

Video Coding using Deep Learning

Focus: Deep Contextual Video Compression

Gerald Schuller

TU Ilmenau

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Outline

Introduction to Video Coding

Deep Learning for Video Coding

Deep Contextual Video Compression (DCVC)

Components of Deep Contextual Video Compression

- Autoencoders

- Encoder

- Decoder

- Context Model

Training Deep Video Compression Models

Evaluation Metrics

Case Study: Deep Contextual Video Compression

Future Directions

Conclusion

Introduction to Video Coding

- ▶ Definition of video coding
- ▶ Importance of video compression
- ▶ Traditional video coding techniques (e.g., MPEG, H.264)

Deep Learning for Video Coding

- ▶ Overview of deep learning
- ▶ Application of deep learning in video compression
- ▶ Advantages over traditional methods

Deep Contextual Video Compression

- ▶ Introduction to Deep Contextual Video Compression
- ▶ Key features and innovations
- ▶ Comparison with traditional methods

DCVC Comparison with traditional methods

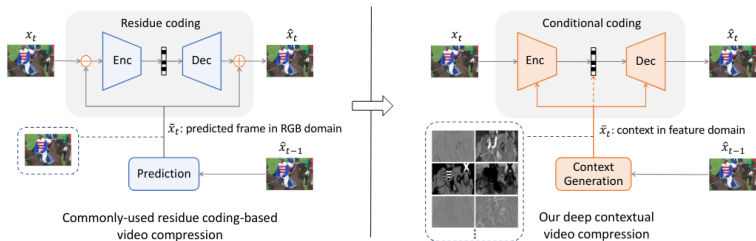


Figure 1: Paradigm shift from residue coding-based framework to conditional coding-based framework. x_t is the current frame. \hat{x}_t and \hat{x}_{t-1} are the current and previous decoded frames. The orange dashed line means that the context is also used for entropy modeling.

Figure: From: Jiahao Li, Bin Li, Yan Lu: "Deep Contextual Video Compression"

DCVC Detailed Structure

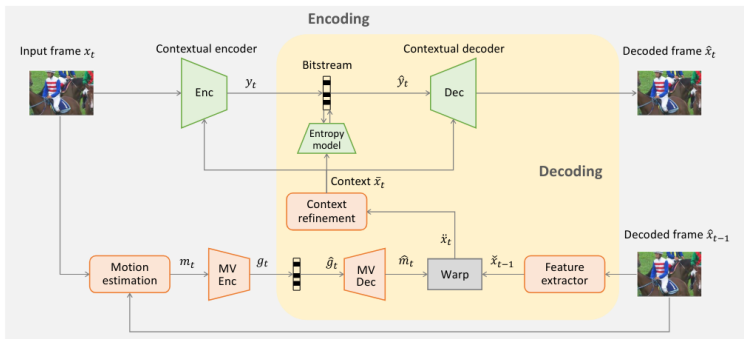


Figure: From: Jiahao Li, Bin Li, Yan Lu: "Deep Contextual Video Compression"

DCVC Bit Per Pixel vs Quality in MS-SSIM

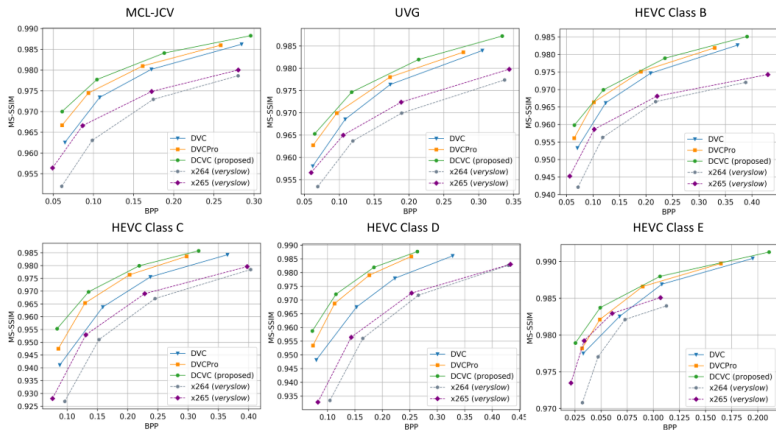


Figure 6: MS-SSIM and bitrate comparison. The DL-based codecs are fine-tuned for MS-SSIM.

Figure: DCVC gets comparable quality at roughly half the bitrate of X264 and x265. From: Jiahao Li, Bin Li, Yan Lu: "Deep Contextual Video Compression"

Autoencoders as Core Component of DCVC

- ▶ Definition and function of autoencoders
- ▶ Types of autoencoders (e.g., Variational Autoencoders, Convolutional Autoencoders)
- ▶ Role of autoencoders in video compression

Autoencoders: Definition

► Definition

- An autoencoder is a type of artificial neural network used to learn efficient codings of input data.
- It consists of two main parts: an encoder that compresses the input into a latent-space representation, and a decoder that reconstructs the input from this representation.

Autoencoders: Function

▶ **Function**

▶ **Dimensionality Reduction**

- ▶ Autoencoders reduce the dimensionality of data, making it easier to process and analyze.

▶ **Feature Learning**

- ▶ They automatically learn the most relevant features of the data without human intervention.

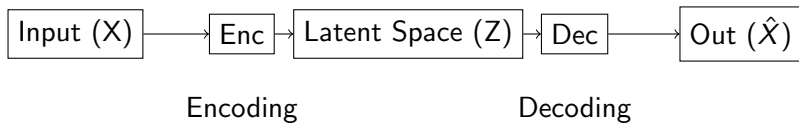
▶ **Data Reconstruction**

- ▶ By reconstructing the input data from the encoded representation, autoencoders can be used for data denoising and anomaly detection.

▶ **Compression in Video Coding**

- ▶ In video compression, autoencoders help in reducing the size of video frames by learning efficient representations, which are then used for reconstructing high-quality frames.

Structure of an Autoencoder



- ▶ **Input (X):** Original data.
- ▶ **Encoder:** Compresses the input data into a latent-space representation (Z).
- ▶ **Latent Space (Z):** Compressed representation of the data.
- ▶ **Decoder:** Reconstructs the data from the latent-space representation.
- ▶ **Output (\hat{X}):** Reconstructed data.

Autoencoder Audio Example Implementation

- ▶ A Colab notebook example for an autoencoder for audio:
- ▶ https://github.com/TUilmenauAMS/AES_Tutorial_2021
- ▶ Chapter: "The Convolutional Autoencoder Network"

Autoencoder Image Example Implementation

- ▶ A Colab notebook example for an autoencoder for images:
- ▶ <https://github.com/TUilmenauAMS/Videocoding/blob/main/imageVAE.ipynb>

Encoder

- ▶ Structure of the encoder
- ▶ Encoding process
- ▶ Techniques for improving encoding efficiency

Decoder

- ▶ Structure of the decoder
- ▶ Decoding process
- ▶ Techniques for improving decoding accuracy

Context Model

- ▶ Definition of context in video compression
- ▶ Building a context model
- ▶ Using context to enhance compression

Training Deep Video Compression Models

- ▶ Data preparation
- ▶ Training process
- ▶ Loss functions and optimization

Evaluation Metrics

- ▶ Common metrics (e.g., PSNR, SSIM)
- ▶ Subjective evaluation
- ▶ Benchmark datasets and comparisons

Case Study: Deep Contextual Video Compression

- ▶ Overview of a specific implementation
- ▶ Results and performance analysis
- ▶ Lessons learned and future directions

Future Directions

- ▶ Emerging trends in video compression
- ▶ Potential improvements with deep learning
- ▶ Research challenges and opportunities

Conclusion

- ▶ Summary of key points
- ▶ Impact of deep learning on video compression
- ▶ Final thoughts

Questions?