



# *Advances in Film-Grain Encoding in the AV1 Codec*

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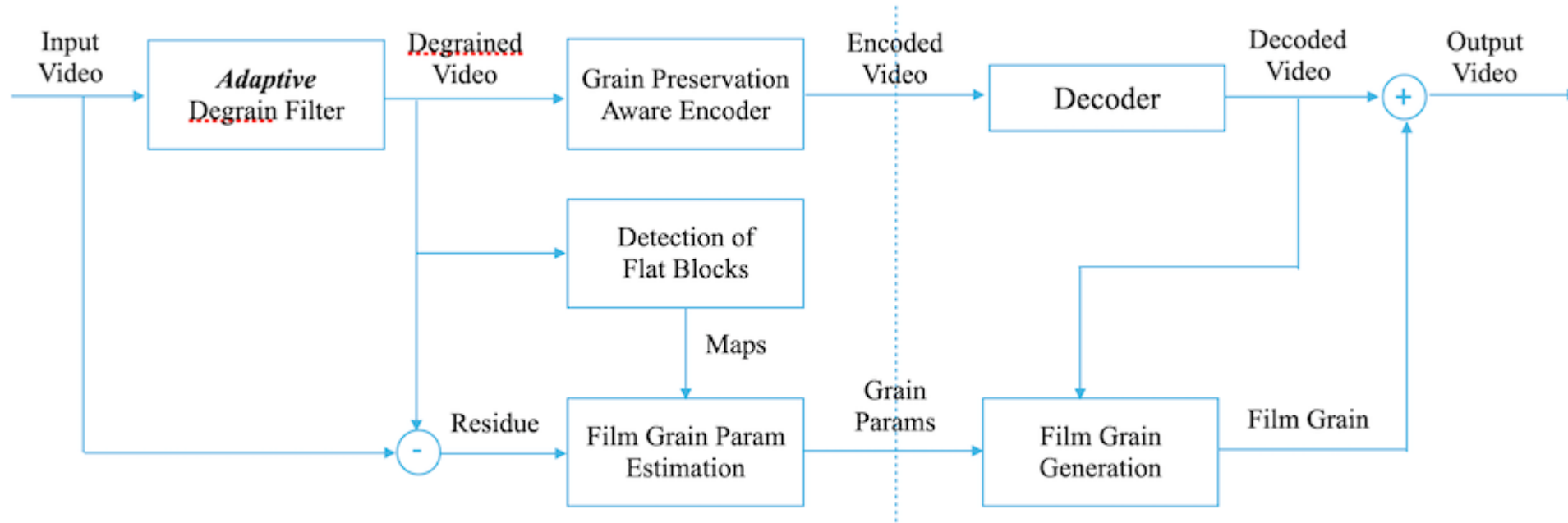
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# Introduction

*Film grain, an essential element in cinematography, contributes to the unique visual texture and character of movies. In the realm of Perceptually Guided Coding (PGC) videos, the challenge lies in preserving this cinematic essence while optimizing compression efficiency.*

- **Importance of Film Grain:**
  - Film grain is not just a visual artifact but a key component that adds a distinct aesthetic quality to videos, enhancing the overall viewing experience.
  - It plays a crucial role in maintaining the cinematic look and feel, especially as we transition from traditional film to digital formats.
- **Challenges in Compression:**
  - Film grain's non-uniform nature poses a significant challenge in the compression process, as traditional compression techniques struggle to preserve its intricate details.
  - The difficulty in compressing film grain without compromising its quality is a hurdle that needs to be addressed for optimal PGC video encoding.
- **Preserving Quality:**
  - Despite the challenges, finding ways to compress film grain effectively is vital for efficient storage, streaming, and transmission of high-quality video content.
  - Our exploration into the AV1 film grain synthesis framework seeks to strike a balance between compression efficiency and the preservation of cinematic authenticity.

# AV1 Film Grain Synthesis Framework



# Impact of Video Denoising

- *Video denoising is a pivotal step in film grain synthesis, influencing noise modeling and encoding efficiency directly. The balance between denoising levels is critical:*
- **Inadequate Denoising:**
  - *Allows residual noise to persist.*
  - *Underestimates grain strength, resulting in weaker synthesized film grain.*
  - *Compromises cinematic quality and increases bitrate.*
- **Overly Aggressive Denoising:**
  - *Risks removal of crucial video details.*
  - *Makes the noise modeler prone to misinterpreting details as film grain noise.*
  - *Leads to stronger, unwanted synthesized film grain.*
  - *Compromises visual fidelity and authenticity.*

# Challenges in Video Denoising

- *Film grain poses unique challenges for denoising due to its diverse characteristics in shape and intensity, demanding precise noise-level estimation. Existing methods encounter several limitations:*
- **Deep Learning Dependencies:**
  - *Effective denoising often relies on deep learning-based approaches.*
  - *These methods demand extensive training datasets, including source-noisy image pairs.*
  - *The need for substantial data can hinder practical implementation and adaptability.*
- **Struggles of Traditional Techniques:**
  - *Traditional denoising techniques face difficulties in eliminating film grain while preserving intricate details.*
  - *Maintaining a delicate balance between noise reduction and detail preservation proves challenging.*
  - *This struggle is exacerbated by the non-uniform characteristics of film grain.*
- **Time Consumption:**
  - *Denoising processes, especially those relying on sophisticated algorithms, can be time-consuming.*
  - *Balancing efficiency with the demand for high-quality results remains a significant consideration.*

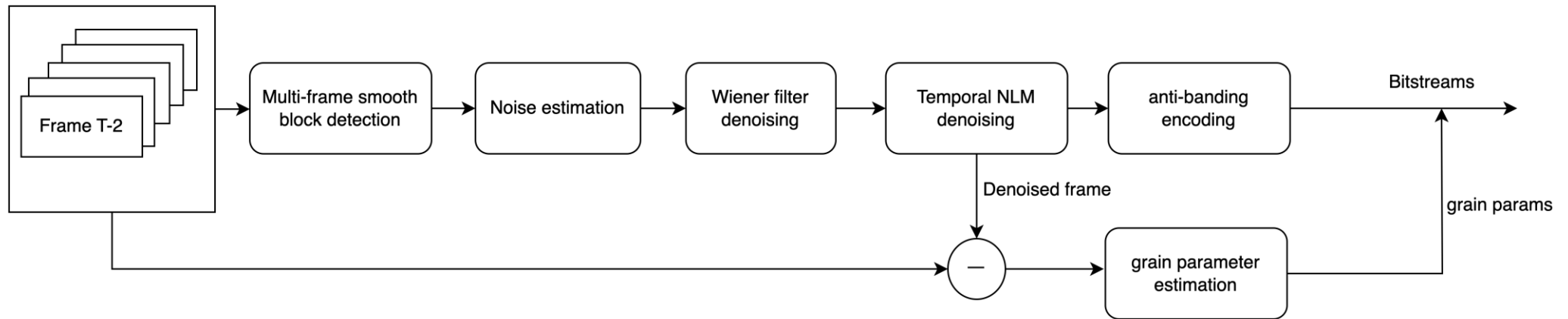
# Our Video Denoising Solution

- *Our denoising solution comprises two stages:*
- **Spatial Denoising:**
  - *Smooth area detection is integrated into the spatial denoising process.*
  - *Variable denoising strengths are applied based on the identified characteristics of each region.*
  - *This adaptive approach ensures effective noise reduction while preserving intricate details.*
- **Temporal Denoising:**
  - *The second stage strategically utilizes the temporal filter results from the video encoder.*
  - *This approach significantly save computational resources while achieving efficient denoising.*
  - *Film grain parameters are then estimated exclusively from the frames that have undergone combined spatial and temporal denoising.*

# Band-Aware Encoding

- *Complementing our denoising approach, we implement band-aware encoding techniques—selective dither and variance-based adaptive quantization (AQ encoding)—to further refine the film grain synthesis process and address potential issues like banding.*
- **Selective Dither to Address Banding:**
  - *To mitigate banding artifacts after denoising, we employ selective dithering.*
  - *This targeted approach focuses on areas prone to banding, while not affecting the coding efficiency of other area.*
- **Variance-Based Adaptive Quantization (AQ Encoding):**
  - *Our implementation of variance-based AQ encoding optimizes the video encoding process.*
  - *Selective dithering is strategically combined with AQ encoding, protecting the smooth area during encoding and ensuring effective banding prevention.*

# Our workflow





# Data and Results

- Following table shows the difference between original noise and synthesis noise

Seq name	spatial-denoising	two-stage-denoising
0c10cb546d8c	-0.18	-0.04
0dbc8af79819	-0.14	-0.05
disney abc grainy	-0.10	-0.02
ghostbusters	-0.47	-0.09
law	-0.21	0.02
tax	-0.25	0.07
e30c54002e8a	0.03	0.05
bdd068e0d028	-0.03	0.00
6de39a859bdf	-0.05	-0.02
sphe-tiger	-0.38	-0.06
Dinner Scene	-0.02	0.05

# Visual comparison of synthesized noise



Left to right shows results of original patch, synthesised noise by spatial denoising only, synthesised noise by two-stage denoiser

# Conclusion

- In conclusion, our film grain synthesis approach combines two-stage video denoising and band-aware encoding techniques to achieve a superior balance between computational efficiency and quality preservation. By strategically applying spatial denoising with smooth area detection and leveraging the temporal filter results from the video encoder for efficient temporal denoising, we minimize computational complexity while preserving non-noise details. Additionally, our band-aware encoding, featuring selective dither and variance-based adaptive quantization, ensures optimal protection for smooth areas, mitigating artifacts like banding.*