

InterCoser: Interactive 3D Character Creation with Disentangled Fine-Grained Features

Yi Wang^{1,2*}, Jian Ma^{1*}, Zhuo Su^{3†}, Guidong Wang³, Jingyu Yang¹, Yu-Kun Lai⁴, Kun Li^{1‡}

¹Tianjin University, ²Changzhou Institute of Technology, ³ByteDance China, ⁴Cardiff University
{stardust66, jianma}@tju.edu.cn, {Zhuo Su, guidong.wang}@bytedance.com, yjy@tju.edu.cn, laiy4@cardiff.ac.uk,
lik@tju.edu.cn

Abstract

This paper aims to interactively generate and edit disentangled 3D characters based on precise user instructions. Existing methods generate and edit 3D characters via rough and simple editing guidance and entangled representations, making it difficult to achieve precise and comprehensive control over fine-grained local editing and free clothing transfer for characters. To enable accurate and intuitive control over the generation and editing of high-quality 3D characters with freely interchangeable clothing, we propose a novel user-interactive approach for disentangled 3D character creation. Specifically, to achieve precise control over 3D character generation and editing, we introduce two user-friendly interaction approaches: a sketch-based layered character generation/editing method, which supports clothing transfer; and a 3D-proxy-based part-level editing method, enabling fine-grained disentangled editing. To enhance 3D character quality, we propose a 3D Gaussian reconstruction strategy guided by geometric priors, ensuring that 3D characters exhibit detailed local geometry and smooth global surfaces. Extensive experiments on both public datasets and in-the-wild data demonstrate that our approach not only generates high-quality disentangled 3D characters but also supports precise and fine-grained editing through user interaction. The code will be available at <http://cic.tju.edu.cn/faculty/likun/projects/InterCoser>.

Introduction

In the fast-paced domains of AIGC, gaming, and AR/VR, creating user-friendly tools for 3D character modeling and editing carries substantial practical significance. A core challenge lies in enabling users to interactively and controllably generate and edit high-quality 3D characters with disentangled fine-grained representations, which is crucial for applications like virtual wardrobe customization and granular character design workflows. In this paper, we propose an innovative approach to the precise and controllable generation and editing of disentangled 3D character representations through direct user interaction, as illustrated in Fig. 1.

*These authors contributed equally.

†Project Lead.

‡Corresponding author

Copyright © 2026, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.

Existing 3D character generation and editing methods struggle with three key limitations: inability to precisely control character generation and editing, entanglement of clothing and body representations limiting customization, and generation quality issues due to the lack of optimization constraints. Firstly, although 3D character generation methods (Cao et al. 2024; Kolotouros et al. 2023; Zhang et al. 2024a,c) support coarse pose/shape editing using pose conditions or SMPL priors, they lack fine-grained part-level control. Although text-based character generation methods (Liao et al. 2024; Gong et al. 2024; Xue et al. 2024) enable limited editing of characters via textual prompts, the semantics of the text cannot precisely localize editable regions, making it difficult to convey complex 3D editing instructions. Secondly, current approaches (Chen et al. 2023; Peng et al. 2024) can only produce results with entangled clothing and body. Although the method (He et al. 2025) achieves separated body and clothing through 3D semantic disentanglement, its clothing diversity remains limited by predefined categories in the dataset and fails to edit unrestricted categories. Third, recent methods (Tang et al. 2024; Li et al. 2024; Zou et al. 2024) have improved 3D appearance quality by combining Multi-View Diffusion (MVD) and Triplane representations with Gaussian Splatting (GS) (Kerbl et al. 2023). These approaches, even when using some 3D priors (e.g., SMPL) or surface constraints, still exhibit artifacts due to insufficient geometric regularization.

To address the aforementioned issues, we propose InterCoser, an innovative method designed to achieve disentangled generation and editing of high-quality 3D characters through user interaction. To achieve this, we introduce two user-friendly interaction approaches: 1) a sketch-based (including hand-drawing) layered character interactive generation and editing approach, and 2) a 3D-proxy-based part-level disentangled editing method. First, to enable precise control over character generation and editing via sketch interactions in a layered manner, and to achieve clothing transfer between differently shaped bodies, we propose the Sketch-to-3D Decoupled Matching (SDM) Network. The SDM network takes character edits (e.g., clothing drawn by users on character images) in arbitrary poses as input, generates four standard-pose views of the edited content via a decoupled MVD, and then produces initial clothing from these views using a fine-tuned LRM model (Hong et al. 2023).

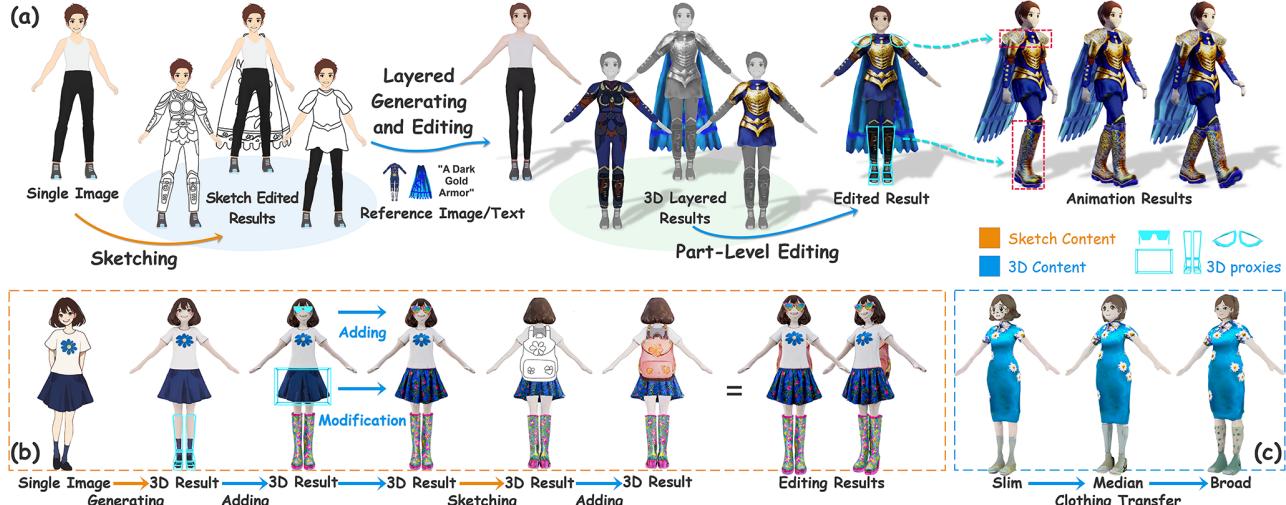


Figure 1: Our InterCoser method enables high-quality disentangled 3D characters generation and editing through user interaction. As shown in (a) and (b), our framework first generates an initial 3D character in A-pose from a single image (in arbitrary poses), then enables layered, part-level editing via sketches and 3D proxies. (b) further shows that our method supports the input of character images with diverse poses, and can perform fine-grained local modifications and additive operations on the 3D characters. (c) demonstrates that our method supports transferring clothing layers between human bodies of different shapes.

Next, our novel 3D Matching Module enables both layer-wise optimization of initial clothing and clothing transfer between differently shaped bodies through layered geometry and semantic matching optimization. Finally, the layered clothing is further refined via our geometry-prior-guided 3D Gaussian reconstruction network. The SDM network enables simultaneous editing from sketches to 3D content, allowing precise interactive editing of character clothing in a layered manner.

To achieve finer-grained part-level editing of 3D characters using intuitive 3D proxies with disentangled representations, we propose an interactive GS-based editing strategy. The 3D proxy is composed of coarse geometric primitives. Unlike existing Gaussian Splatting (GS) editing methods (Wang et al. 2024; Chen et al. 2024b), which only supervise the local semantics of edited content, our proposed strategy employs a multi-branch SDS (Score Distillation Sampling) loss combined with a Gaussian Splatting object ID (GS Object ID) mechanism to jointly optimize local edits for global character semantic consistency. Among them, the object ID of each Gaussian point is assigned through volumetric selection by the 3D proxy. Meanwhile, to enhance the quality of GS editing, we employ a progressive GS attribute decay strategy and adaptive interactive semantic loss. The GS attribute decay strategy stabilizes early edits, while allowing flexibility for new points by gradually increasing attribute regularization based on generation order. Experiments show that this interactive editing strategy can generate fine-grained, high-quality 3D disentangled content aligned with character semantics, such as glasses and accessories.

To further refine the quality of 3D characters in a layered manner while enabling topology-free editing capability, we propose a novel geometry-prior-guided 3D Gaussian reconstruction strategy. We place all GS components on the mesh layer as convex combinations of face vertices and super-

vise GS normals using a fine-tuned model (Bae and Davison 2024). Experiments conducted on public datasets (VRoid 2022) and in-the-wild datasets demonstrate that our method not only generates high-quality, representation-disentangled 3D characters, but also enables convenient interactive and controllable character editing.

In summary, our paper makes the following key contributions:

- We propose a novel interactive 3D character generation and editing framework—InterCoser, which enables precise control of 3D character generation and editing via user instructions, using disentangled character representations. Extensive experiments show our method enables layered, part-level editing while generating high-quality GS-based 3D characters.
 - We introduce the Sketch-to-3D Decoupled Matching (SDM) Network, which can interactively generate and edit layered dressed characters based on sketches, and supports the transfer of layered clothing across different body shapes.
 - We design a disentangled interactive editing strategy based on Gaussian Splatting with intuitive 3D proxies, enabling fine-grained part-level manipulation of 3D characters.
 - We introduce a geometry-prior-guided 3D Gaussian reconstruction strategy that ensures detailed local geometry while maintaining global surface smoothness for layered character models.

Related Work

3D Character Generation and Editing. Diffusion-based text-to-3D generation methods (Ren et al. 2023; Cao et al. 2024; Zhang et al. 2024a) leverage score distillation

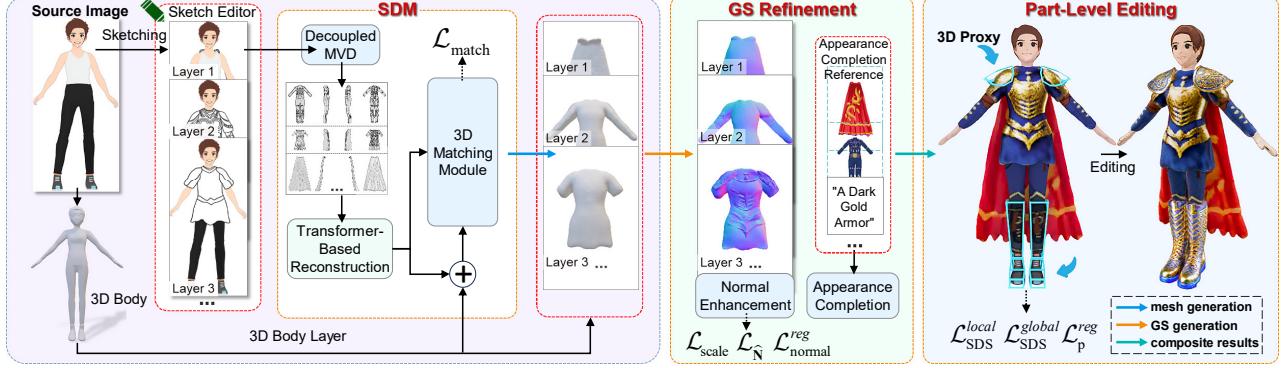


Figure 2: **Overview of our InterCoser.** We propose an interactive framework for 3D character generation and editing with disentangled representation. The framework first generates an initial 3D character model in A-pose from a single input image of a character in an arbitrary pose. Users can then perform layered editing through sketch-based interactions. Next, the system converts the layered mesh into a refined Gaussian Splatting (GS) representation, leveraging geometric priors. Finally, the GS-based layered character can be further edited through fine-grained, part-level interactive manipulation.

tion or LLM integration, while skeletal/Gaussian-based approaches (Huang et al. 2023; Hu, Hong, and Liu 2024; Alvin et al. 2023; Yuan et al. 2024; Pan et al. 2024; Shao et al. 2024) utilize geometric priors. Single-image reconstruction combines implicit diffusion (Kolotouros et al. 2024; Zhang et al. 2024b; Ho et al. 2024) with explicit 3D guidance (Cao et al. 2023; Zhou et al. 2024; Xue et al. 2024), whereas sparse-view transformers (Peng et al. 2024; Chen et al. 2023; Men et al. 2024; Jiang et al. 2023) address stylized domains. However, the above 3D character generation methods do not support disentangled representation generation, whereas our approach enables layered and part-level decoupled generation and editing. Although STDGEN (He et al. 2025) achieves component-wise generation, it loses geometric details with sparse semantic segmentation, and the precomputed textures in DAGSM (Zhuang et al. 2025) constrain fine-grained local editing, despite its clothing separation.

3D Content Editing. For text-guided 3D editing, CustomNeRF (He et al. 2024) introduces foreground-aware editing via Local-Global Iterative Editing; DreamEditor (Zhuang et al. 2023) pioneers semantic-driven NeRF optimization for geometric edits, and TipEditor (Zhuang et al. 2024) leverages 3D GS for alignment accuracy in bounded edits. Recent advances like methods (Qu et al. 2025; Luo et al. 2025; Dong and Wang) enable direct 3D manipulation via control points, while MVDrag3D (Chen et al. 2024a) achieves multi-view consistent editing via diffusion priors. For sketch-based editing, methods (Mikaeili et al. 2023; Liu et al. 2024a; Zang et al. 2024) enable 3D creation from sketches, and interactive methods like Progressive3D (Cheng et al. 2023) enable multi-step localized editing via coarse selection, while Interactive3D (Dong et al. 2024) supports drag-and-drop operations. However, existing methods face three key limitations: text-based approaches lack precise region localization, sketch-based systems require either multiple inputs or manual 3D guidance, and interactive tools rely on coarse selection and drag-and-drop operations. Our method overcomes these issues by enabling precise editable region definition via single-sketch input with intuitive 3D proxies, while preserving superior geomet-

ric fidelity. We summarize the main differences between our work and related work in Tab. 1.

Method	Multi-Layer Generation	Disentangled Results	Layer-wise Editing	Part-level Editing
LGM (Tang et al. 2024)	✗	✗	✗	✗
CharacterGen (Peng et al. 2024)	✗	✗	✗	✗
SKED (Mikaeili et al. 2023)	✗	✗	✗	✓
SketchDream (Liu et al. 2024a)	✗	✗	✗	✓
STDGEN (He et al. 2025)	✗	✓	✗	✓
Ours	✓	✓	✓	✓

Table 1: Comparison with state-of-the-art (SoTA) single-image-based 3D generation and editing methods.

Method

As shown in Fig. 2, we propose an interactive 3D character generation framework for creating and editing 3D characters in a disentangled representation manner. To achieve this, we introduce a Sketch-to-3D Decoupled Matching (SDM) network during the sketch-based layered generation and editing stage. This network maps arbitrarily posed character images and their corresponding sketch edits into a four-view A-pose representation, generating an initial layered 3D dressed character and supporting clothing transfer. Next, in the 3D GS Refinement stage, we reconstruct a high-fidelity 3D character with detailed local geometry and smooth surfaces based on the layered 3D mesh, using a geometry-prior-guided 3D GS reconstruction strategy. Finally, to enable finer-grained part-level editing of the character in a disentangled manner, we introduce a GS-based interactive editing strategy for part-level manipulation.

Sketch-to-3D Decoupled Matching (SDM) Network

The SDM network aims to interactively generate layered 3D characters with editable clothing based on sketch-based input. Existing text/image-guided 3D character generation lacks precise control over generation and editing due to inadequate pose/structure capture in text inputs, missing image-based editing cues, and entangled representations blocking clothing transfer. To address these challenges, we design the SDM network.

Interactive Sketch-Based Editing The SDM network supports the generation of 3D characters M_{char} from character images or hand drawings I_{char} , by fine-tuning the LRM model (Hong et al. 2023) in the dataset (VRoid 2022). Furthermore, to enable interactive editing of M_{char} via sketch-based edits I_{char}^{edit} applied to character image I_{char} in arbitrary poses, we design a decoupled MVD that processes I_{char}^{edit} to generate four standard-pose views V_{char}^{edit} of the edited content. Denote by V_{char} the four canonical views generated from input I_{char} , by V'_{char} latent representation of V_{char} in the diffusion model, by F_{ij} the correspondence matrix between sketch edit I_{char}^{edit} and views V_{char} , and by M_{edit} the four-view noise prediction mask. The process is defined as follows:

$$V_{char}^{edit} = \mathcal{D}_\theta(V'_{char} \odot (1 - M_{edit}), \epsilon \odot M_{edit}, t), \quad (1a)$$

$$M_{edit} = \mathcal{C}_{region}(I_{char}^{edit}, F_{ij}, V_{char}), \quad (1b)$$

$$F_{ij} = \mathcal{M}_{sparse}(I_{char}^{edit}, V_{char}), \quad \begin{cases} i \in I_{char}^{edit} \\ j \in V_{char} \end{cases} \quad (1c)$$

where the decoupled MVD is trained on pairs of single view character images in arbitrary poses and their corresponding canonical four views using the dataset (VRoid 2022). First, correspondence matrix F_{ij} (Eq. 1c) is obtained using a sparse feature matching method (Lindenberger, Sarlin, and Pollefeys 2023). Then, noise prediction mask M_{edit} (Eq. 1b) is computed through a confidence network $\mathcal{C}_{region}(\cdot)$.

Next, through diffusion denoising (Eq. 1a), identity-consistent edited four views V_{char}^{edit} matching V_{char} are obtained, where t is a time step and ϵ is the scheduled noise at t . Unlike other MVD methods (Hu et al. 2024; Liu et al. 2024b; Melas-Kyriazi et al. 2024) that apply a uniform noise injection rate, we use M_{edit} to control noise ϵ , ensuring that noise is only injected into editable regions. Finally, decoupled four views V_{decoup}^{edit} are obtained from V_{char}^{edit} via F_{ij} , and initial clothing M_{cloth} is generated from V_{decoup}^{edit} using the fine-tuned LRM.

3D Matching Module Then, to optimize initial clothing or accessories M_{cloth} in a layer-wise manner and match it with the initial character model M_{char} , we design a novel 3D Matching Module with dual optimization stages for geometric and semantic matching.

First, to make the n -th layer mesh M_{cloth}^n geometrically match the combined mesh M_{cp} formed by the previous n layers (clothing + body), we use a normal offset prediction network to optimize the vertices vs_{cloth} of M_{cloth}^n to prevent vs_{cloth} from penetrating the combined mesh M_{cp} . Specifically, the position of the vertices vs_{cloth} is optimized along their normal direction n_{cloth} . For each vertex $v_{cloth} \in vs_{cloth}$, its nearest neighboring vertices are searched on the mesh M_{cp} , and the view-visible vertices $v_{cloth}^{nn} \in vs'_{cp} \subseteq vs_{cp}$ are selected. Meanwhile, a penalty term is introduced when the normalized direction \vec{d}_{cloth} from v_{cloth} to its corresponding v_{cloth}^{nn} opposes the direction of n_{cloth} . Similarly, for each vertex $v_{cp} \in vs'_{cp}$, its corresponding nearest neighbor $v_{cp}^{mm} \in vs_{cloth}$ is located on M_{cloth}^n , and a penalty is applied if the normalized direction \vec{d}_{cp} from v_{cp} to v_{cp}^{mm} op-

poses the normal direction n_{cp} . Finally, the matching loss function is defined as follows:

$$\mathcal{L}_{match} = (\lambda_{cp} \cdot \vec{d}_{cp} \cdot n_{cp} - \lambda_{cloth} \cdot \vec{d}_{cloth} \cdot n_{cloth}) + \lambda_{reg} \|\Delta v_{cloth} + \Delta v_{cp}\|_2^2, \quad (2)$$

where $\|\Delta v_{cloth} + \Delta v_{cp}\|_2^2$ is the displacement regularization term for v_{cloth} and v_{cp} . λ_{cp} , λ_{cloth} , and λ_{reg} are the weight attributes of each loss.

Furthermore, to enable fine-grained semantic alignment between M_{cloth}^n and M_{cp} , we introduce a semantic matching loss into the 3D Matching Module. The optimization objective is as follows:

$$\nabla_\theta \mathcal{L}_{SDS}^{cloth}(\phi, \mathbf{x}) \triangleq \mathbb{E}_{t,\epsilon} \left[\omega(t) (\hat{\epsilon}_\phi(\mathbf{x}_t^{cloth}; y^{cloth}, t) - \epsilon) \frac{\partial \mathbf{x}}{\partial \theta} \right], \quad (3)$$

$$\nabla_\theta \mathcal{L}_{SDS}^{cp}(\phi, \mathbf{x}) \triangleq \mathbb{E}_{t,\epsilon} \left[\omega(t) (\hat{\epsilon}_\phi(\mathbf{x}_t^{cp}; y^{cp}, t) - \epsilon) \frac{\partial \mathbf{x}}{\partial \theta} \right], \quad (4)$$

where $\mathcal{L}_{SDS}^{cloth}$ and \mathcal{L}_{SDS}^{cp} are used to optimize the n -th clothing layer for semantic alignment with the previous n layers. \mathbf{x}_t^{cloth} , y^{cloth} and \mathbf{x}_t^{cp} , y^{cp} denote noisy samples of normal maps and text prompts corresponding to the 3D content of the n -th clothing layer and the previous n layers, respectively. See preliminary of Suppl. for other SDS definitions. In addition, the 3D Matching Module supports transferring clothing layers across characters with different body shapes, as illustrated in Fig. 1(c).

The overall objective of sketch-based layered generation and editing is as follows:

$$\mathcal{L}_{layer} = \lambda_{match} \mathcal{L}_{match} + \lambda_{cloth} \mathcal{L}_{SDS}^{cloth} + \lambda_{cp} \mathcal{L}_{SDS}^{cp}, \quad (5)$$

where λ_{match} , λ_{cloth} , and λ_{cp} are the weights of loss terms.

3D Gaussian Refinement

To address the lack of surface constraints during the optimization of GS-based generation methods, which often leads to poor surface reconstruction quality, we design a geometry-prior-guided 3D Gaussian reconstruction strategy. Moreover, the strategy ensures that our method achieves high-fidelity appearance and topology-free editing capabilities based on Gaussian Splatting (GS).

First, to ensure proper initialization of the Gaussian distributions, we place the Gaussian components of each reconstruction layer on the surface of the corresponding initial mesh layer. For each triangle face V on the mesh, we represent the Gaussian mean as a convex combination of the vertices of V .

Second, to make the GS distributions better conform to the geometry, we optimize the GS distributions to become flattened, using the smallest scaling axis as an approximate normal vector. Specifically, we compute the rotation matrix R and the scale vector $s(s_1, s_2, s_3)$ from the GS quaternion, and define the geometric normal of the Gaussian as:

$$n_i = R \cdot \text{OneHot}(\arg \min(s_1, s_2, s_3)), \text{OneHot}(\cdot) \in \mathbb{R}^3. \quad (6)$$

The optimization objective to minimize the smallest scaling axis of s is:

$$\mathcal{L}_{\text{scale}} = \sum_i \|\arg \min(s_{i,1}, s_{i,2}, s_{i,3})\|_1 \quad (7)$$

Meanwhile, the normals are composed by alpha, and the estimated normal at each rasterized pixel is computed as:

$$\hat{\mathbf{N}} = \sum_i n_i \alpha_i T_i, \quad (8)$$

where α_i and T_i denote opacity value and cumulative transmittance, respectively. To obtain smoother normal estimations, we supervise the predicted normals $\hat{\mathbf{N}}$ using the normal map \mathbf{N} predicted by model (Bae and Davison 2024), with the following optimization objective:

$$\mathcal{L}_{\hat{\mathbf{N}}} = \frac{1}{|\hat{\mathbf{N}}|} \sum \|\hat{\mathbf{N}} - \mathbf{N}\|_1. \quad (9)$$

Additionally, we apply a regularization loss on the gradient of the predicted normals to enforce smoothness across neighboring pixels:

$$\mathcal{L}_{\text{normal}}^{\text{reg}} = \sum_{m,n} \left(\|\nabla_m \hat{\mathbf{N}}_{m,n}\|_1 + \|\nabla_n \hat{\mathbf{N}}_{m,n}\|_1 \right), \quad (10)$$

where $\hat{\mathbf{N}}_{mn}$ denotes the estimated normal in pixel (m, n) and ∇ represents the finite difference operator computed by convolving with $[-1, 1]$ along the m axis and its transpose $[-1, 1]^T$ along the n axis. The overall objective of 3D Gaussian refinement is as follows:

$$\mathcal{L}_{\text{normal}} = \lambda_{\text{scale}} \mathcal{L}_{\text{scale}} + \lambda_{\mathbf{N}} \mathcal{L}_{\hat{\mathbf{N}}} + \lambda_n^{\text{reg}} \mathcal{L}_{\text{normal}}^{\text{reg}}, \quad (11)$$

where λ_{scale} , $\lambda_{\mathbf{N}}$, and λ_n^{reg} are the weight attributes of each loss. Finally, the appearance of the GS reconstruction is refined and completed using a pre-trained appearance completion module (refer to Supplementary Material).

Part-Level Interactive Editing

Finally, to enable finer-grained part-level editing of the character, we introduce a GS-based disentangled interactive editing strategy.

Local-to-Global Semantic Consistency To ensure that local editing regions remain semantically consistent with the overall character, the proposed strategy employs a local-to-global semantic optimization combined with the GS Object ID to optimize the local editing region, unlike other methods that constrain only local semantics. The optimization objective is as follows:

$$\nabla_{\theta} \mathcal{L}_{\text{SDS}}^{\text{local}}(\phi, \mathbf{x}) \triangleq \mathbb{E}_{t,\epsilon} \left[\omega(t) (\hat{\epsilon}_{\phi}(M_l \otimes \mathbf{x}_t; y^l, t) - \epsilon) \frac{\partial \mathbf{x}}{\partial \theta} \right], \quad (12)$$

$$\nabla_{\theta} \mathcal{L}_{\text{SDS}}^{\text{global}}(\phi, \mathbf{x}) \triangleq \mathbb{E}_{t,\epsilon} \left[\omega(t) (\hat{\epsilon}_{\phi}(\mathbf{x}_t; y^g, t) - \epsilon) \frac{\partial \mathbf{x}}{\partial \theta} \right], \quad (13)$$

where $\mathcal{L}_{\text{SDS}}^{\text{local}}$ and $\mathcal{L}_{\text{SDS}}^{\text{global}}$ are used to jointly optimize local character editing while maintaining semantic consistency with the overall character. M_l denotes the GS mask for the locally edited region, obtained by using the Object ID. The Object ID of each Gaussian point is determined by the volume selection of the initial 3D proxy. \mathbf{x}_t denotes noisy samples of the character image. y^l and y^g refer to the text prompts for the local and global regions of the character, respectively. See preliminary of Suppl. for other SDS definitions.

Enhancing GS Editing Quality Meanwhile, to improve the quality of generated edits, we employ a progressive GS attribute decay strategy and an adaptive interactive semantic loss. The stochastic and discrete GS optimization, without hierarchical networks' memory capacity, often causes unstable training convergence. We introduce a GS attribute decay strategy to consolidate early GS editing results, while allowing new GS points a degree of flexibility. The loss of regularization on the GS attributes is defined as follows:

$$\mathcal{L}_{\text{p}}^{\text{reg}} = \sum_{i=0}^k \lambda_i \|p_i - \hat{p}_i\|_2^2, \quad (14)$$

where k denotes the total number of Gaussians and p_i denotes a certain property of Gaussian points. \hat{p}_i refers to the historical value of p_i from the previous optimization iteration. λ_i denotes the regularization strength applied to each Gaussian property. The overall objective of part-level interactive editing is as follows:

$$\mathcal{L}_{\text{edit}} = \lambda_{\text{loc}} \mathcal{L}_{\text{SDS}}^{\text{local}} + \lambda_{\text{glob}} \mathcal{L}_{\text{SDS}}^{\text{global}} + \lambda_p^{\text{reg}} \mathcal{L}_{\text{p}}^{\text{reg}}, \quad (15)$$

where λ_{loc} , λ_{glob} , and λ_p^{reg} are the weight attributes of each loss.

EXPERIMENTS

Implementation Details

Training Details. We utilize the VRoid dataset (VRoid 2022), applying a stringent filtering process to exclude non-human characters and low-quality data. This results in a final selection of 15,000 high-quality character samples, split into training and test sets at a 50:1 ratio. For our SDM network, we adopt the Stable Diffusion 2.1 model as the base architecture. A normal prediction model is trained based on the model (Bae and Davison 2024). The normal prediction model takes an RGB image of the character as input and generates the corresponding character normal map as output. Initial 3D character generation, single-layered editing, and part-level Gaussian Splatting editing take approximately 1/2/2 min (speed-priority) and 1/5/5 min (quality-priority), respectively, on a single NVIDIA RTX 4090 GPU.

Hyperparameters. Initial model generation: 3k-step DMTet optimization; Layered editing: 2.5k-step editing optimization, with 1 : 5 alternate training (n -th layer vs. first n layers); Gaussian refinement: 10k-step geometry optimization and part-level editing: 2.5k-step editing optimization. All four stages use the AdamW optimizer, with learning rates of 0.001, 0.001, 0.001 and 0.01, respectively.

Results

Notably, our method can not only generate high-quality layered 3D dressed characters in any pose, but also allows for fine-grained interactive editing of the layered characters using a convenient sketch and 3D proxy. As shown in Fig. 3, our method enables intuitive editing of the initial 3D character through simple doodles or hand-drawn sketches in a layered and input-consistent manner. Moreover, by combining our proposed joint local-global semantic optimization with the GS Object ID, the fine-grained, high-quality editing results can be achieved, such as localized modifications to the

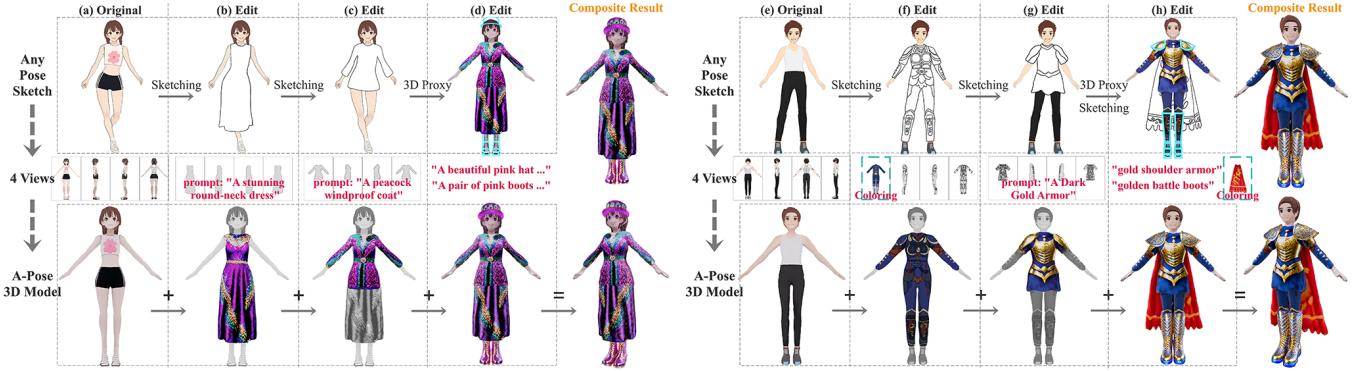


Figure 3: **Interactive 3D Character Generation and Editing Results.** Our method supports both layered editing of 3D characters through direct clothing sketching on the initial character image, such as (b), (c), (f) and (g), and fine-grained part-level editing via simple 3D proxy specification, such as (d) and (h).

boots and armor in Figs. 3(d),(h) and the glasses and skirt in Fig. 1(b). Importantly, these edits are fully decoupled. Specifically, our SDM network supports the free transfer of layered-generated clothing between human bodies of different shapes, which greatly facilitates virtual outfit changes, as demonstrated in Fig. 1(c). Additional generation results can be found in the supplementary materials and demo videos.

Comparison

We compare our generation method with three state-of-the-art (SoTA) single-image-based 3D generation methods: (1) LGM (Tang et al. 2024), which uses a large multi-view Gaussian model to generate 3D models from text prompts or single-view images; (2) CharacterGen (Peng et al. 2024), which uses an image-conditioned diffusion model to generate 3D content from a single character sketch; and (3) STDGEN (He et al. 2025), which employs a semantic-aware large reconstruction model to generate semantically decomposed 3D characters from single images.

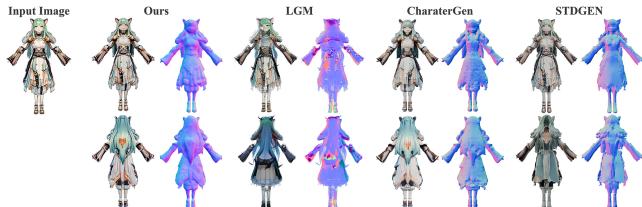


Figure 4: Qualitative comparison of single-image-based generation methods (For a detailed view, please zoom in.)

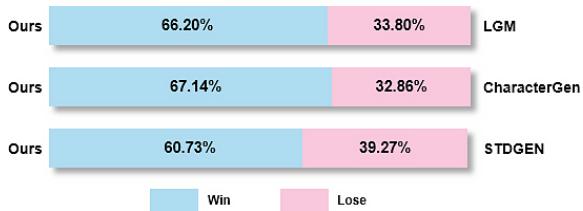


Figure 5: User preference comparison to single-image-based generation methods.

Qualitative Results To compare under a unified posture, we use a single character image in A-pose as input for a

qualitative comparison between our generation method and SoTA methods (Tang et al. 2024; Peng et al. 2024; He et al. 2025). Fig. 4 shows that our generation results outperform SoTA results (see Supp. for more comparisons). LGM lacks fine textures and smooth geometric structures due to its lightweight asymmetric U-Net architecture, which sacrifices some texture details. CharacterGen loses local geometry such as hair or clothing, despite its introduction of multi-view pose normalization to improve handling of complex poses. While STDGEN uses multi-view normal maps for geometry, its 3D segmentation from sparse 2D representations yields geometric artifacts. In contrast, our method generates 3D results with fine geometric details and smooth surfaces through our geometry-prior-based reconstruction strategy.

Method	SSIM \uparrow	LPIPS \downarrow	FID \downarrow
LGM (Tang et al. 2024)	0.5632	0.3176	231.56
CharacterGen (Peng et al. 2024)	0.5525	0.4058	205.68
STDGEN (He et al. 2025)	0.5586	0.4111	227.66
InterCoser (Ours)	0.5643	0.3106	184.24

Table 2: Quantitative fidelity comparison to single-image-based generation methods.

Method	GSDM \downarrow	Sobel \downarrow	B-IoU: \uparrow
LGM (Tang et al. 2024)	0.2540	0.0417	0.0092
CharacterGen (Peng et al. 2024)	0.1976	0.0462	0.0153
STDGEN (He et al. 2025)	0.1953	0.0502	0.0136
InterCoser (Ours)	0.1917	0.0397	0.0180

Table 3: Normal quality comparison to single-image-based generation methods. GSDM, Sobel, and B-IoU denote the gradient magnitude similarity deviation of normal maps, normal map edge smoothness, and the contour IoU between normal maps and input images.

Quantitative Results We quantitatively compare the proposed method with three SoTA methods (Tang et al. 2024; Peng et al. 2024; He et al. 2025). Inspired by (Kirstain et al. 2023), we use user preference metrics to compare the generation quality to the SoTA methods. Fig. 5 shows the superior

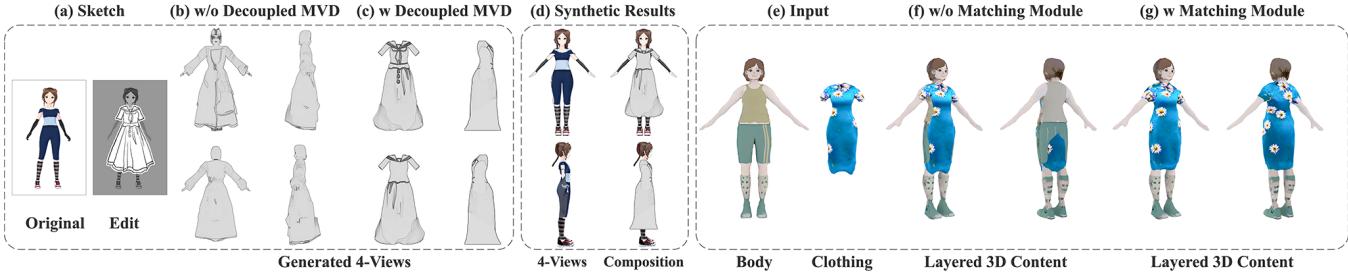


Figure 6: Ablation study of the Sketch-to-3D Decoupled Matching (SDM) Network.

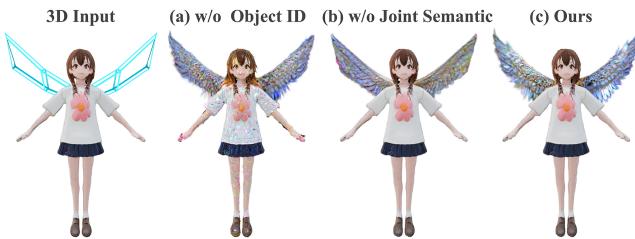


Figure 7: Ablation study of the Part-Level Interactive Editing.

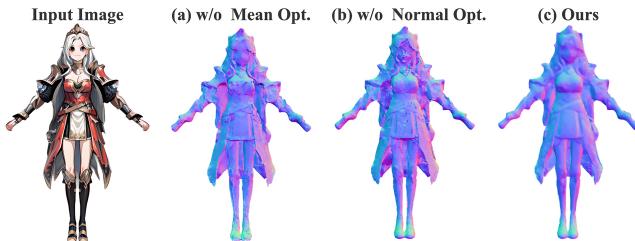


Figure 8: Ablation study of the Geometry-Prior-Guided 3D GS Reconstruction.

performance of our method compared to the SoTA methods in generation quality. Additionally, we calculate the FID score (Heusel et al. 2017) between the rendered views of the 3D characters and the input reference images. Tab. 2 shows that our method achieves the lowest FID score, indicating the best generation quality. Furthermore, as shown in Tab. 2, our method achieves the highest SSIM score and the lowest LPIPS score, further validating its ability to produce detailed and accurate character appearances. Notably, Tab. 3 demonstrates our method achieves the lowest GSDM (Chen, Yang, and Xie 2006) and Sobel scores, along with the highest B-IoU, indicating our method’s superior normal map smoothness and optimal alignment with input image contours.

Ablation Study

Effectiveness of the Sketch-to-3D Decoupled Matching (SDM) Network. Our decoupled MVD (Figs. 6 (b-d)) maintains semantic consistency with inputs while ensuring precise multi-view alignment. The 3D Matching Module (Fig. 6 (f-g)) resolves sparse-view semantic mismatches and enables clothing adaptation to varying body shapes. Additionally, the 3D Matching Module confines inter-layer penetrality

percentage to within 1.5%.

Effectiveness of the Part-Level Interactive Editing. Fig. 7(a) shows that without the Object ID mechanism, GS points move randomly during training, preventing precise edit confinement. Fig. 7(b) reveals that without joint local-global optimization, edited objects (like wings) lack global semantic consistency and may hinder convergence. Fig. 7(c) demonstrates our complete model achieves optimal semantic consistency, fine details, and perfect preservation of unedited regions.

Effectiveness of the Geometry-Prior-Guided 3D GS Reconstruction. Fig. 8(a) demonstrates that unconstrained Gaussian means cause excessive positional freedom, creating artifacts. Fig. 8(b) shows that without normal constraints on GS, the results lack smooth surfaces and fine details. Fig. 8(c) shows that our complete model achieves optimal quality with both smooth surfaces and high-fidelity details.

CONCLUSIONS

This paper introduces InterCoser, an innovative and effective framework for interactively generating and editing 3D characters in a disentangled manner. Our key contribution is enabling precisely controlled disentangled generation and fine-grained editing of clothed 3D characters while maintaining high-quality results. Specifically, we introduce a novel SDM network to enable layered character generation and editing through intuitive sketch interactions, while supporting clothing transfer seamlessly across human bodies with different shapes. We also propose a part-level interactive editing approach that maintains local-to-global semantic consistency using simple 3D proxy manipulations, and a geometry-prior guided 3D Gaussian reconstruction method that simultaneously achieves both high-fidelity local details and globally smooth surfaces. Experiments validate InterCoser’s superior performance in high-quality generation, precise interactive editing, and fine-grained disentanglement for 3D characters.

Acknowledgments

This work was supported in part by National Key R&D Program of China (2023YFC3082100), National Natural Science Foundation of China (62501416), Science Fund for Distinguished Young Scholars of Tianjin (No. 22JCJQJC00040), and Natural Science Foundation of Tianjin (24JCYBJC01300).

References

- Alvin, L.; Yuxiao, Z.; Tao, W.; et al. 2023. HumanGaussian: Text-Driven 3D Human Generation with Structural Priors. *arXiv:2311.17061*.
- Bae, G.; and Davison, A. J. 2024. Rethinking inductive biases for surface normal estimation. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 9535–9545.
- Cao, Y.; Cao, Y.-P.; Han, K.; Shan, Y.; and Wong, K.-Y. K. 2023. Guide3d: Create 3d avatars from text and image guidance. *arXiv preprint arXiv:2308.09705*.
- Cao, Y.; Cao, Y.-P.; Han, K.; Shan, Y.; and Wong, K.-Y. K. 2024. Dreamavatar: Text-and-shape guided 3d human avatar generation via diffusion models. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 958–968.
- Chen, G.-H.; Yang, C.-L.; and Xie, S.-L. 2006. Gradient-based structural similarity for image quality assessment. In *2006 international conference on image processing*, 2929–2932. IEEE.
- Chen, H.; Lan, Y.; Chen, Y.; Zhou, Y.; and Pan, X. 2024a. Mvdrag3d: Drag-based creative 3d editing via multi-view generation-reconstruction priors. *arXiv preprint arXiv:2410.16272*.
- Chen, S.; Zhang, K.; Shi, Y.; Wang, H.; Zhu, Y.; Song, G.; An, S.; Kristjansson, J.; Yang, X.; and Zwicker, M. 2023. Panic-3d: Stylized single-view 3d reconstruction from portraits of anime characters. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 21068–21077.
- Chen, Y.; Chen, Z.; Zhang, C.; Wang, F.; Yang, X.; Wang, Y.; Cai, Z.; Yang, L.; Liu, H.; and Lin, G. 2024b. Gaussianeditor: Swift and controllable 3d editing with gaussian splatting. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 21476–21485.
- Cheng, X.; Yang, T.; Wang, J.; Li, Y.; Zhang, L.; Zhang, J.; and Yuan, L. 2023. Progressive3d: Progressively local editing for text-to-3d content creation with complex semantic prompts. *arXiv preprint arXiv:2310.11784*.
- Dong, J.; and Wang, Y.-X. ???? 3DGS-Drag: Dragging Gaussians for Intuitive Point-Based 3D Editing. In *The Thirteenth International Conference on Learning Representations*.
- Dong, S.; Ding, L.; Huang, Z.; Wang, Z.; Xue, T.; and Xu, D. 2024. Interactive3d: Create what you want by interactive 3d generation. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 4999–5008.
- Gong, C.; Dai, Y.; Li, R.; Bao, A.; Li, J.; Yang, J.; Zhang, Y.; and Li, X. 2024. Text2avatar: Text to 3d human avatar generation with codebook-driven body controllable attribute. In *ICASSP 2024-2024 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 16–20. IEEE.
- He, R.; Huang, S.; Nie, X.; Hui, T.; Liu, L.; Dai, J.; Han, J.; Li, G.; and Liu, S. 2024. Customize your nerf: Adaptive source driven 3d scene editing via local-global iterative training. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 6966–6975.
- He, Y.; Zhou, Y.; Zhao, W.; Wu, Z.; Xiao, K.; Yang, W.; Liu, Y.-J.; and Han, X. 2025. Stdgen: Semantic-decomposed 3d character generation from single images. In *Proceedings of the Computer Vision and Pattern Recognition Conference*, 26345–26355.
- Heusel, M.; Ramsauer, H.; Unterthiner, T.; Nessler, B.; and Hochreiter, S. 2017. Gans trained by a two time-scale update rule converge to a local nash equilibrium. *Advances in neural information processing systems*, 30.
- Ho, I.; Song, J.; Hilliges, O.; et al. 2024. Sith: Single-view textured human reconstruction with image-conditioned diffusion. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 538–549.
- Hong, Y.; Zhang, K.; Gu, J.; Bi, S.; Zhou, Y.; Liu, D.; Liu, F.; Sunkavalli, K.; Bui, T.; and Tan, H. 2023. LRM: Large reconstruction model for single image to 3D. *arXiv preprint arXiv:2311.04400*.
- Hu, H.; Zhou, Z.; Jampani, V.; and Tulsiani, S. 2024. Mvd-fusion: Single-view 3d via depth-consistent multi-view generation. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 9698–9707.
- Hu, T.; Hong, F.; and Liu, Z. 2024. Structldm: Structured latent diffusion for 3d human generation. In *European Conference on Computer Vision*, 363–381. Springer.
- Huang, Y.; Wang, J.; Zeng, A.; Cao, H.; Qi, X.; Shi, Y.; Zha, Z.-J.; and Zhang, L. 2023. Dreamwaltz: Make a scene with complex 3d animatable avatars. *Advances in Neural Information Processing Systems*, 36: 4566–4584.
- Jiang, R.; Wang, C.; Zhang, J.; Chai, M.; He, M.; Chen, D.; and Liao, J. 2023. Avatarcraft: Transforming text into neural human avatars with parameterized shape and pose control. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, 14371–14382.
- Kerbl, B.; Kopanas, G.; Leimkühler, T.; and Drettakis, G. 2023. 3D Gaussian splatting for real-time radiance field rendering. *ACM Trans. Graph.*, 42(4): 139–1.
- Kirstain, Y.; Polyak, A.; Singer, U.; Matiana, S.; Penna, J.; and Levy, O. 2023. Pick-a-pic: An open dataset of user preferences for text-to-image generation. *Advances in neural information processing systems*, 36: 36652–36663.
- Kolotouros, N.; Alldieck, T.; Corona, E.; Bazavan, E. G.; and Sminchisescu, C. 2024. Instant 3d human avatar generation using image diffusion models. In *European Conference on Computer Vision*, 177–195. Springer.
- Kolotouros, N.; Alldieck, T.; Zanfir, A.; Bazavan, E.; Fieraru, M.; and Sminchisescu, C. 2023. Dreamhuman: Animatable 3d avatars from text. *Advances in neural information processing systems*, 36: 10516–10529.
- Li, Z.; Chen, Y.; Zhao, L.; and Liu, P. 2024. Controllable text-to-3D generation via surface-aligned Gaussian splatting. *arXiv preprint arXiv:2403.09981*.
- Liao, T.; Yi, H.; Xiu, Y.; Tang, J.; Huang, Y.; Thies, J.; and Black, M. J. 2024. Tada! text to animatable digital avatars. In *2024 International Conference on 3D Vision (3DV)*, 1508–1519. IEEE.

- Lindenberger, P.; Sarlin, P.-E.; and Pollefeys, M. 2023. Lightglue: Local feature matching at light speed. In *Proceedings of the IEEE/CVF international conference on computer vision*, 17627–17638.
- Liu, F.-L.; Fu, H.; Lai, Y.-K.; and Gao, L. 2024a. Sketch-dream: Sketch-based text-to-3d generation and editing. *ACM Transactions on Graphics (TOG)*, 43(4): 1–13.
- Liu, M.; Shi, R.; Chen, L.; Zhang, Z.; Xu, C.; Wei, X.; Chen, H.; Zeng, C.; Gu, J.; and Su, H. 2024b. One-2-3-45++: Fast single image to 3d objects with consistent multi-view generation and 3d diffusion. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 10072–10083.
- Luo, Z.; Cui, Z.; Luo, S.; Chu, M.; and Li, M. 2025. VR-Doh: Hands-on 3D Modeling in Virtual Reality. *ACM Transactions on Graphics (TOG)*, 44(4): 1–12.
- Melas-Kyriazi, L.; Laina, I.; Rupprecht, C.; Neverova, N.; Vedaldi, A.; Gafni, O.; and Kokkinos, F. 2024. Im-3d: Iterative multiview diffusion and reconstruction for high-quality 3d generation. *arXiv preprint arXiv:2402.08682*.
- Men, Y.; Lei, B.; Yao, Y.; Cui, M.; Lian, Z.; and Xie, X. 2024. En3d: An enhanced generative model for sculpting 3d humans from 2d synthetic data. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 9981–9991.
- Mikaeili, A.; Perel, O.; Safaee, M.; Cohen-Or, D.; and Mahdavi-Amiri, A. 2023. Sked: Sketch-guided text-based 3d editing. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, 14607–14619.
- Pan, P.; Su, Z.; Lin, C.; Fan, Z.; Zhang, Y.; Li, Z.; Shen, T.; Mu, Y.; and Liu, Y. 2024. HumanSplat: Generalizable Single-Image Human Gaussian Splatting with Structure Priors. In *Advances in Neural Information Processing Systems (NeurIPS)*.
- Peng, H.-Y.; Zhang, J.-P.; Guo, M.-H.; Cao, Y.-P.; and Hu, S.-M. 2024. Charactergen: Efficient 3d character generation from single images with multi-view pose canonicalization. *ACM Transactions on Graphics (TOG)*, 43(4): 1–13.
- Qu, Y.; Chen, D.; Li, X.; Li, X.; Zhang, S.; Cao, L.; and Ji, R. 2025. Drag your gaussian: Effective drag-based editing with score distillation for 3d gaussian splatting. In *Proceedings of the Special Interest Group on Computer Graphics and Interactive Techniques Conference Papers*, 1–12.
- Ren, J.; He, C.; Liu, L.; Chen, J.; Wang, Y.; Song, Y.; Li, J.; Xue, T.; Hu, S.; Chen, T.; et al. 2023. Make-a-character: High quality text-to-3d character generation within minutes. *arXiv preprint arXiv:2312.15430*.
- Shao, Z.; Wang, Z.; Li, Z.; Wang, D.; Lin, X.; Zhang, Y.; Fan, M.; and Wang, Z. 2024. Splattingavatar: Realistic real-time human avatars with mesh-embedded gaussian splatting. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 1606–1616.
- Tang, J.; Chen, Z.; Chen, X.; Wang, T.; Zeng, G.; and Liu, Z. 2024. Lgm: Large multi-view gaussian model for high-resolution 3d content creation. In *European Conference on Computer Vision*, 1–18. Springer.
- VRoid. 2022. VRoid Hub.
- Wang, Y.; Yi, X.; Wu, Z.; Zhao, N.; Chen, L.; and Zhang, H. 2024. View-consistent 3d editing with gaussian splatting. In *European conference on computer vision*, 404–420. Springer.
- Xue, Y.; Xie, X.; Marin, R.; and Pons-Moll, G. 2024. Human-3Diffusion: Realistic Avatar Creation via Explicit 3D Consistent Diffusion Models. *Advances in Neural Information Processing Systems*, 37: 99601–99645.
- Yuan, Y.; Li, X.; Huang, Y.; De Mello, S.; Nagano, K.; Kautz, J.; and Iqbal, U. 2024. Gavatar: Animatable 3d gaussian avatars with implicit mesh learning. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 896–905.
- Zang, Y.; Han, Y.; Ding, C.; Zhang, J.; and Chen, T. 2024. Magic3dskech: Create colorful 3d models from sketch-based 3d modeling guided by text and language-image pre-training. *arXiv preprint arXiv:2407.19225*.
- Zhang, H.; Chen, B.; Yang, H.; Qu, L.; Wang, X.; Chen, L.; Long, C.; Zhu, F.; Du, D.; and Zheng, M. 2024a. Avatarverse: High-quality & stable 3d avatar creation from text and pose. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 38, 7124–7132.
- Zhang, J.; Li, X.; Zhang, Q.; Cao, Y.; Shan, Y.; and Liao, J. 2024b. Humanref: Single image to 3d human generation via reference-guided diffusion. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 1844–1854.
- Zhang, M.; Feng, Q.; Su, Z.; Wen, C.; Xue, Z.; and Li, K. 2024c. Joint2Human: High-quality 3D Human Generation via Compact Spherical Embedding of 3D Joints. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*.
- Zhou, M.; Hyder, R.; Xuan, Z.; and Qi, G. 2024. Ultravatar: A realistic animatable 3d avatar diffusion model with authenticity guided textures. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 1238–1248.
- Zhuang, J.; Kang, D.; Bao, L.; Lin, L.; and Li, G. 2025. Dagsm: Disentangled avatar generation with gs-enhanced mesh. In *Proceedings of the Computer Vision and Pattern Recognition Conference*, 292–303.
- Zhuang, J.; Kang, D.; Cao, Y.-P.; Li, G.; Lin, L.; and Shan, Y. 2024. Tip-editor: An accurate 3d editor following both text-prompts and image-prompts. *ACM Transactions on Graphics (TOG)*, 43(4): 1–12.
- Zhuang, J.; Wang, C.; Lin, L.; Liu, L.; and Li, G. 2023. Dreameditor: Text-driven 3d scene editing with neural fields. In *SIGGRAPH Asia 2023 Conference Papers*, 1–10.
- Zou, Z.-X.; Yu, Z.; Guo, Y.-C.; Li, Y.; Liang, D.; Cao, Y.-P.; and Zhang, S.-H. 2024. Triplane meets gaussian splatting: Fast and generalizable single-view 3d reconstruction with transformers. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 10324–10335.