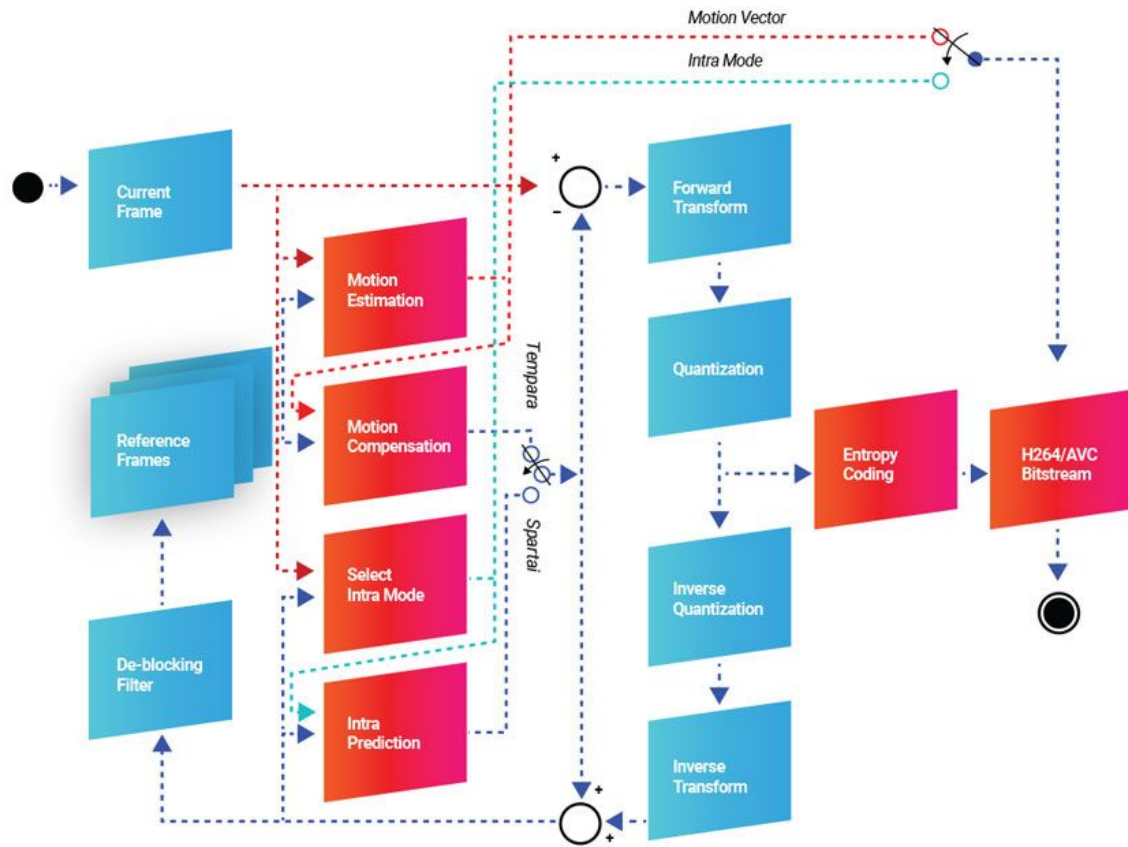Figure 5: The composition of a VCL NALU, only one slice in a picture.

Figure 6: H. 264 Architecture

02

Intra-frame compression

Intra-frame Compression

- Reduces size of each frame independently by reducing redundant information within the frame
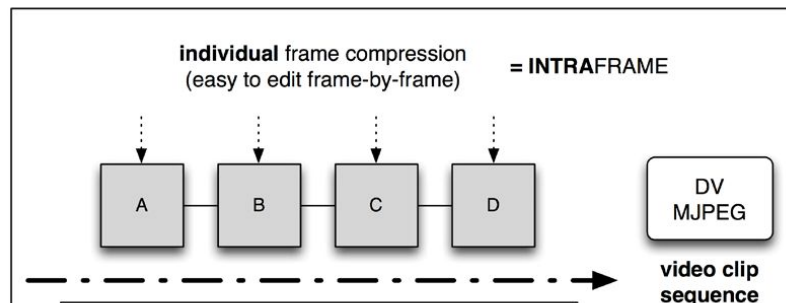- Reduces file size while maintaining high image quality.

Figure 9: IntraFrame Compression

Figure 10: IntraFrame Compression through pictures

03

Inter-frame compression

Inter-frame Compression

- Reduces file size across multiple frames (creating a starting point and only saving the changes in subsequent frames.)
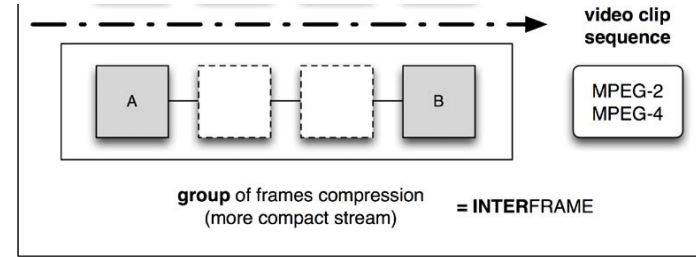- Only the changes between frames are saved -> drastically reduced file sizes.

Figure 11: InterFrame Compression

Figure 12: InterFrame Compression through pictures

Differences

Intraframe Compression
Every frame is encoded individually

Interframe Compression
Only the differences between frames are encoded

Figure 13: Difference between Intraframe and Interframe Compression

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Frame Types

Type Frames:
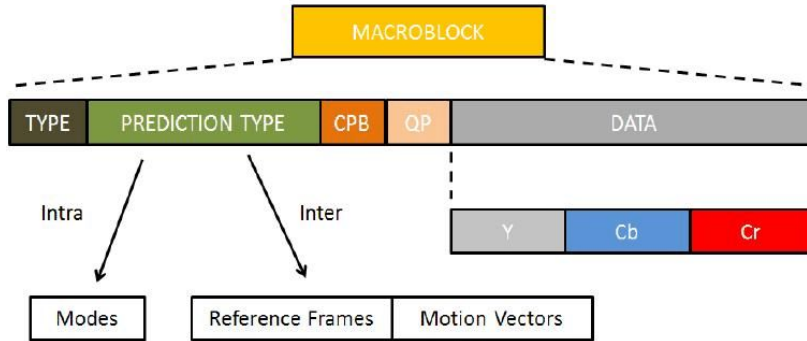
- I type frames (INTRA)
- P frames (INTER)
- B frames (INTER)

Figure 7: Type of macroblocks per frame type

Figure 8: H.264 Macroblock Representation

04

Motion compensation

Motion Compensation

What is Motion Compensation

Predicts the motion of objects in frame, allowing for greater compression, while retaining quality.

Macroblocks and Partitions

Splitting the frame in macroblocks improves compression.
Smaller partitions allow for precise motion tracking.

Motion Vectors

Each macroblock/partition has a motion vector.
Memory saved by only storing the vector

Reference Frames

H.264 can use multiple reference frames.
Increases accuracy, specially in high-motion content.

05

Entropy
Coding

Entropy Coding

CABAC

- Binary arithmetic coding.

- Adapts to data frequency.

- Lower complexity and resource consumption.

- Ideal for devices with processing limitations.

CAVLC

- Adaptive binary arithmetic coding.

- High compression efficiency, adapting to data context.

- More complex and demanding in terms of processing.

- Used when the priority is higher compression without significant quality loss.

06

H.264
APPLICATIONS

H.264 APPLICATIONS

STREAMING SERVICES

Used in platforms like YouTube, Netflix, and Amazon Prime. Ensures smooth streaming on various devices and network conditions.

VIDEO CONFERENCING

Used in applications like Zoom, Skype, and Microsoft Teams. Enables real-time communication with low latency.

BROADCASTING

Adopted in digital TV broadcasting (e.g., DVB, ATSC). Suitable for live TV and satellite broadcasts.

SECURITY AND SURVEILLANCE

Used in IP cameras and CCTV systems.
Reduces storage and bandwidth requirements for continuous recording.
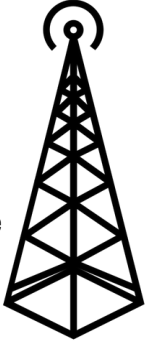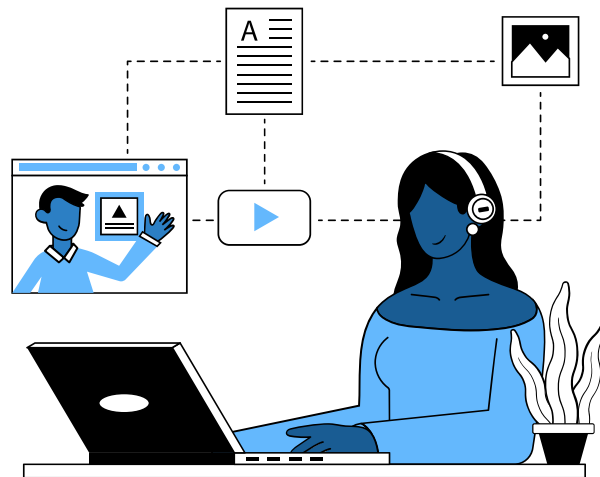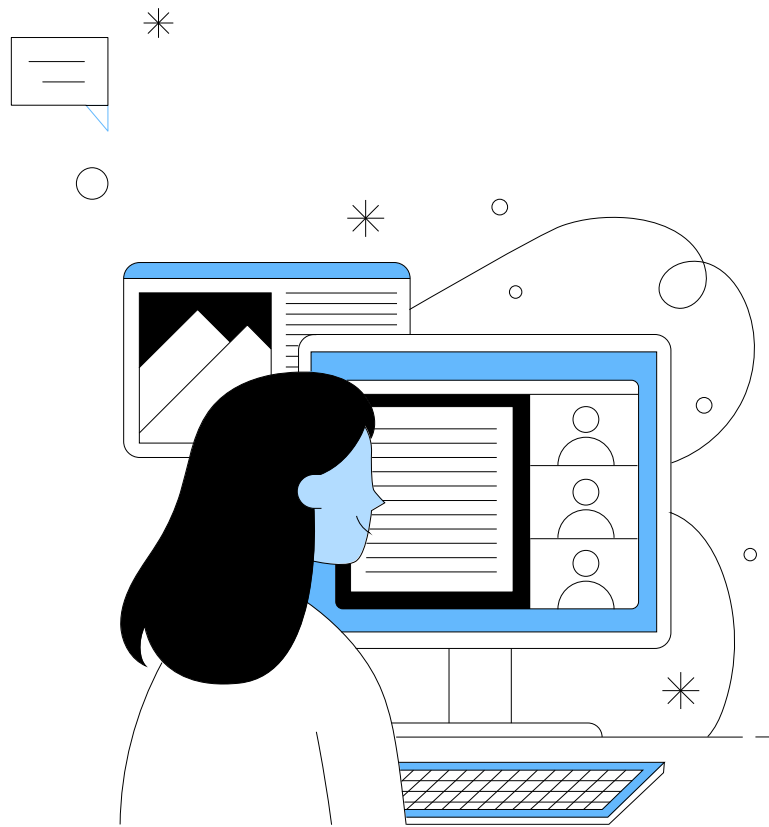
BLU-RAY DISKS

Standard format for Blu-ray video compression. Ensures compatibility across Blu-ray players and high-definition screens.

Conclusion

- Wide range of supported devices

- Important for backward compatibility

- Reliable alternative to newer standards (HVEC, AV1)

THANKS!

DOES ANYONE HAVE ANY QUESTIONS?

Fábio Matias - 108011
Gonçalo Cunha - 108352
Matilde Teixeira - 108193