CoTextor: Training-Free Modular Multilingual Text Editing via Layered Disentanglement and Depth-Aware Fusion

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Figure 1: Motivation. While prior work addresses text generation, detection, tampering, and removal, *controllable multilingual text editing*, with layout preservation and visual consistency, remains largely unsolved. *CoTextor* fills this gap by offering a modular, depth-aware framework for human-guided, reversible visual transformation.

Abstract

We introduce *CoTextor*, a modular and training-free framework for multilingual text editing in images, designed to support human-AI co-creation through a user-controllable and reversible workflow. Unlike diffusion-based systems that operate as black boxes, CoTextor separates the editing process into transparent layers (foreground extraction, background inpainting, semantic rewriting, and depth-aware reintegration), allowing precise user-guided operations such as rotation, translation, scaling, and warping. To ensure realism, we introduce a perceptually guided integration module that enhances photometric and geometric coherence during text reinsertion. Built entirely from publicly available pretrained components, *CoTextor* is accessible to non-technical, multilingual users, requiring no retraining or annotation. Through real-world scenarios in poster localization, street art remixing, and

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educational content creation, we demonstrate how *CoTextor* enables inclusive and expressive visual storytelling across cultural and linguistic contexts.

1 Introduction

Text in images plays a multifaceted role, as it communicates information, anchors visual narratives, facilitates cross-cultural understanding, and often embodies aesthetic and cultural intent [31, 3, 57, 47, 25, 52, 67]. In real-world creative practices, such as poster localization, comic adaptation, or street art remixing, text is not merely rendered, but reimagined through design-driven manipulation [22, 8, 60, 44, 24, 51]. Artists and educators frequently reshape semantics, reposition layout, or stylize embedded language to suit audience, format, and intent. These tasks often require not only linguistic fluency but also visual sensitivity, especially when communicating across cultures and media formats [56, 59, 15, 65, 30]. Moreover, such editing is rarely a one-step operation, as it typically involves iterative revision, feedback, and adjustment, especially in collaborative or educational settings [21, 7, 58, 54, 64, 29].

Recent progress in generative AI, especially diffusion-based models [40, 43, 48, 38, 7, 66], has improved multilingual rendering and visual synthesis. However, these models often function as opaque generators with limited spatial control and no support for post-editing. Their one-shot, prompt-only design makes them ill-suited for iterative workflows, layout preservation, or collaborative human-AI co-creation [4, 63, 33, 12]. While impressive in image realism, these models lack the transparency and interactivity needed in real-world authoring scenarios. As a result, creators are often forced to trade expressiveness and precision for automation, especially in multilingual or design-sensitive tasks (see Figure 1).

In this work, we propose ***CoTextor***, a modular and *training-free* framework that enables controllable multilingual text editing in images. Instead of optimizing for generation fidelity or new model architectures [53], *CoTextor* focuses on usability, transparency, and creative control. It decomposes the editing process into interpretable modules: text extraction, background reconstruction, prompt-guided rewriting, and depth-aware reintegration. Each module exposes clear control points to the user, allowing them to intervene at any stage of the workflow without retraining or coding effort. This design supports not only technical modularity, but also creative flexibility, allowing human decisions to shape the outcome dynamically and deliberately [21, 26]. *CoTextor* is designed to empower users, especially non-technical, multilingual, or culturally diverse creators. By supporting layout-aware control and script-sensitive rendering, it allows human intent to guide the system at every stage. Unlike conventional systems that center model output, *CoTextor* centers human authorship, prioritizing reversibility, customization, and co-creative expression [16, 11, 28]. This shift from prompt-driven generation to editable, interpretable workflows broadens the accessibility of creative AI tools. Through case studies in multilingual design, visual remixing, and educational content creation, we show how *CoTextor* contributes to the broader vision of Creative AI: not just automating outputs, but augmenting authorship [50, 5, 27].

Our main contributions are: (1) **A user-controllable editing workflow.** We present *CoTextor*, a modular and training-free system that supports human-in-the-loop multilingual text editing through a layered, reversible pipeline. (2) **Perceptually guided integration.** We employ a lightweight, depth-aware composition module that enhances photometric and geometric coherence, supporting realism in human-authored visual narratives. (3) **Culturally inclusive and accessible design.** *CoTextor* enables creative users, including non-technical and multilingual audiences, to perform expressive transformations without code, annotations, or retraining.

2 Related Work

2.1 Generative Models for Text-in-Image Editing

Diffusion-based models have become foundational in generative vision pipelines, enabling high-quality text-to-image synthesis from prompts [40, 41, 43, 37, 36]. Models like DALL·E and Stable Diffusion [49] inspired follow-up work targeting embedded text rendering, including AnyText [48] and TextDiffuser [8], which integrate OCR [23, 13, 34, 7]signals and stylized rendering for multilingual scenarios. However, these systems are typically optimized for one-shot generation rather than iterative or user-guided editing. Their architectures prioritize visual plausibility over spatial control-

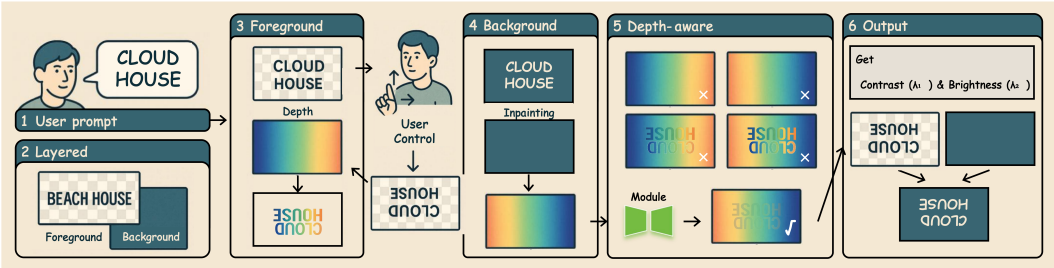

Figure 2: Overview of the *CoTextor* framework. The pipeline consists: (1) OCR- and SAM-based foreground extraction; (2) Background inpainting after text removal; (3) User-control geometric transformation of the text layer; (4) Depth-aware composition to ensure realistic integration.

lability or layout preservation, making them less suitable for workflows involving back-and-forth revision, geometric reasoning, or narrative adaptation [4, 35, 9]. For instance, once a diffusion-based result is generated, there is often no native way to adjust a specific text element without rerunning the full model. Some recent works such as Muse [6] and RePaint [32] attempt inpainting-based regeneration, but still offer limited textual consistency and geometric control. Crucially, these tools position users as prompt writers, not as co-creators [63].

2.2 Controllability and Human-Guided Editing

Recent efforts have explored controllable editing interfaces, particularly to expand the creative scope of generative models. For instance, GlyphControl [53] enables glyph-aware style transfer, and Instruct-Pix2Pix [4] supports high-level region editing via natural language. TextDiffuser [8] incorporates segmentation masks to constrain placement, but remains prompt-bound and non-reversible.

Other systems such as DreamBooth [42] and ControlNet [63] introduce conditioning strategies to guide generation via keypoints, depth maps, or sketches. While these enhance controllability to some extent, they still operate on fixed generative flows and do not expose editable layers or iterative workflows. In most cases, the user has limited agency beyond initial conditioning. These approaches still treat editing as a downstream task to generation, rather than designing editing-first systems. They often lack support for visual feedback, explicit undo, or bidirectional control, which are key elements in any human-centered creative process [21, 10, 61]. Our work builds on these ideas, but repositions control as the starting point, not the afterthought.

2.3 Modular Design and Disentangled Creativity

Foreground-background disentanglement has long been useful in image editing [1, 55]. Modern inpainting models such as LaMa [45] improve photorealistic filling, but typically treat foreground and background as stylistic artifacts rather than semantically distinct elements.

In the context of text editing, the semantic-visual duality of glyphs, both symbolic and graphical, requires more structured separation. A few recent works such as DeepRemaster [18] and SEAN [68] begin to explore layer-wise disentanglement for style manipulation, though not in the context of interactive textual editing. *CoTextor* adopts this principle not only as an architectural convenience but as a creative affordance. By modularizing the process into text recognition, region selection, tampering, and recomposition, it supports reversible, interpretable, and multilingual editing. More importantly, this design foregrounds human agency, allowing creators to guide not just what is edited, but how and why [50, 62].

3 Human-AI Co-Creation Workflow

CoTextor is designed not as a monolithic generation engine, but as a modular editing framework that supports human-AI co-creation. Its architecture encourages active user participation at every stage, enabling a collaborative interplay between human intent and algorithmic support in shaping visual outcomes (see Figure 2 and Figure 3(a)).

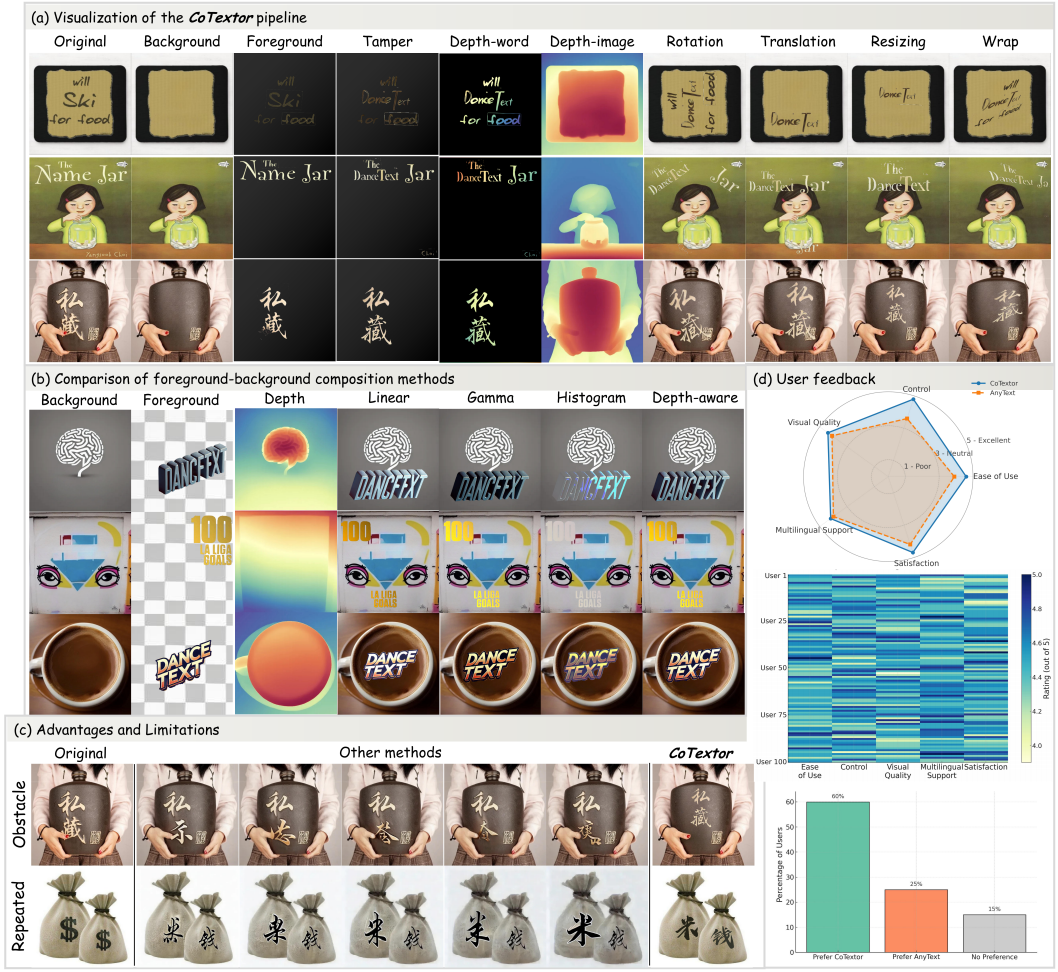

Figure 3: *CoTextor* framework and evaluation overview. (a) Visual pipeline. (b) Composition quality comparison. (c) Performance under challenging scenarios. (d) User study summary.

Stage 1: Interactive Foreground Extraction. Users begin by identifying one or more text regions in the image. An OCR model (e.g., EasyOCR [19]) detects all textual elements, after which the user selects which content to edit. *CoTextor* applies the Segment Anything Model (SAM) [20] for initial segmentation, followed by k-Means clustering to remove residual noise. This results in a clean and editable foreground layer, giving users direct control over *what* to modify.

Stage 2: Clean Background Reconstruction. After text removal, the background is automatically reconstructed to preserve visual context. A pretrained inpainting model (e.g., LaMa [45]) synthesizes plausible textures in masked regions, producing a scene-consistent canvas on which new edits can be placed. This enables fluid repositioning without breaking layout harmony.

Stage 3: Prompt-Guided Tampering and Geometric Transformation. Users rewrite selected text through multilingual prompts using AnyText, and apply geometric transformations, such as rotation, translation, scaling, and warping, via intuitive controls. Unlike prompt-only models, *CoTextor* supports real-time visual feedback, empowering users to iteratively refine layout, semantics, and style. This stage prioritizes creative exploration and non-linear editing.

Stage 4: Depth-Aware Reintegration. To maintain perceptual realism, *CoTextor* estimates depth maps for both the inpainted background and the transformed foreground. A depth-aware fusion module then adjusts contrast and brightness to align with local lighting and geometry. This ensures the edited content integrates seamlessly, even under complex scene conditions.

By disentangling recognition, manipulation, and composition, *CoTextor* enables expressive visual editing that is interactive, reversible, and culturally adaptable. Its modular structure foregrounds user agency, allowing creators not just to generate content, but to actively author visual meaning across languages and contexts.

4 Implementation Details

CoTextor is built entirely from publicly available pretrained models. We evaluate *CoTextor* on real-world samples drawn from the AnyWord-3M benchmark [48]. Metrics include Structural Accuracy (SA) [48], Normalized Edit Distance (NED) [48], Fréchet Inception Distance (FID) [17], Bhattacharyya Coefficient (BC) [2], Chi-Square Distance (CS) [14], Correlation (Corr) [39], and Histogram Intersection (Inter) [46]. All experiments were conducted on a single NVIDIA RTX 4090 GPU. The full implementation, including mathematical formulations and ablation settings, is provided in Appendix A to support transparency and reproducibility.

5 Evaluation: Human-Centered Visual Editing

5.1 Qualitative Use Cases: Human-AI Co-Creation in Practice

To assess the practical impact of *CoTextor* in real-world creative workflows, we present three illustrative use cases involving multilingual design, public expression, and educational adaptation. These scenarios demonstrate how modularity, reversibility, and spatial control enable users to co-author expressive visual content across cultural and linguistic contexts.

Multilingual Poster Redesign. A visual designer begins with an English-language promotional poster and aims to localize it into Arabic and Chinese. *CoTextor* enables selective text extraction, prompt-based rewriting via AnyText, and flexible layout adjustment through geometric transformation. The designer is not constrained by prompt syntax or static outputs but actively reshapes the composition to fit new audiences. The depth-aware fusion module ensures that the localized text blends with the scene's lighting and perspective, an essential need in culturally adaptive visual storytelling.

Street Art Remix. In a reinterpretation of urban graffiti, a user selects stylized text on a brick wall and transforms the message (e.g., from `I love you` to `I hate you`), while retaining its style and curvature. *CoTextor* supports real-time warping and lighting-aware rendering, allowing users to reimagine public messages without disrupting scene integrity. Unlike black-box pipelines, *CoTextor* gives users control over both message and form, a key factor in creative reappropriation.

Educational Storybook Translation. An educator localizing visual materials for multilingual learners replaces in-image labels such as `start` or `help`. *CoTextor* preserves the surrounding illustration while enabling precise word-level substitution. With reversible editing and previewable iterations, educators can ensure clarity and consistency across language versions, making it easier to support diverse learning communities.

These cases highlight *CoTextor*'s ability to support visual authorship that is not only technically plausible but also socially and culturally responsive. The user is repositioned not as a prompt-giver but as a co-creator, shaping narrative, layout, and linguistic voice.

5.2 Perceptual Consistency Analysis

We evaluate *CoTextor*'s depth-aware fusion against standard composition methods (linear blending, gamma correction, and histogram matching) using four perceptual metrics: brightness consistency (BC), color shift (CS), semantic correlation (Corr), and interaction coherence (Inter) (see Figure 3(b), Table 1). *CoTextor* achieves the highest Corr (0.9915) and Inter (1.8251), indicating better semantic alignment and scene integration. Although histogram matching yields better BC, it underperforms in semantic fidelity. These results confirm the effectiveness of depth-guided adjustment for perceptually coherent and trustworthy text editing. Additional quantitative comparisons are provided in Appendix D.

5.3 User Study and Preference Analysis

To complement our quantitative metrics, we conducted a small-scale user study involving 30 participants with backgrounds in visual design, language education, and digital media. Each participant was asked to complete editing tasks using both CoTextor and a baseline diffusion model. As shown in Figure 3(d), users rated CoTextor higher in controllability (mean: 4.6/5), visual quality (4.5), and overall satisfaction (4.7), citing its modular workflow and real-time feedback as key strengths.

6 Discussion

Table 1: Ablation study of the depth-aware module.

Method	**BC** ↑	**CS** ↓	**Corr** ↑	**Inter** ↑
Linear	0.7882	63.2225	0.0388	0.3965
Gamma	0.4205	15.2911	0.9649	1.5315
Histogram	**0.8465**	64.5014	0.0141	0.3329
Depth-aware	0.2546	**0.7881**	**0.9915**	**1.8251**

Limitations. (1) Assumption of planar scenes and clean separation. The current framework is optimized for 2D, front-facing layouts with well-isolated text regions. In scenarios involving occlusion, curved surfaces, or noisy segmentation (such as the obstacle example in Figure 3(c)), text extraction and reintegration can still fail. Future work may explore 3D-aware text alignment and self-correcting segmentation to enhance reliability. **(2) Difficulty handling repeated or ambiguous elements.** Although *CoTextor* performs better in repeated-object scenes (e.g., bags with different characters), it may still confuse glyph style or placement when semantic cues are limited. This highlights the need for more context-aware rewriting mechanisms that leverage both visual and linguistic consistency. Beyond static images, future extensions could incorporate temporal modeling for video and AR content, as well as feedback-driven personalization to support interactive and adaptive co-creation.

System Capabilities Comparison. To better understand *CoTextor*'s positioning among visual text editing tools, we compare it with representative baselines along five human-centered capabilities: geometric control (for layout authorship), reversible editing (for iteration), depth-aware composition (for perceptual realism), training-free deployment (for accessibility), and multilingual support (for cultural inclusivity). As shown in Table 2, *CoTextor* is the only system to fulfill all five criteria. This highlights *CoTextor*'s unique value as a modular, user-controllable framework. It enables creators to iteratively adjust layout, appearance, and language without requiring code, annotations, or retraining, which are features essential for real-world, cross-lingual, and inclusive creative workflows.

Table 2: Comparison of capabilities among visual text editing systems.

Method	GeoControl	Reversible	Depth	Train-Free	MultiLanguage
AnyText	✗	✗	✗	✗	✓
TextDiffuser	△	✗	✗	✗	✓
CoTextor	✓	✓	✓	✓	✓

Notes: ✓: supported, ✗: not supported, △: partially supported

7 Conclusion

We presented *CoTextor*, a modular, training-free framework for controllable multilingual text editing in images. By disentangling the editing process into layered, reversible stages, *CoTextor* supports a user-controllable workflow that centers human input in multilingual and creative contexts. Our depth-aware fusion module enhances photometric and geometric consistency, ensuring perceptual realism in visually complex scenes. Designed for accessibility and inclusivity, *CoTextor* empowers non-technical and culturally diverse users to perform expressive transformations without requiring code, annotations, or retraining. This work contributes to the growing vision of Creative AI systems that foreground transparency, adaptability, and shared authorship.

Code Available

The code can be found at here.

Appendix

The appendix can be downloaded from here.

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