MagicCity: Geometry-Aware 3D City Generation from Satellite Imagery with Multi-View Consistency

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1.Introduction of our work

Task: Generate 3D urban scene on a given satellite image.

Why important: Games, urban simulation, and mapping services; transform real-world into digital twins.

2. How does previous work do?

(1) Geometry Prior-based Methods:

- InfiniCity
- CityDreamer
- GaussianCity

❌ *Lack style diversity and texture quality*

(2) Image Prior-based Methods:

- CAT3D
- DimensionX
- DreamScene

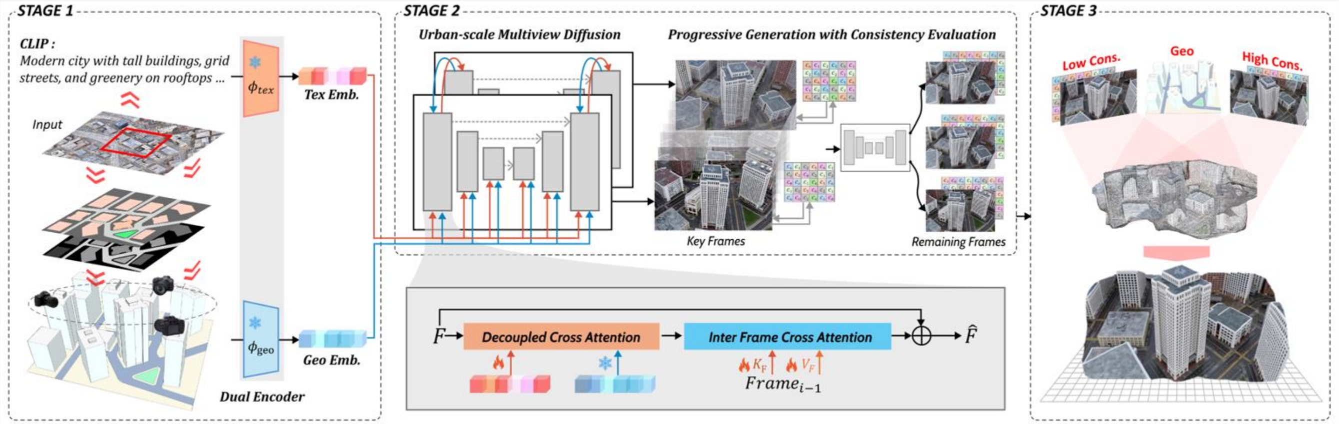
❌ *Lack geo. consistency in large scenes*

Motivation: How to achieve high texture quality while maintain geometric consistency?

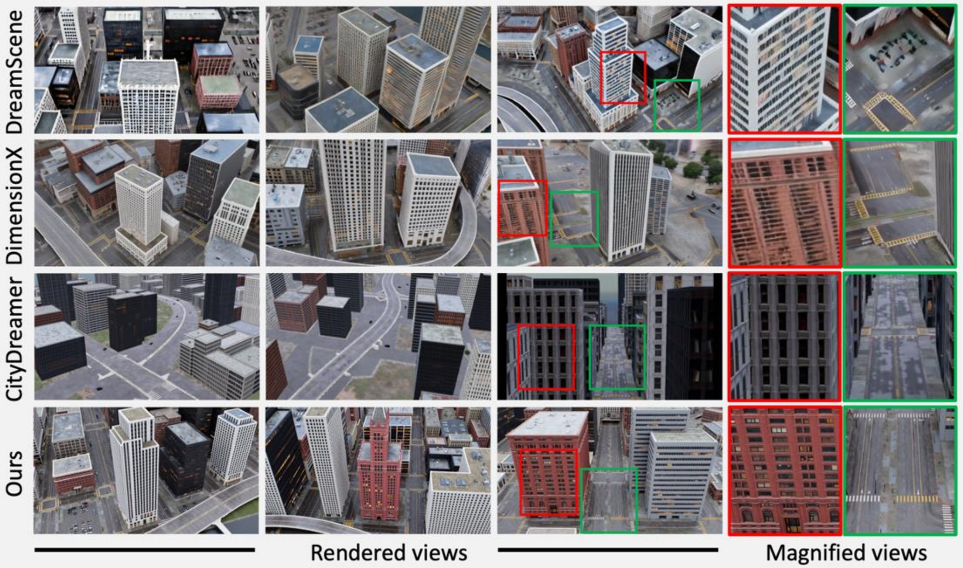
3. Our methods

Pipeline overview: Scene Initialization -> Multiview images Generation -> Robust Reconstruction

Insights: Multiview images gen. with *city-level consistency* ; Robust 3D reconstruction on *generated images*



4.Experimental Results



Dataset: CityVista, consisting of 500 high-quality city scenes.

Metrics: Texture quality & Geometric consistency.

Qualitative: Our method produces *higher-quality* 3D cities with *better consistency* compared with the baselines.

Quantitative: MagicCity outperforms the baselines *across all metrics.*

	CityDreamer	DimensionX	DreamScene	Ours
FID	155.390	126.890	104.627	**86.096**
KID	0.251	0.175	0.125	**0.087**
NIQE	8.632	6.595	6.018	**4.553**
BRISQUE	86.773	70.207	30.311	**28.018**
DE	0.157	-	0.223	**0.137**
CE	0.083	-	0.371	**0.072**

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5.Applications

Example: Make a city in Blender.

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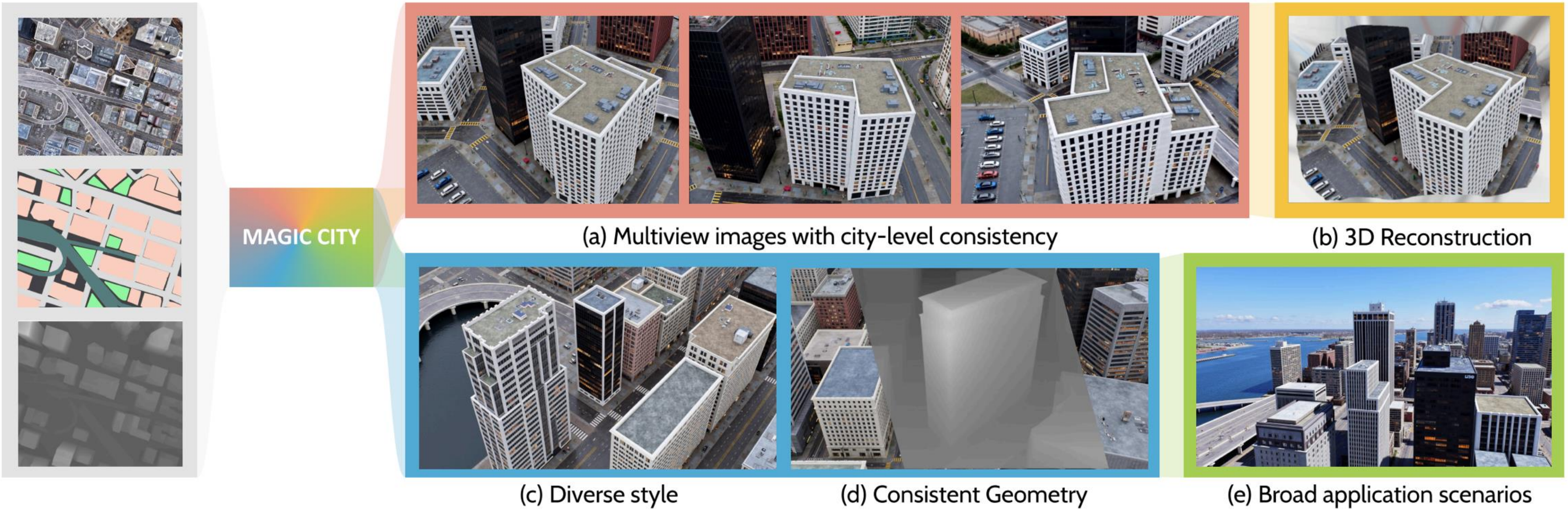
- **Motivation:**
  - Generating 3D cities supports autonomous driving simulations and model training.
  - However, traditional models struggle to generate large scenes with high consistency.
- **Achievements:**
  - Given satellite input, our method generates multi-view images with *city-level consistency*.
  - These images are then fed into a *robust reconstruction* pipeline to generate a 3D city.
  - Our approach achieves *diverse style* generation while maintaining *geometric consistency* across views.



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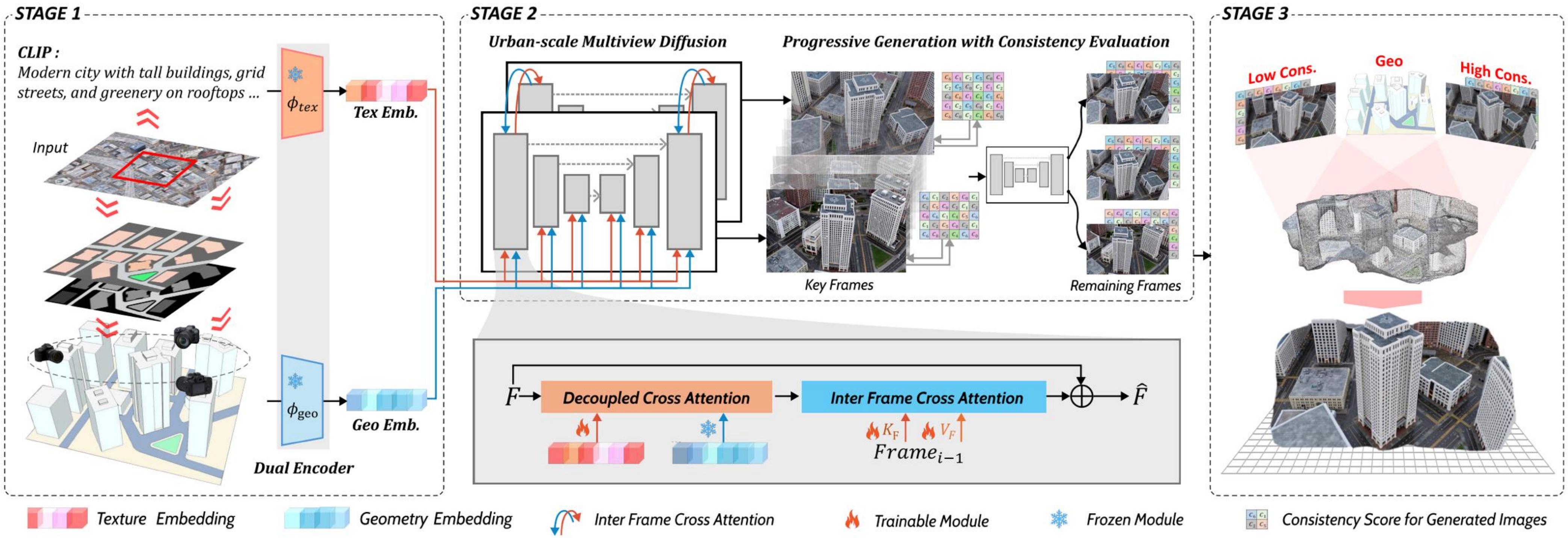
- **Key Contributions :**
  - We introduce **MagicCity**, a novel framework to generate photorealistic 3D cities from satellite imagery while maintaining scene-level geometric consistency.
  - We propose a city-scale multi-view diffusion model that generates 3D-consistent images by incorporating explicit geometric constraints.
  - We develop a robust 3D Gaussian Splatting strategy for synthesizing detailed 3D reconstructions from generated multi-view images.



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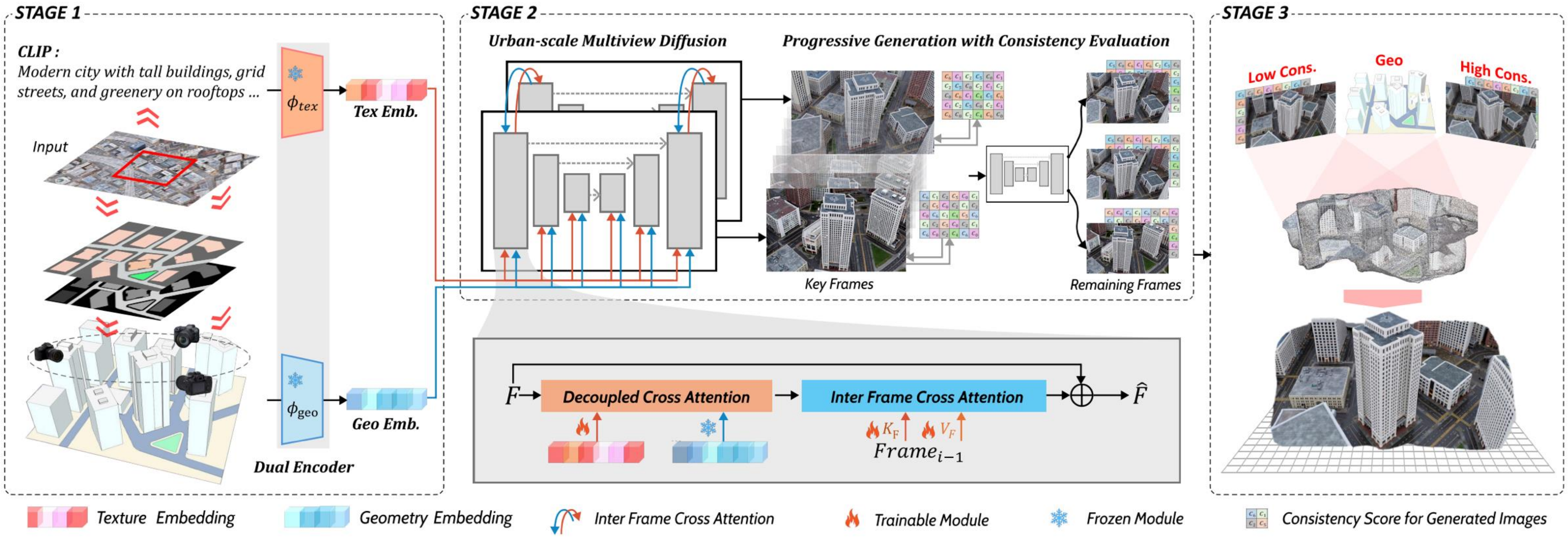
- ***Stage 1. Scene Initialization and Dual Encoding***
  - **Input:** Satellite images (x, y, r, g, b)
  - **Scene Initialization：** Segmentation+ Depth maps → 3D volume (x, y, z, r, g, b, s)
  - **Dual Encoder：**
    - **Texture**: CLIP → semantic tokens → texture features (f_{tex})
    - **Geometry**: 3D volume → multi-view renders → geometric features (f_{geo}^{i})



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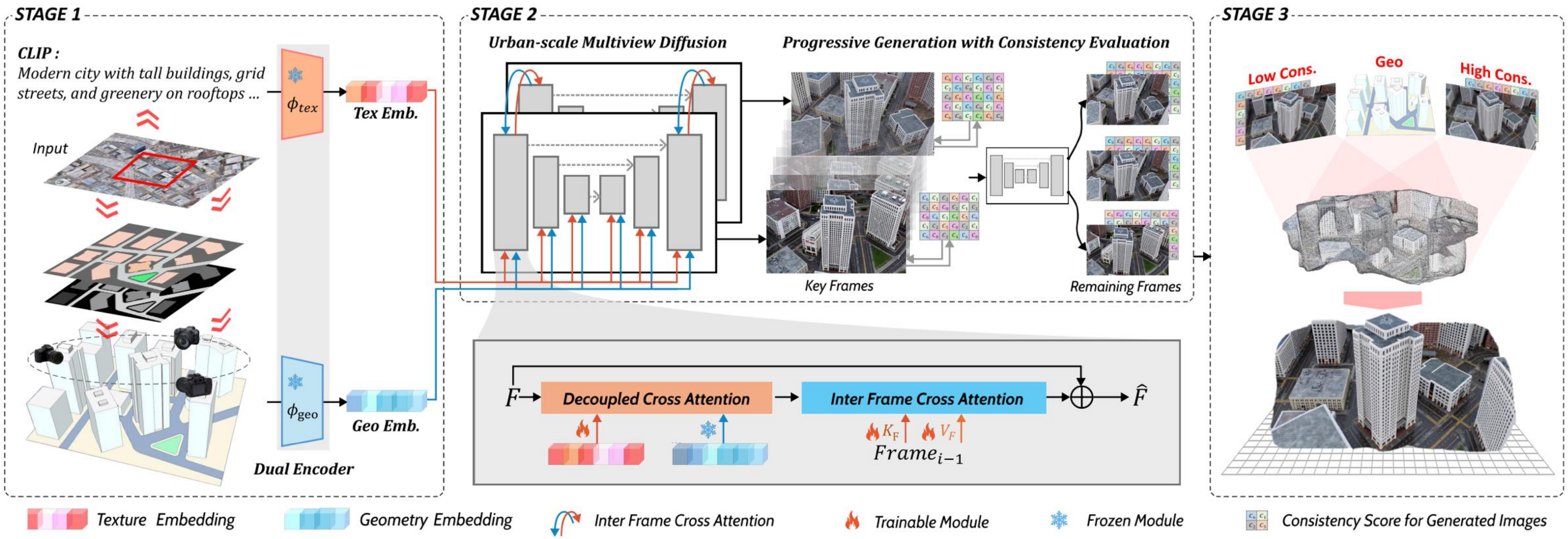
- ***Stage 2. City-scale Multi-view Generation with Consistency Evaluation***
  - **Goal**：Generate multi-view images with city-level consistency
  - (1) Dual Embedding Injection: $\tilde{F}_i = F_i + \mathcal{A}(F_i, f_{tex}) + \mathcal{A}(F_i, f^i_{geo})$
  - (2) Inter-Frame Cross-Attention: $M_i = \sum_{l \neq i} \mathrm{softmax}(W_q\tilde{F}_i \cdot W_k\tilde{F}_r^T) \cdot W_v\tilde{F}_r$
  - (3) Consistency Evaluation: $C^k_i = \frac{1}{|V_i|} \sum_{j \in V_i} \cos(f^k_i, f^j_i)$



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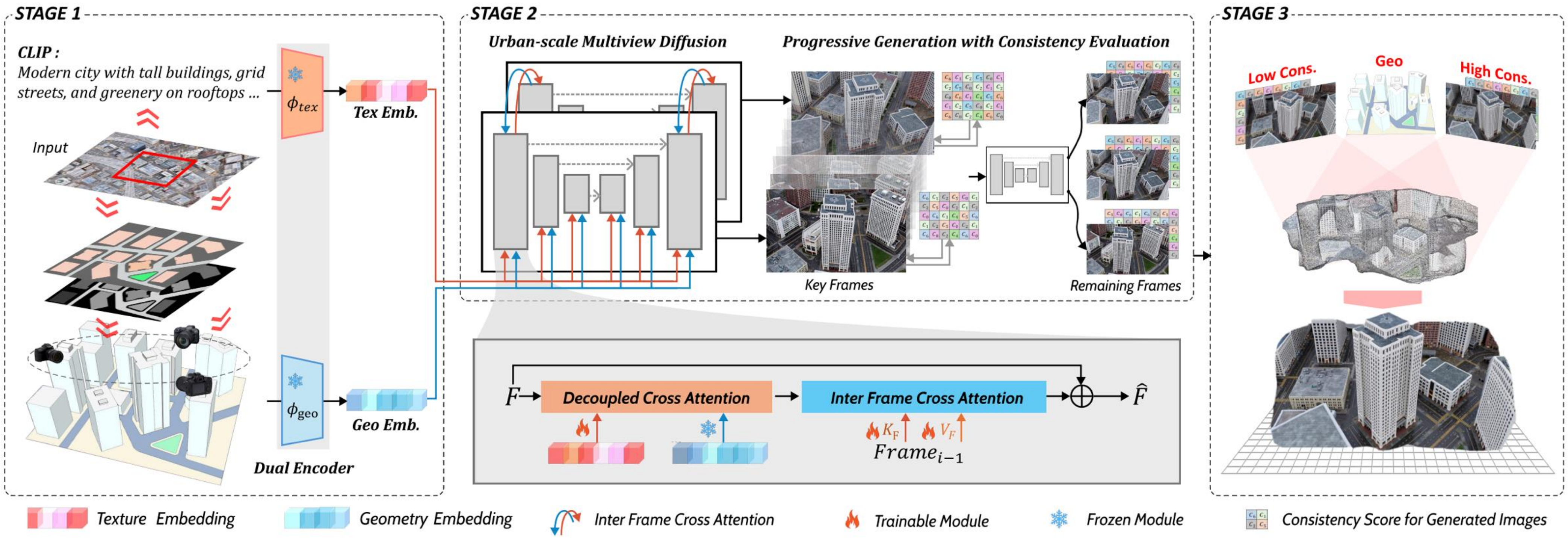
- ***Stage 3. Consistency Score-guided 3D Reconstruction***
  - Challenge: Even SOTA video generation models lack pixel-level consistency → poor 3DGS
  - Reconstruct 3D cities guided by consistency scores
  - Prioritize colors from high-confidence pixels or images
  - Point Cloud Initialization: $c_p = \frac{\sum_k (C_i^k \cdot c_k)}{\sum_k C_i^k}$ Optimization: $L_p = L_{\text{render}}^p \cdot C_p$



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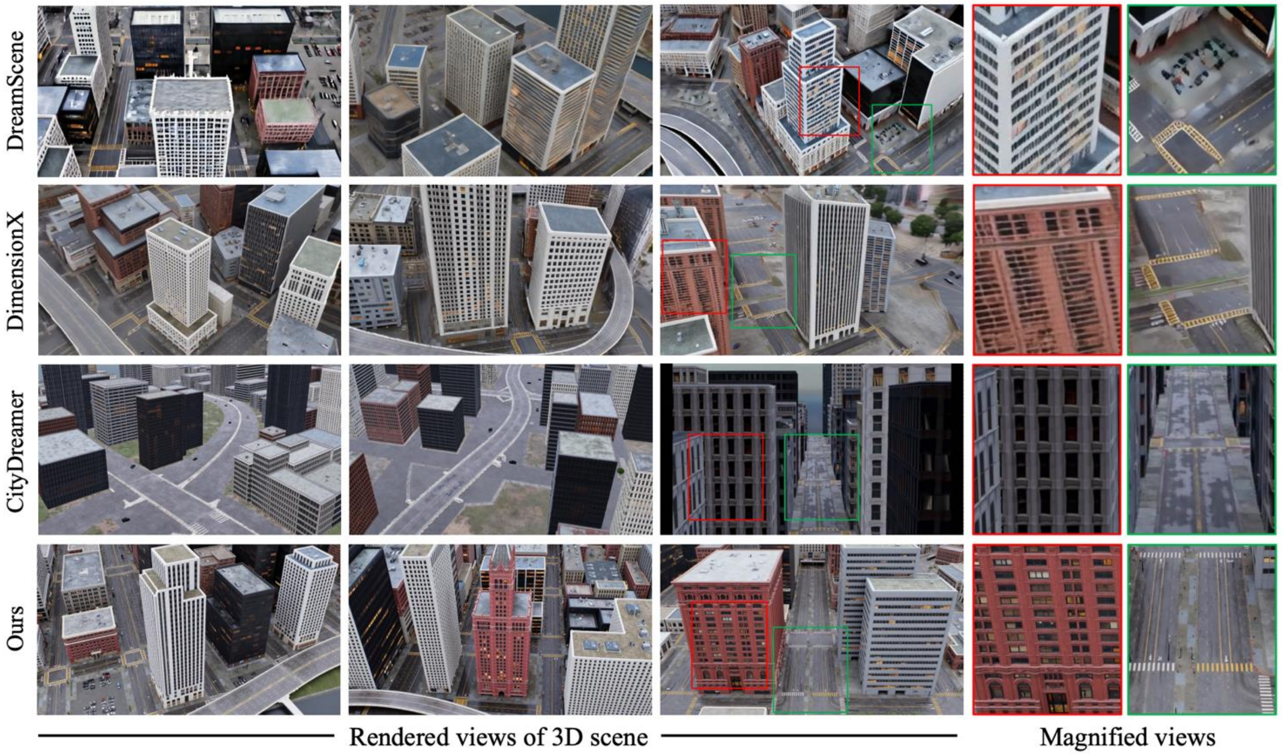
Results：

1. Qualitative Comparison

- Superior structure preservation compared to competitors；
- More realistic textures for buildings and ground details；
- Rich variety without synthetic artifacts；

2. Quantitative Evaluation

- Distribution Metrics: Lowest FID (86.096) and KID (0.087)
- Perceptual Quality: Best NIQE (4.553) and BRISQUE (28.018)
- Geometric Accuracy: Lowest Depth Error (0.137) and Camera Error (0.072)



Method	FID ↓	KID ↓	NIQE ↓	BRISQUE ↓	DE ↓	CE ↓
CityDreamer [38]	155.390	$0.251^{\pm 0.012}$	$8.632^{\pm 0.709}$	$86.773^{\pm 11.492}$	0.157	0.083
DimensionX [35]	126.890	$0.175^{\pm 0.006}$	$6.595^{\pm 0.425}$	$70.207^{\pm 7.157}$	-	-
DreamScene [17]	104.627	$0.125^{\pm 0.002}$	$6.018^{\pm 0.671}$	$30.311^{\pm 11.732}$	0.223	0.371
Ours	**86.096**	$\mathbf{0.087}^{\pm 0.001}$	$\mathbf{4.553}^{\pm 0.412}$	$\mathbf{28.018}^{\pm 5.634}$	**0.137**	**0.072**