Data Compression Conference

Butterfly: Multiple Reference Frames Feature Propagation Mechanism for Neural Video Compression

Feng Wang, Haihang Ruan, Fei Xiong, Jiayu Yang, Litian Li, and Ronggang Wang

Outline

- **Background**
- **Propagation Mechanism**
  - *MLVC & Butterfly*
- **Duplication Strategy**
  - *Further-frame Duplication & Near-frame Duplication*
- **Experiments**
- **Conclusion**

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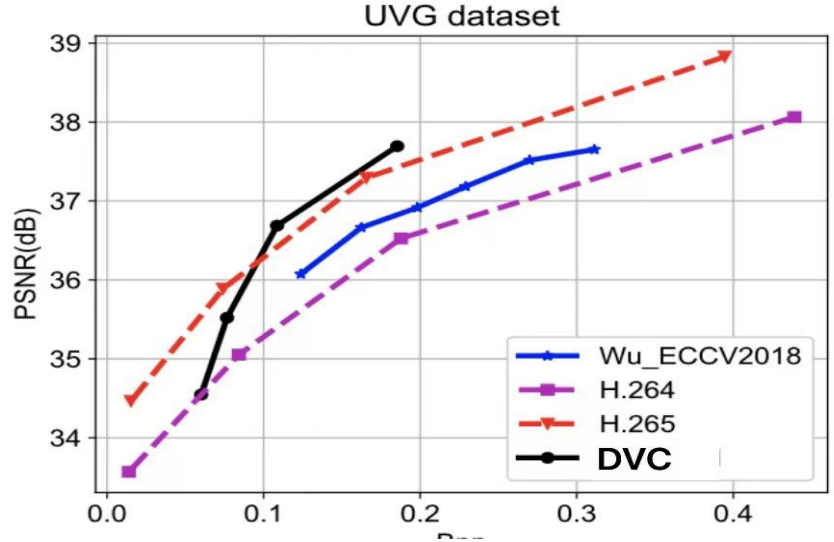
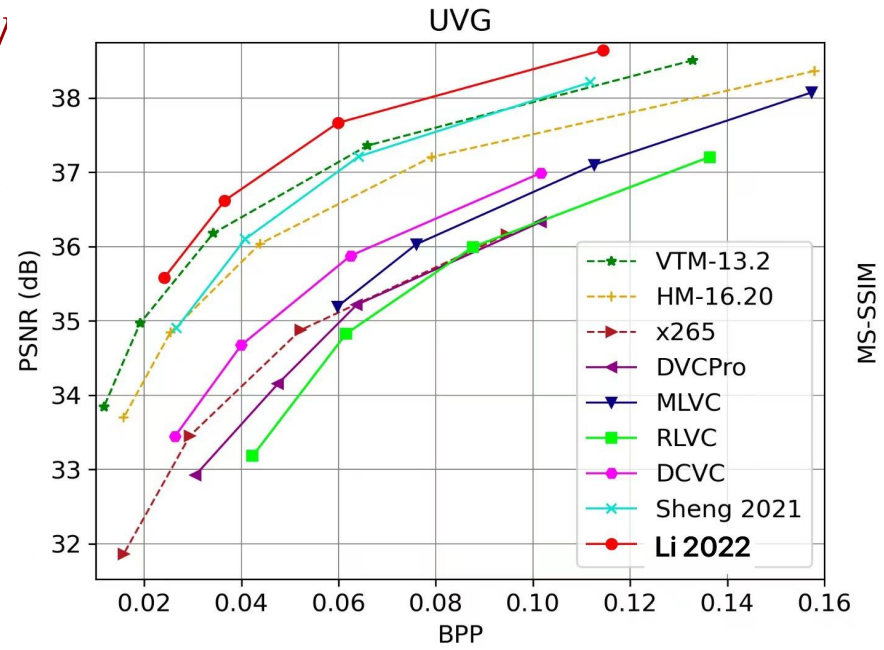
Background

- Traditional Video Compression Standards are difficult to optimize jointly.
- Neural Video Compression develop rapidly.
- Using more reference frames can significantly improve the compression efficiency in neural video compression.
- Current Multi-Ref NVC methods are simple and not designed specifically.





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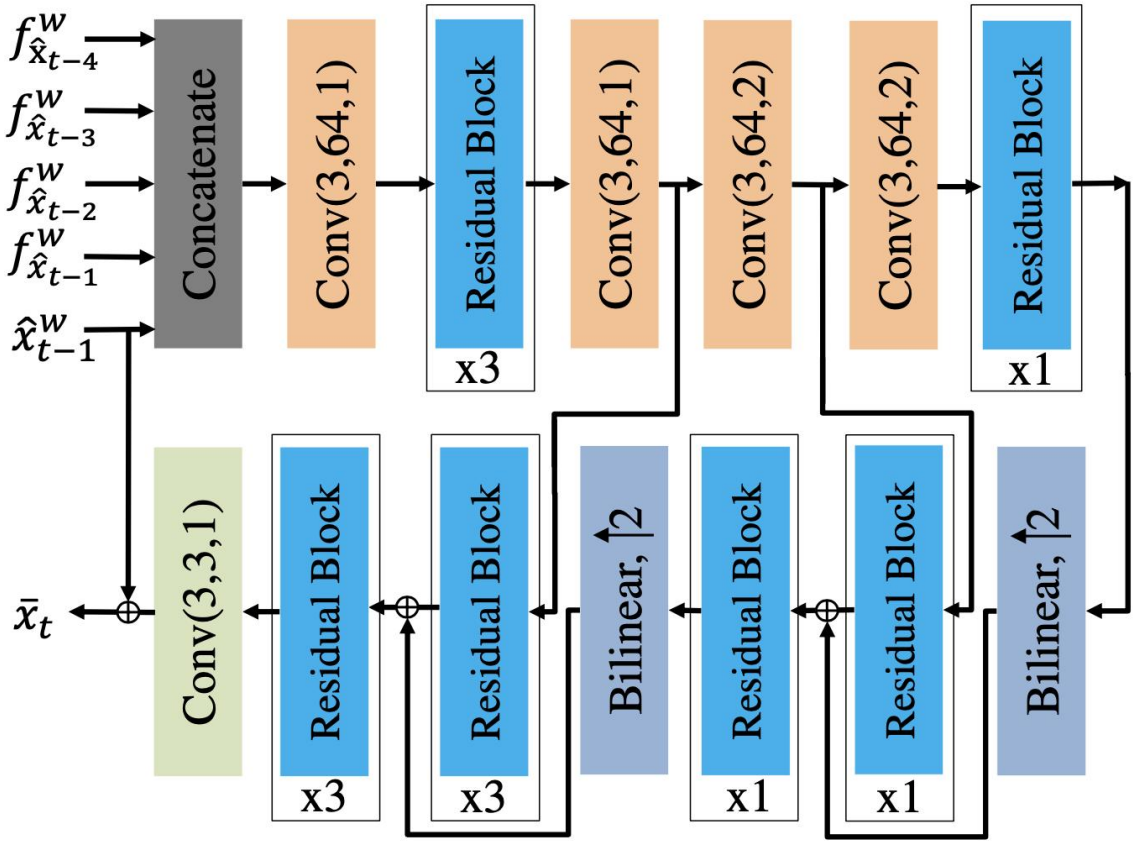
Propagation Mechanism

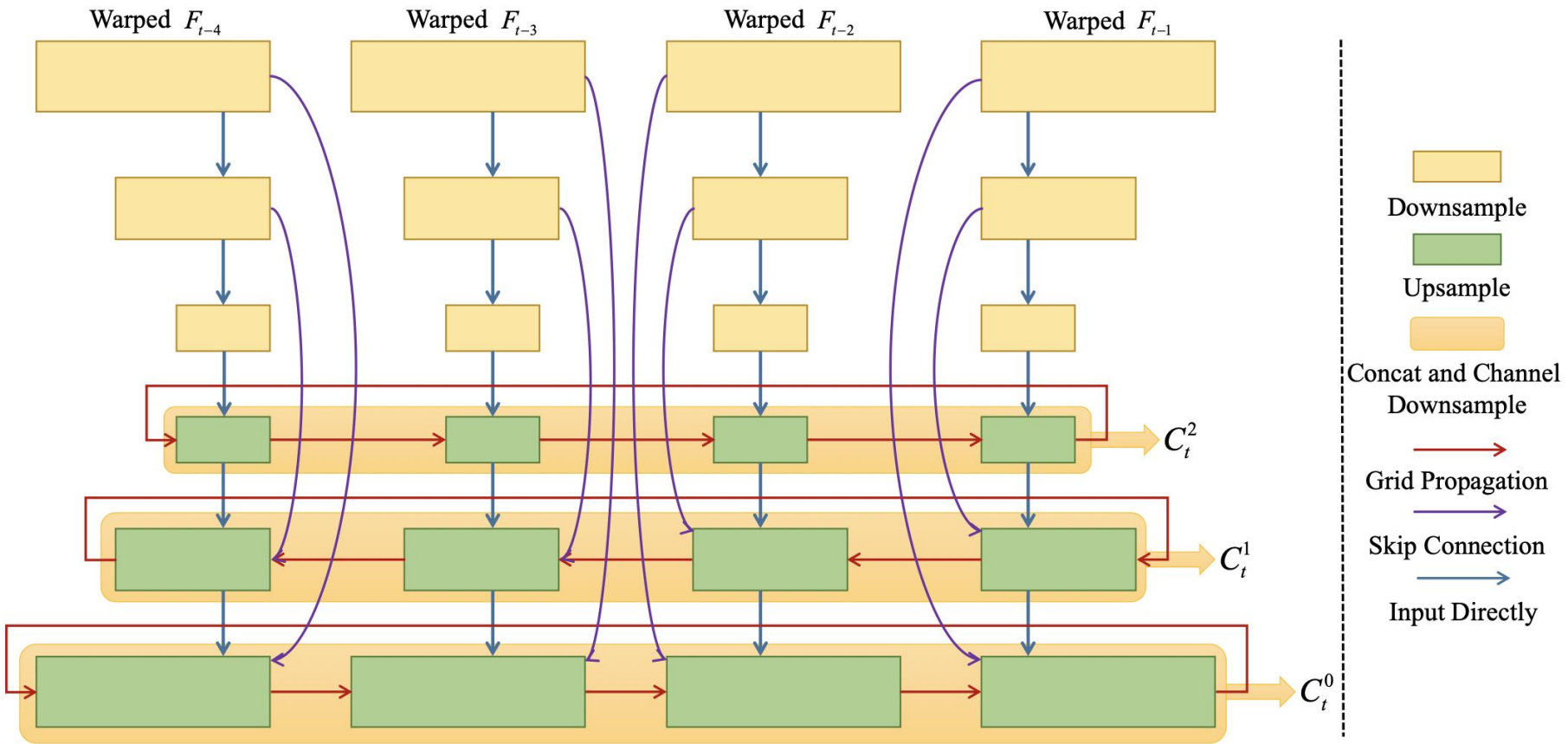
- **MLVC's multi-reference frames feature propagation mechanism**

  - Concats the four previous reference frames before down-sample.
  - This will obliterate some key information in a frame when fusing these previous multiple reference frames.



Propagation Mechanism

- **Butterfly's multi-reference frames feature propagation mechanism**



Propagation Mechanism

- **Butterfly's multi-reference frames feature propagation mechanism**
  - Downsampling & Upsampling
    - Down: independently downsample to obtain features of different scales.
    - Up: use the grid propagation to fuse features of different scales and frames.
  - Not only prevent some key information in a frame from being obliterated during fusing the multiple reference frames.
  - But also aggregate information from different spatiotemporal locations and different scales.

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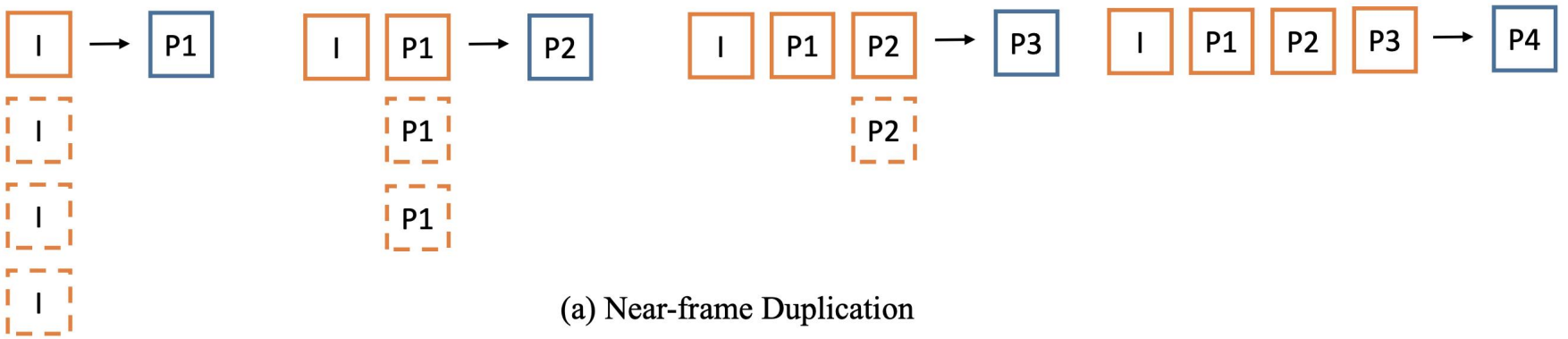
Duplication Strategy

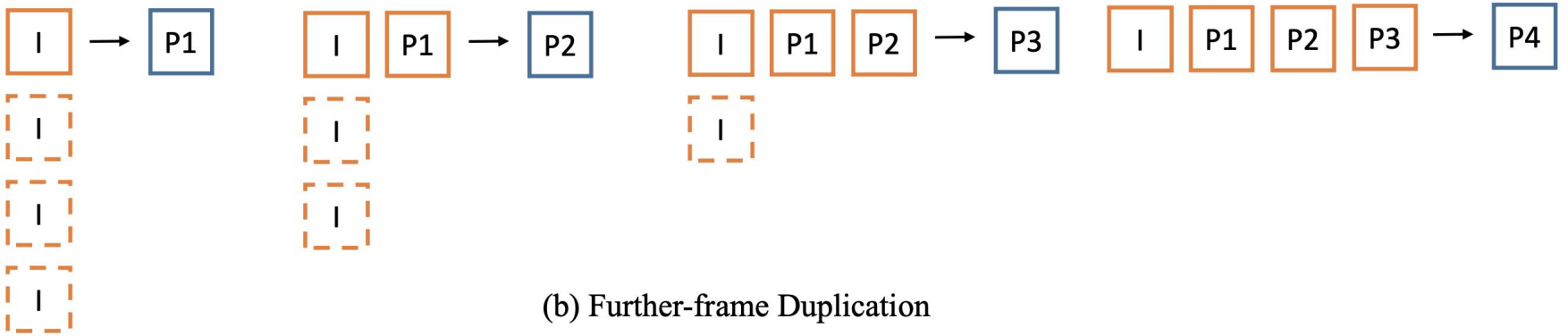
- **Question:**
  - Decoded frames doesn't meet the required number of reference frames.
  - How to do ?
- **Answer:**
  - It is necessary to duplicate a frame that has been decoded.
- **Solution:**
  - Duplicate the near-frame or the further frame.

Duplication Strategy

- Near-frame Duplication & Further-frame Duplication



(a) Near-frame Duplication



(b) Further-frame Duplication

Duplication Strategy

- Near-frame Duplication & Further-frame Duplication
  - The percentage increment of information lost in each frame compared to the previous frame is a fixed value α.
  - The correlation between adjacent frames is also a fixed value β.

  - **When the percentage increment of information lost α less than a critical value in one NVC method, using Near-Frame Duplication can get smaller information loss and achieve better compression efficiency.**

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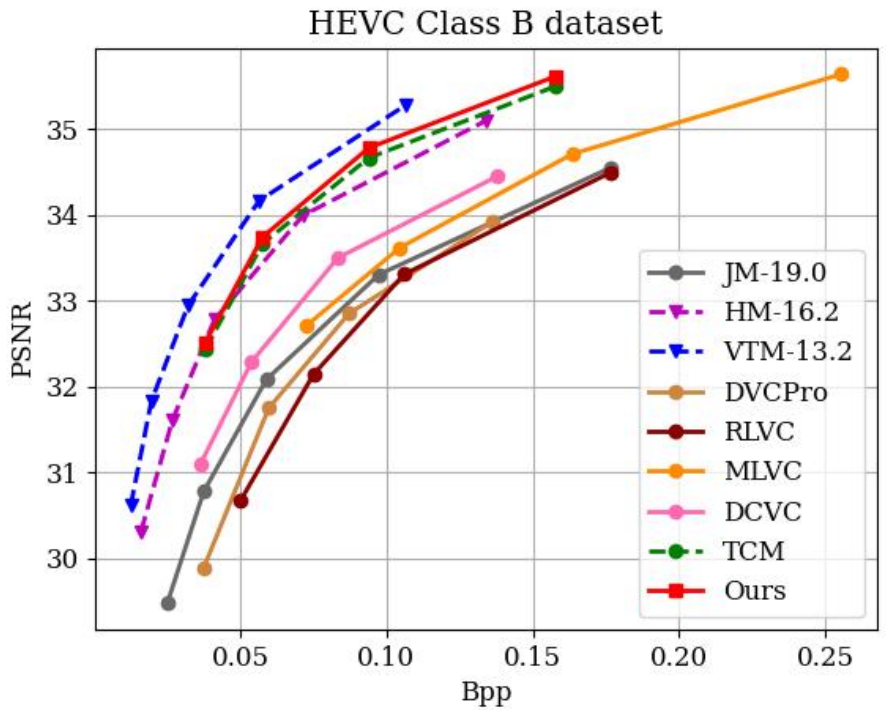
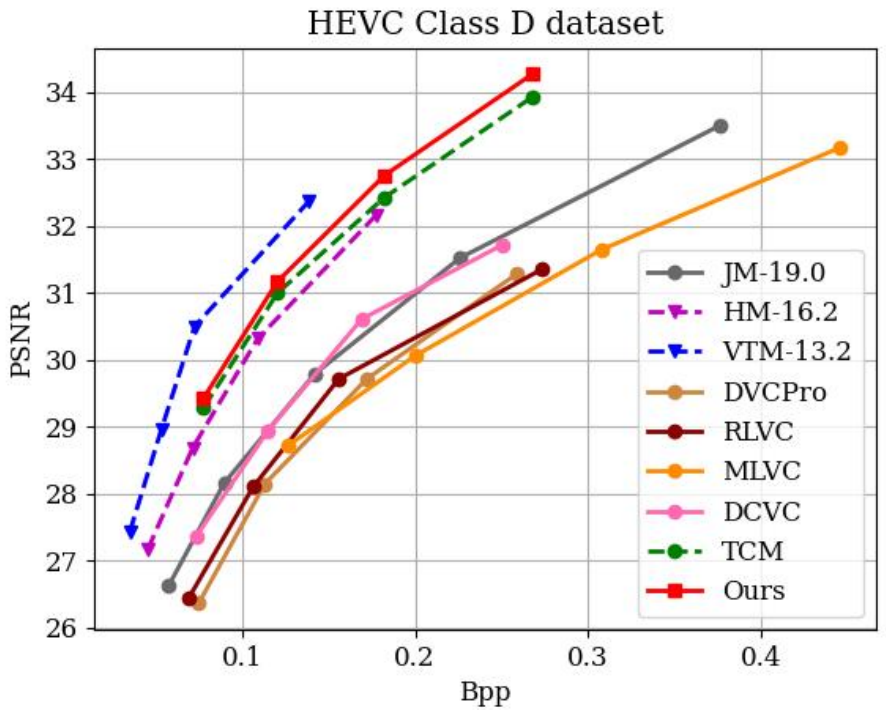
Experiments

- **Experimental Setup**
  - Baseline:
    - TCMVC (*https://github.com/microsoft/DCVC/tree/main/TMM_TCMVC*)
  - Datasets:
    - Train: Vimeo-90K
    - Test: HEVC Class B, C, D, E, RGB, UVG, MCL-JCV
  - Platform:
    - 2 × NVIDIA Tesla V100 GPU

Experiment

- **PSNR and BPP curves**





Experiment

- **BD-Rate (%) comparison for PSNR**

	B	C	D	E	RGB	UVG	MCL-JCV
HM-16.2 [19]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JM-19.0 [18]	96.9	56.6	50.0	80.5	102.4	108.1	95.4
VTM-13.2 [20]	-28.8	-29.0	-26.5	-29.1	-29.7	-28.9	-31.2
DVCPro [11]	123.7	124.0	93.6	283.0	102.1	137.7	99.3
RLVC [8]	122.6	118.9	81.2	246.2	114.2	140.1	124.8
MLVC [10]	61.4	124.1	96.1	138.8	82.1	66.5	66.8
DCVC [4]	56.0	76.9	52.8	156.8	51.9	67.3	42.8
TCM [5]	-5.3	15.1	-5.4	18.5	-14.4	-9.0	-3.2
Ours	-10.4	7.5	-12.6	8.3	-17.5	-15.6	-6.2

Experiment

- **Ablation Study**

	B	C	D	E	RGB	Average
Proposed Butterfly	0.0	0.0	0.0	0.0	0.0	0.0
Up and Down Sampling Together	0.6	1.1	0.8	1.0	0.5	0.8
Up and Down Sampling Independent	0.8	1.2	0.7	1.0	0.8	0.9

	B	C	D	E	RGB	Average
Near-frame Duplication (**Our**)	0.0	0.0	0.0	0.0	0.0	0.0
Further-frame Duplication	1.4	1.0	1.5	2.2	1.6	1.5

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Conclusion

- **This paper explore and design a butterfly multiple reference frames feature propagation mechanism for neural video compression, which can effectively fuse the features of multi-previous reference frames.**

- **This paper prove that when the number of reference frames can't meet the required number, it is better duplicating the nearest reference frame.**

- **This paper can provide a better choice for multiple reference frames feature propagation mechanism in the research of neural video compression.**

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Thanks

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