Unified Video Editing as Temporal Reasoner

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Figure 1. VideoCoF's video editing capabilities emerge from its **seeing, reasoning, then editing framework**. Trained on only **50k** data (33 frames), this teaser shows multi-instance editing and robust 4x+ length generalization.

Abstract

*Existing video editing methods face a critical trade-off: expert models offer precision but rely on task-specific priors like masks, hindering unification; conversely, unified temporal in-context learning models are mask-free but lack explicit spatial cues, leading to weak instruction-to-region mapping and imprecise localization. To resolve this conflict, we propose **VideoCoF(VideoCoF)**, a novel **Chain-of-Frames** approach inspired by Chain-of-Thought reasoning. VideoCoF enforces a "see → reason → edit" procedure by compelling the video diffusion model to first predict rea-*

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soning tokens (edit-region latents) before generating the target video tokens. This explicit reasoning step removes the need for user-provided masks while achieving precise instruction-to-region alignment and fine-grained video editing. Furthermore, we introduce a RoPE alignment strategy that leverages these reasoning tokens to ensure motion alignment and enable length extrapolation beyond the training duration. We demonstrate that with a minimal data cost of only 50k video pairs, VideoCoF achieves state-of-the-art performance on VideoCoF-Bench, validating the efficiency and effectiveness of our approach.

1. Introduction

The development of Video Diffusion Models (VDM) [12, 27, 33, 37] has enabled high-fidelity video generation across a wide range of concepts. Building on these advances, video editing methods support users in designing video by adding [26], removing [15, 43], swapping [6, 36] visual concepts, and performing global style transformation [39].

Current video editing methods mainly follow two strategies: (i) **expert models** [1, 15, 26, 36, 41], which use adapter-based modules to feed *external masks* into the video generation model, yielding precise, localized edits but requiring additional inputs and per-task overhead; and (ii) **unified temporal in-context learning models** [9, 16, 38], which concatenate source tokens with noised edit tokens along the temporal dimension and use self-attention mechanism to guide the edit. However, without explicit spatial cues, these models often exhibit weak accuracy, especially in cases that need multi-instance recognition or spatial reasoning (Fig. 2, left). In short, there is a *trade-off*: expert models are accurate but mask-dependent, while unified in-context models are mask-free but less precise; This raises a critical question: **Can we maintain former's precision and latter's unification without the mask dependency?**

Inspired by Chain-of-Thought (CoT) multi-step reasoning [30], we *compel* the video diffusion model to first predict the edit region and then perform the edit, enforcing a "**see** → **reason** → **edit**" procedure. Accordingly, we propose ***VideoCoF***, a Chain-of-Frames approach that predicts *reasoning tokens* (edit-region latents) before generating the target video tokens, thereby removing the need for user-provided masks while achieving precise instruction-to-region alignment. To explicitly model the reasoning process, we leverage visual grounding, which is naturally suited to simulating reasoning about the edit region. Empirically, we find a soft, gradually highlighted grayscale region is the most effective reasoning format. Additionally, we introduce a RoPE alignment strategy. By explicitly accounting for the reasoning latent, we reset the temporal indices of the edited video's rotary position embeddings to match those of the source segment, ensuring motion alignment and length extrapolation.

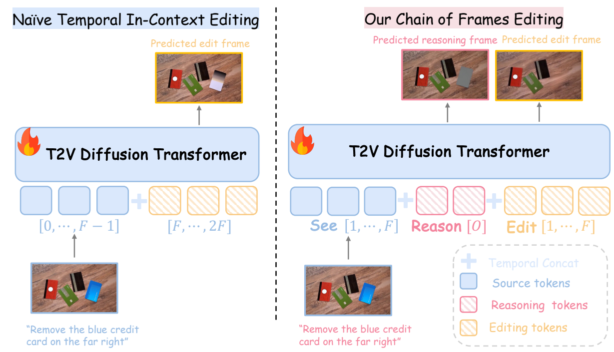

Figure 2. lustration of the difference between previous methods and our VideoCoF. We enhances the editing accuracy by forcing the video diffusion model to first predict the editing area, and then perform the editing.

To holistically evaluate fine-grained video editing, we further construct VideoCoF-Bench. VideoCoF trained on only **50k** video pairs, outperforms a strong baseline ICVE [16] that uses ∼1M pretraining videos plus 150k for SFT. Specifically, we improves the instruction-following score by **+15.14%** and the success ratio by **+18.8%**. Our contributions can be summarized as follows:

- We propose VideoCoF, the first framework to introduce a Chain of Frames approach to video editing, enabling temporal reasoning for fine-grained video editing.
- Building on VideoCoF, we explore an effective reasoning format for video diffusion models, and introduce a RoPE alignment strategy that allowing generalization to longer frames exceeding the training duration.
- We demonstrate that with a minimal data cost (only **50k** video pairs), we achieve state-of-the-art quantitative and qualitative performance on VideoCoF-Bench, validating the efficiency and effectiveness of our approach.

2. Related Work

Video Editing Methods. Early training-free video editing methods [21, 33] used inversion and consistency techniques (e.g., attention manipulation [21] or optical flow [5]) but often lack precise control and struggle with complex edits. Data-driven, training-based methods [2, 4] have become the focus, offering higher quality and edit diversity. A concurrent line of research [18, 29, 40] integrates MLLMs to guide the editing process, though this adds significant training and inference cost, which our pure VDM approach avoids.

In-Context Video Editing. Recently, in-context learning (ICL) has emerged as a promising paradigm for unified editing [10, 35, 42]. Methods like UNIC [38] and ICVE [16] concatenate video conditions along the temporal axis to perform ICL. However, these methods are often limited by mask requirements [38] or, as we identify, suffer

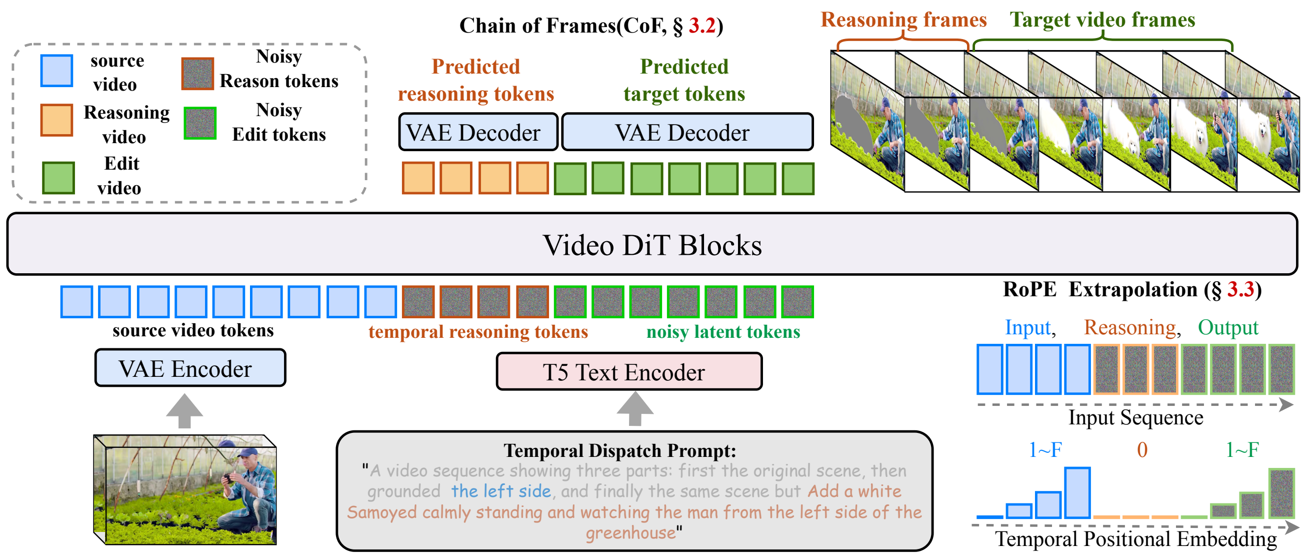

Figure 3. Overview of VideoCoF framework. Our model processes source (blue), reasoning (orange), and target (green) tokens in a unified sequence to "reason" then "edit". **Bottom right:** Our RoPE design enables length extrapolation.

from fundamental issues with editing accuracy and a lack of length extrapolation due to their naive temporal concatenation. While EditVerse [9] also explored unified in-context learning, it was built on a LLaMA-style DiT backbone, whereas our work explores these capabilities within a standard video diffusion transformer.

Chain of Thought in Vision. Chain-of-Thought (CoT) prompting [11, 30] elicits multi-step reasoning in LLMs by having them "think step-by-step." This concept of emergent reasoning has also been identified in large video generative models [3, 31] that can solve visual puzzles. However, how to leverage visual reasoning for the task of unified video editing remains unexplored. In this work, we investigate whether generative video models can perform a "chain of frames" reasoning to achieve this.

3. Methods

3.1. VideoCoF Framework

As illustrated in Figure 3, VideoCoF employs a VideoDiT [27] for unified video editing. We model editing as a reasoning-then-generation process: the model first reasons where to edit, then generates the intended content in that area. We call this process **"Chain of Frames (CoF)"** (Sec 3.2). All visual inputs (source, reasoning, and target frames) are encoded separately by a Video VAE and then concatenated temporally. The unified frame sequence is then fed into the model, performing unified in-context learning via self-attention and language control via cross-attention. To enable video alignment and variable-length inference, we revisit the design of positional encoding. We adapt the temporal RoPE for source-to-target alignment and reasoning tokens' RoPE for explicit spatial guidance (Sec 3.3). Subsequent sections detail the insights behind our design choices and data curation pipeline (Sec 3.5).

3.2. Chain of Frames

Seeing, Reasoning, then Editing. Previous video in-context editing methods, such as UNIC [38], ICVE [16], or EditVerse [9], perform in-context learning by temporally concatenating clean source video tokens with noised editing video tokens. However, this approach lacks an explicit constraint mapping the editing instruction to the specific editing region, leading to editing accuracy problems, as shown in Fig 2. Recently, VDM have been shown to possess reasoning capabilities, as demonstrated in [31]. Inspired by this, we explicitly model the reasoning tokens, forcing the model to actively learn the relationship between the editing instruction and the target edit region first. The edit is then executed *after* reasoning, following a "see, reason, then edit" process.

Inspired by Chain of Thought prompting in Large Language Models (LLMs) [30], we argue that a video generative model should also have an analogous chain-reasoning ability. Given the generative priors in video editing, the visual-chain should be progressive, moving from the original video to a visual reference of the editing region, and finally to the edited video. Visual grounding is naturally suitable for this representation. Since video diffusion models are often insensitive to grounding masks (black or white pixels). Therefore, we choose to use a gray highlight to delineate the "grounding region,", which is also evidence in [7]. Finally, the gray-highlighted area as the ground truth for the reasoning frames, teaching the diffusion model to reason about where the edit should occur.

Consequently, the entire video editing task is reformu-

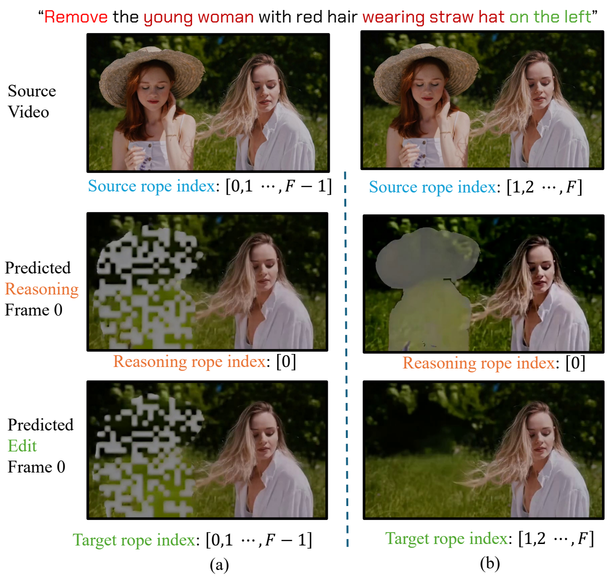

Figure 4. How our RoPE design avoid index collision.

lated as a chained process: first "seeing" the original video, then "reasoning" by predicting the grounding region, and finally "editing" to generate the new video content within that specified area. We call this **Chain of Frames (*CoF*)**.

Let $\mathcal{E}(\cdot)$ denote the video VAE encoder. We use F and L for frames in the source/target and reasoning latent space, respectively, and denote channel, height, and width by C, H, and W. Given a triplet source-reasoning-target video pair $\{\mathbf{s}, \mathbf{r}, \mathbf{e}\}$, we first encode them into latent representations. The source $\mathbf{s}$ and target video $\mathbf{e}$ yield latent $z_s = \mathcal{E}(\mathbf{s})$ and $z_e = \mathcal{E}(\mathbf{e})$, both with shape $\mathbb{R}^{F\times C\times H\times W}$. The reasoning video $\mathbf{r}$ yields a latent $z_r = \mathcal{E}(\mathbf{r})$ with shape $\mathbb{R}^{L\times C\times H\times W}$. This separate encoding ensures intra-causal relations and inter-video independence. Then, we perform temporal concatenation to get the unified latent representation:

$$\mathbf{z}^{(t)}_{full} = \underbrace{z_s^{(0)}}_{\text{seeing}} \parallel \underbrace{z_r^{(t)}}_{\text{reasoning}} \parallel \underbrace{z_e^{(t)}}_{\text{editing}} \in \mathbb{R}^{(F+L+F)\times C\times H\times W}, \tag{1}$$

where the $z_s = \mathbf{z}^{(0)}_{0:F-1}$ denotes anchoring the source video latent at timestep 0. $z_r = \mathbf{z}^{(t)}_{F:F+L-1}$ and $z_e = \mathbf{z}^{(t)}_{F+L:2F+L-1}$ mean the reasoning and target noised video latents at timestep t. At each denoising step, only the $L+F$ reasoning and target frames are denoised, and the source video latents are kept clean.

3.3. RoPE Design for Length Extrapolation

In VideoDiT, 3D factorized RoPE [23] provides spatio-temporal positions. A naive in-context learning approach applies sequential temporal indices (e.g., 0 to $2F-1$) across concatenated source and target videos. However, this hinders video length extrapolation, as the model overfits to a static $[0, F-1] \rightarrow [F, 2F-1]$ mapping and fails to generalize to videos longer than F frames.

A better strategy is to repeat the temporal indices. For our CoF triplet (consider $L = 1$ for reasoning frame), a straightforward reset configuration is to assign temporal indices: $[0, F-1]$ to the source, "0" to the reasoning frame, and $[0, F-1]$ to the target.

However, as illustrated in Figure 4 (a), this naive reset leads to index collisions at temporal position 0, shared by the source, reasoning, and target frames. This overlap introduces visual artifacts that propagate from the reasoning tokens into the first target frame.

To resolve this index collision, we set the temporal indices for both the source video and the target video to the range $[\mathbf{1}, \mathbf{F}]$, while keeping the reasoning frame's temporal index at $\mathbf{0}$. This isolates the reasoning token and prevents artifact leakage while maintaining length generalization.

3.4. Training and Inference Paradigm

Algorithm 1 Chain of Frame (CoF) Training

Input: Dataset $\mathcal{D}$ with tuples $(\mathbf{z_s}^{(0)}, \mathbf{z_r}^{(0)}, \mathbf{z_e}^{(0)}, \mathbf{c})$
Output: Fine-tuned parameters $\boldsymbol{\theta}$

foreach minibatch $(\mathbf{z_s}^{(0)}, \mathbf{z_r}^{(0)}, \mathbf{z_e}^{(0)}, \mathbf{c}) \sim \mathcal{D}$ **do**
  foreach sample in minibatch **do**
    $\mathbf{z}^{(0)}_{full} \leftarrow \mathbf{z_s}^{(0)} \| \mathbf{z_r}^{(0)} \| \mathbf{z_e}^{(0)}$ Sample $t \sim \mathcal{U}[0,1]$
    Sample $\boldsymbol{\varepsilon} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ with the same shape $\mathbf{z}^{(0)}_{full}$ $\mathbf{v} \leftarrow (\boldsymbol{\varepsilon} - \mathbf{z}^{(0)}_{full})$
    $\mathbf{z}^{(t)}_{r,e} \leftarrow (1-t)(\mathbf{z_r}^{(0)} \| \mathbf{z_e}^{(0)}) + t(\boldsymbol{\varepsilon}_{F:2F+L-1})$ $\mathbf{z}^{(t)} \leftarrow \mathbf{z_s}^{(0)} \| \mathbf{z}^{(t)}_{r,e}$
    $\hat{\mathbf{v}} \leftarrow \mathbf{F}_{\boldsymbol{\theta}}(\mathbf{z}^{(t)}, t, \mathbf{c})$
    $\mathcal{L} \leftarrow \frac{1}{L+F} \sum_{i=F}^{2F+L-1} \|\mathbf{v}_i - \hat{\mathbf{v}}_i\|_2^2$
  Update $\boldsymbol{\theta}$ using gradients of $\mathcal{L}$

Given a concatenated full latent sequence $\mathbf{z}^{(0)}_{\text{full}} = \text{TemporalConcat}\left(\mathbf{z}_s^{(0)}, \mathbf{z}_r^{(0)}, \mathbf{z}_e^{(0)}\right)$, we treat the reasoning+editing block as the generation target during training.

Given timestep $t \in [0,1]$ and Gaussian noise $\boldsymbol{\varepsilon} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$, we only progressively noise the reasoning and editing parts, $\mathbf{z}^{(t)}_{r,e} = (1-t)\left(\mathbf{z}_r^{(0)} \| \mathbf{z}_e^{(0)}\right) + t\,\boldsymbol{\varepsilon}_{F:2F+L-1}$, and form the model input $\mathbf{z}^{(t)} = \mathbf{z}_s^{(0)} \| \mathbf{z}^{(t)}_{r,e}$, The target velocity field is $\mathbf{v} = \boldsymbol{\varepsilon} - \mathbf{z}^{(0)}_{\text{full}}$. Our model $\mathbf{F}_\theta(\cdot)$ predicts this velocity field from the partially noised input, and we train it by minimizing the mean squared error between predicted and true velocities. Concretely, we only supervise the reasoning and target frames, so the training loss can be written

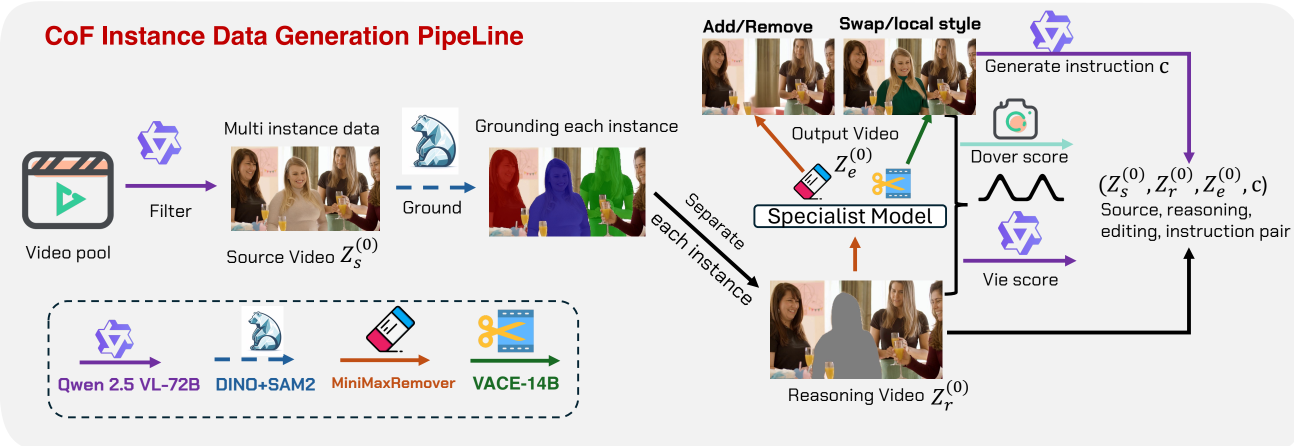

Figure 5. Our data curation pipeline for multi-instance data.

in per-frame form as

$$\mathcal{L} = \frac{1}{L+F} \sum_{i=F}^{2F+L-1} \left\| \mathbf{v}_i - \left[\mathbf{F}_\theta(\mathbf{z}^{(t)}, t, \mathbf{c})\right]_i \right\|_2^2, \quad (2)$$

where $\left[\mathbf{F}_\theta(\mathbf{z}^{(t)}, t, \mathbf{c})\right]_i$ denotes the model's prediction for frame i and $\mathbf{c}$ is the text condition. The model parameters $\mathbf{F}_\theta(\cdot)$ are updated via a gradient step computed from this loss. The full training procedure is summarized in Algorithm 1.

During inference we initialize the reasoning+editing block from Gaussian noise, $\mathbf{z}_{r,e}^{(1)} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ and form the full latent at $t = 1$ by temporal concatenation with the clean source $\mathbf{z}_{\text{full}}^{(1)} = \text{TemporalConcat}\left(\mathbf{z}_s^{(0)}, \mathbf{z}_{r,e}^{(1)}\right)$. An ODE solver guided by our model $\mathbf{F}_\theta$ evolves $\mathbf{z}_{\text{full}}^{(t)}$ to $\mathbf{z}_{\text{full}}^{(0)}$. The source latents $\mathbf{z}_s^{(0)}$ are held fixed during inference, so only the reasoning/editing parts change. We then extract the edited-target latent using the same slicing index as in training: $\mathbf{z}_{\text{edit}}^{(0)} = \left(\mathbf{z}_{\text{full}}^{(0)}\right)_{F+L:2F+L-1}$ and decode the final edited video: $\mathbf{x}_{\text{edit}} = \mathcal{D}\left(\mathbf{z}_{\text{edit}}^{(0)}\right)$.

3.5. Video Data Curation

The training of our VideoCoF requires a large and diverse dataset structured as source, reasoning, and edited video triplets. However, existing video editing datasets and methods predominantly focus on single-instance-level object manipulation. This limitation is a significant barrier, as real-world videos contain complex visual cues, multiple interacting instances, and intricate spatial relationships (e.g., physical left/right, object-to-object interactions). Enabling a generative model to comprehend these complex, instance-level dynamics is a critical step toward true reasoning-based video editing. Therefore, we develop a comprehensive data curation pipeline, illustrated in Figure 5, to specifically generate and process complex, instance-level video data.

Instance-Level Curation Pipeline. Our pipeline begins with a large pool of diverse videos sourced from Pexels [20]. First, we employ the Qwen-VL 72B [28] to perform multi-instance identification, scanning the videos to find scenes that contain multiple, distinct objects. Once these videos are identified, we use Grounding-SAM2 [22] to perform precise segmentation, generating distinct segmentation masks for each individual instance. With these instance-specific masks, we generate triplets for a variety of editing tasks:

- **Object Addition/Removal:** We utilize the Minimaxremover [43] to erase a specific instance from the video. The data for object addition is then created by simply reversing this process.
- **Object Swap and Local Style Transfer:** For these tasks, we leverage the VACE 14B [8] in its inpainting mode to fill the specified masked regions. Critically, the creative prompts for these inpainting edits are generated by GPT-4o[19], as we found Qwen-VL 72B's imaginative capabilities for this specific task to be limited.

Filtering and Final Dataset. All generated video pairs are rigorously evaluated to ensure quality. We use the Dover Score [32] to assess aesthetic quality and the VIE Score [13] to measure editing fidelity and coherence. A weighted combination of these scores is used to filter for high-quality, successful edits. Finally, we use this pipeline to filter from the large-scale open-source Señorita 2M [44] dataset, and distill a high-quality subset of **50k** videos to supplement our training data. This multi-pronged approach yields our final large-scale dataset, rich in the instance-level complexity required for reasoning-based video editing.

4. Experiments

4.1. Implementation Details.

VideoCoF is trained on WAN-14B [27]. We employ a resolution-bucketing strategy to support multiple aspect ratios, using spatial resolutions of 336×592, 400×704, 400×752, and 400×944 (and the corresponding vertical variants, e.g., 592×336). Training videos are sourced from

Model	GPT-4o Score (avg.)				Perceptual Quality (avg.)		
	Instruct Follow↑	Preservation↑	Quality↑	Success Ratio↑	CLIP-T↑	CLIP-F↑	DINO↑
InsV2V [4]	3.41	6.15	5.51	6.39%	26.19	0.988	0.978
Señorita [44]	3.26	6.30	5.48	10.35%	26.04	0.994	0.988
VACE [8]	7.47	5.82	7.61	26.60%	27.02	0.994	0.990
ICVE [16]	7.79	8.06	**8.14**	57.76%	27.49	0.992	0.986
Lucy Edit [25]	5.24	6.50	6.37	29.64%	26.98	0.991	0.986
VideoCoF (Ours)	**8.97**	**8.20**	<u>7.77</u>	**76.36%**	**28.00**	0.992	0.991

Table 1. We compare VideoCoF with SOTA baselines on VideoCoF-Bench: InsV2V [4], Señorita [44] (an I2V model guided by InsP2P [2]), VACE-14B [8] (using GPT-4o–generated captions), the concurrent ICVE [16] (pretrained on 1M videos and fine-tuned on 150k), and LucyEdit [25]. Despite the extensive training data used by baselines, VideoCoF is fine-tuned on only 50k video pairs and achieves superior instruction-following and success ratio.

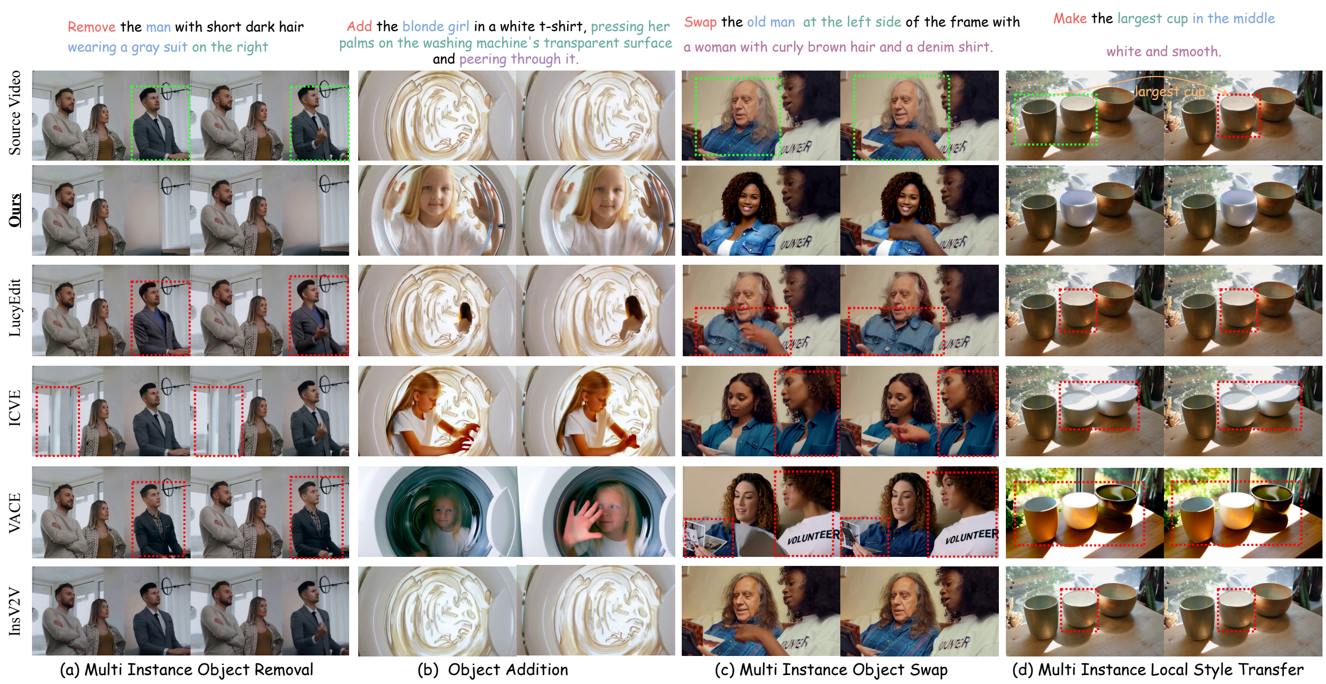

Figure 6. Visual comparsion between our VideoCoF and other methods on diverse video editing tasks.

Señorita [44] and are 33 frames long, we only training on **50k** curated video data finally. Thanks to our RoPE alignment design, the model generalizes to longer sequences at inference (e.g., **141 frames and above**). By default we use 33 frames source video, 33 frames edited video, and 4 frames reasoning clip. We train with a global batch size of 16 for approximately 8k iterations, optimizing with AdamW [17] and a base learning rate of 1×10^{-4}.

4.2. VideoCoF-Bench and Experimental Setting

VideoCoF-Bench. Previous video-editing benchmarks such as V2VBench [24], TGVE [34], and FIVE-Bench [14] focus on target-prompt edits and mostly are focused on class-level object swap. They were mainly designed for training-free methods and are not suitable for instruction-guided or instance-level video editing. Real-world editing requires precise instruction understanding, including instance- and part-level control (e.g., distinguishing multiple people or left vs. right), and complex reasoning. To address these gaps, we introduce VideoCoF-Bench. It contains 200 high-quality videos collected from Pexels [20], covering diverse scenes and both landscape and portrait aspect ratios. VideoCoF-Bench includes four task: Object Removal, Object Addition, Object Swap, and Local Style Transfer, each with 50 samples. Half of these samples per task are instance-level cases with instance-focused editing prompts.

Evaluation Metrics. To evaluate editing performance on VideoCoF-Bench, we employ MLLM-as-a-Judge to provide a holistic evaluation score. This is achieved by prompt-

Ablation on Chain of frames and RoPE design			
	Naive Temporal in Context		VideoCoF
CoF	✗	✗	✓
RoPE Design	0–2F-1	0–F-1, 0–F-1	**1–F, 0, 1–F**
GPT-4o Score			
Instruct Follow↑	8.109	8.064	**8.973**
Preservation↑	7.930	7.793	**8.203**
Quality↑	7.394	7.217	**7.765**
Success Ratio↑*	72.41%	65.52%	**76.36%**
Perceptual Quality			
CLIP-T↑	26.880	27.088	**28.000**
CLIP-F↑	0.9907	0.9905	**0.9915**
DINO↑	0.9857	0.9826	**0.9913**

Table 2. Ablation on Chain of frames and RoPE design.

ing **GPT-4o** [19] to assess multiple criteria given the original video, edited video, and user instruction: (1) Instruction Following (editing accuracy), (2) Preservation (unedited regions), (3) Video Quality. (4) Success ratio: we prompt the GPT-4o to provide a binary Success Ratio (Yes/No) to judge the overall success of the edit. We report three perceptual quality metrics quantify low- and high-level visual similarity between source and target frames: CLIP-T for image–text alignment, CLIP-F for temporal consistency, and DINO for structural consistency.

4.3. Comparison on VideoCoF-Bench

We show qualitative and quantitative comparisons of VideoCoF-Bench in this section. As shown in Table 1, we evaluate VideoCoF against five baseline methods on the VideoCoF-Bench benchmark, which spans four distinct video editing tasks: multi-instance removal, object addition, multi-instance swap, and multi-instance local style transfer.

Overall, VideoCoF demonstrates the best performance in **Instruct Follow** and **Success Ratio** across all categories. Compared to naive temporal in-context editing approaches like ICVE [16], our method achieves significantly higher success rates and better instruction adherence using only **50k** reasoning pairs, whereas ICVE is pre-trained on 1M samples and fine-tuned on 150k data.

Qualitatively (see Figure 6), our method also shows clearer, more faithful edits at the instance level:(a) Multi-instance removal: we precisely remove the right instance while ICVE[16] incorrectly removes the left instance. (b) Object addition: the added girl is correctly placed inside the washing machine, matching the instruction. (c) Object swap: we replace the elderly person's face and update clothing; Lucy Edit [25] changes only clothing, ICVE fails to disambiguate instances, and VACE often alters non-target people. (d) Local style (multi-instance): our model correctly identifies and edits the largest cup among several similar objects; other methods either fail to edit or mistakenly edit a bowl. These qualitative examples demonstrate VideoCoF's stronger instance-level reasoning and higher editing fidelity.

4.4. Ablation Study

To verify our novel Chain of Frames (CoF) design, particularly its "reasoning frames" and the RoPE design for length exploration, we conduct an ablation study on the reasoning frames, RoPE alignment strategy and reasoning format.

Naive Temporal Incontext *VS.* CoF. As shown in Table 2, we compare VideoCoF against a "Naive Temporal in-context" baseline. This applies temporal in-context learning by using the source video as a condition through temporal concatenation, an approach similar to ICVE [16].

In contrast, our approach introduces **reasoning frames** as a core component of the (CoF) design. This ensures the video editing follows a reasoning process, i.e., forcing the model to predict the editing region first and then execute the versatile edit within that specific area.

The efficacy of this design is evident when comparing the first ($[0, 2F-1]$) and third (VideoCoF) columns in Table 2. The inclusion of CoF brings substantial gains: the instruct follow score increases by 10.65% and the success ratio improves by 5.46%. Furthermore, the 4.16% increase in CLIP-T confirms that our reasoning frames effectively enhance the model's editing accuracy and precision.

Figure 7. Length exploration on frames more than training

Rope Design for length Extrapolation. As illustrated in Fig 7, the naive approach ($[0, 2F-1]$) only learns a fixed temporal mapping (e.g., mapping frame 0_{th} to frame 33_{th}). This prevents length extrapolation, causing severe degradation (blurriness, motion misalignment, and artifacts) when a 33-frame trained model is tested on 81 frames (second row).

In contrast, our RoPE alignment design ($[1-F, 0, 1-F]$) generalizes to unseen lengths without quality degradation (third row). As demonstrated in Fig 1, our model extrapolates to 141 frames (4x training length) and beyond, supporting theoretically infinite extrapolation.

This effectiveness is also quantified in Table 2 (third vs. first column). We observe a 3.4% relative increase in the preservation score. Furthermore, the improved DINO score confirms that our RoPE design better preserves the original video's spatio-temporal structure during editing.

RoPE Design for Motion Alignment. Setting the temporal index for the reasoning frame latent is a critical design

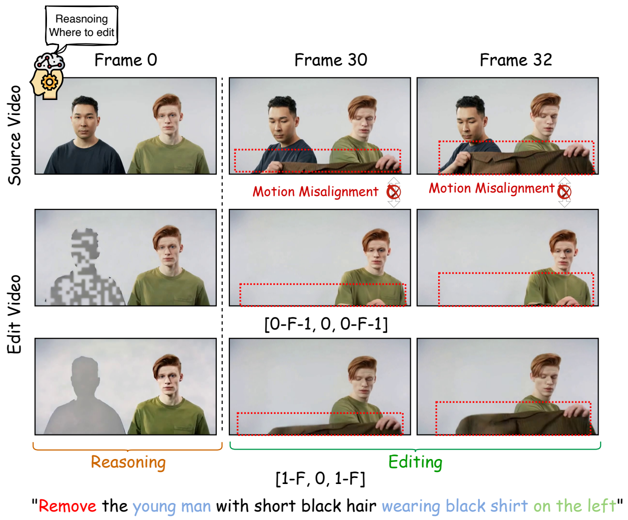

Figure 8. Motion alignment benefit by our rope design

Ablation on Reasoning Frame Format				
Color	**Black (bg)**	**Red**	**Gray**	**Gray**
Transparency	(0%)	(50%)	(0%)	**(0-75%)**
GPT-4o Score				
Instruct Follow↑	7.512	7.805	8.069	**8.973**
Preservation↑	7.034	7.350	7.709	**8.203**
Quality↑	6.155	6.501	6.926	**7.765**
Success Ratio↑*	52.170%	60.330%	67.980%	**76.36%**
Perceptual Quality				
CLIP-T↑	26.550	26.810	27.143	**28.000**
CLIP-F↑	0.9810	0.9855	0.9890	**0.9915**
DINO↑	0.9750	0.9790	0.9826	**0.9913**

Table 3. Ablation on transparency mask settings.

choice. A naive approach is to set its index to 0, aligning it with the first video frame. This causes two severe issues.

First, it leads to significant motion misalignment (e.g., the subject fails to perform the ”lifting clothes” motion in Fig 8, second row). Second, this ”0-index” design causes interference with the first editing video frame (also index 0), leading to artifacts where the model incorrectly predicts the first frame as the reasoning frame (Fig 4).

Therefore, we fix the reasoning latent's index to 0, while the source and edited video indices range from 1 to F (denoted as $[1-F, 0, 1-F]$). This strategy allows the reasoning frame to provide clear spatial guidance on **where** to edit, without disrupting the video's temporal structure and motion alignment. The improvements across all metrics in Tab 2 (column 3 vs. column 2) validate this design.

Reasoning Frame Format. First, we explore the most suitable color for the reasoning frame mask. As shown in Table 3, we compare three formats: (1) A black mask over the unedit region; (2) A red, 50% transparent highlight, same as veggie [40]; and (3) A pure gray mask (value 127, 0% transparency). The quantitative results show that using a gray mask (column 3) for the edit region yields the best performance.

Furthermore, we argue that the reasoning frame should act as a gradual transition from the source video to the edited video. Therefore, we test progressive gray mask. Instead of a single static mask, we interpolate gray mask reasoning frame and editing frame, with transparency is progressively increased (e.g., 0%, 25%, 50%, 75%). As shown by comparing column 4 and column 3 in Table 3, this progressive gray reasoning frame approach works best.

Qualitatively, as shown in Figure 9, the mask format is critical. The black mask fails the deletion task, while the red mask incorrectly deletes content on the right side. In contrast, our progressive gray mask accurately performs the intended deletion on the left. We conclude from these experiments that the optimal reasoning format is a gray mask with progressive transparency.

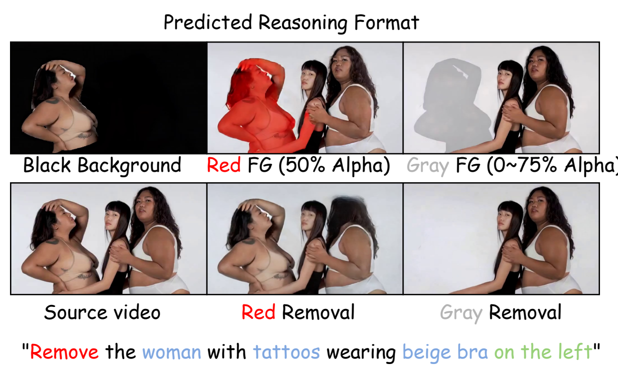

Figure 9. Ablation on reasoning frame format

5. Conclusion

In this paper, we introduced VideoCoF, a unified model for universal video editing via temporal reasoning. We identified that existing temporal in-context learning approaches often fail due to a lack of explicit spatial cues, leading to weak instruction-to-region mapping and imprecise localization. To address these issues, we proposed the innovative Chain of Frames. CoF compels the video diffusion model to follow a “see, reason, then edit” process by first predicting the editing region before executing the versatile edit. Furthermore, to solve the length generalization challenge, we developed a novel RoPE alignment paradigm that accounts for the reasoning latent. This design enables 4 times exploration in the inference. Experimental results show that VideoCoF achieves SOTA performance using a mere 50k video pairs, validating the efficiency and effectiveness of our temporal reasoning design.

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