CAP: An Advanced No-Reference Quality Assessment Method for AI-Generated 3D Meshes

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Introduction

- AIGC has shown outstanding performance in many fields.
- But the quality of 3D AIGC is difficult to meet people's needs.

Fig.1. “The Dog and The Boy”: An animated film co-produced by AI

- the relatively early stage of development in 3D generation technology.
- the absence of standardized evaluation criteria

Fig.2. Differences in time cost and quality between 3D PGCs and AIGCs.

3DGCQA: A Quality Assessment Database for 3D AI-Generated Contents

3DGCQA Database

Visualization and Distortions

- The selected generation methods are generally effective in producing the required 3DGCs
- Six common distortions are summarized.

Fig.1. Overview of 3DGCs in the 3DGCQA database and corresponding category labels.

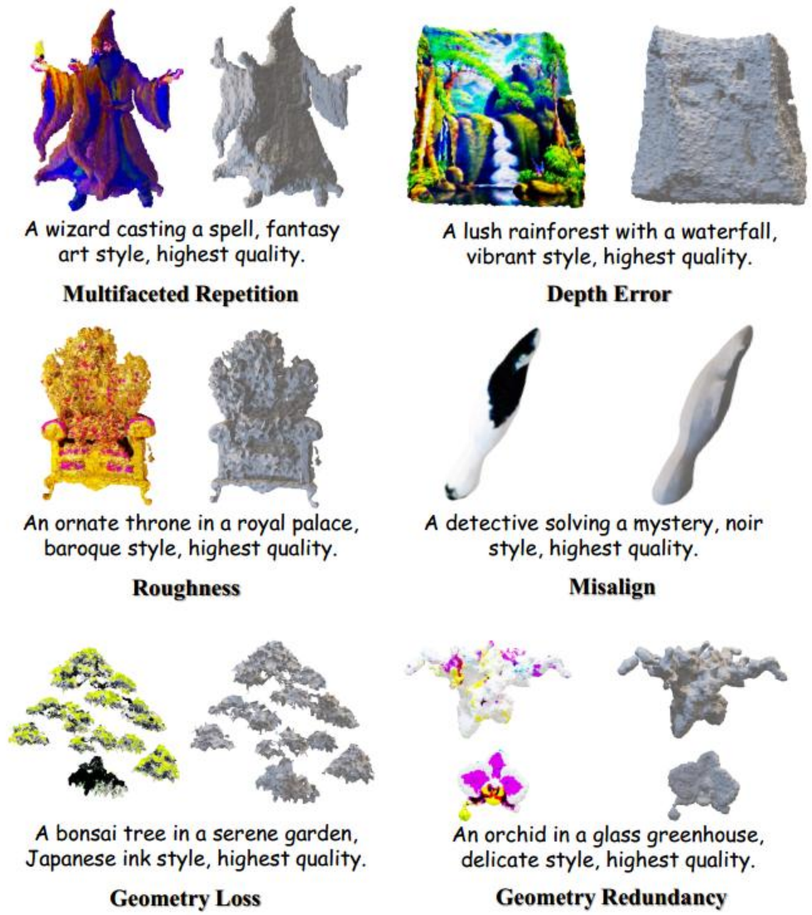
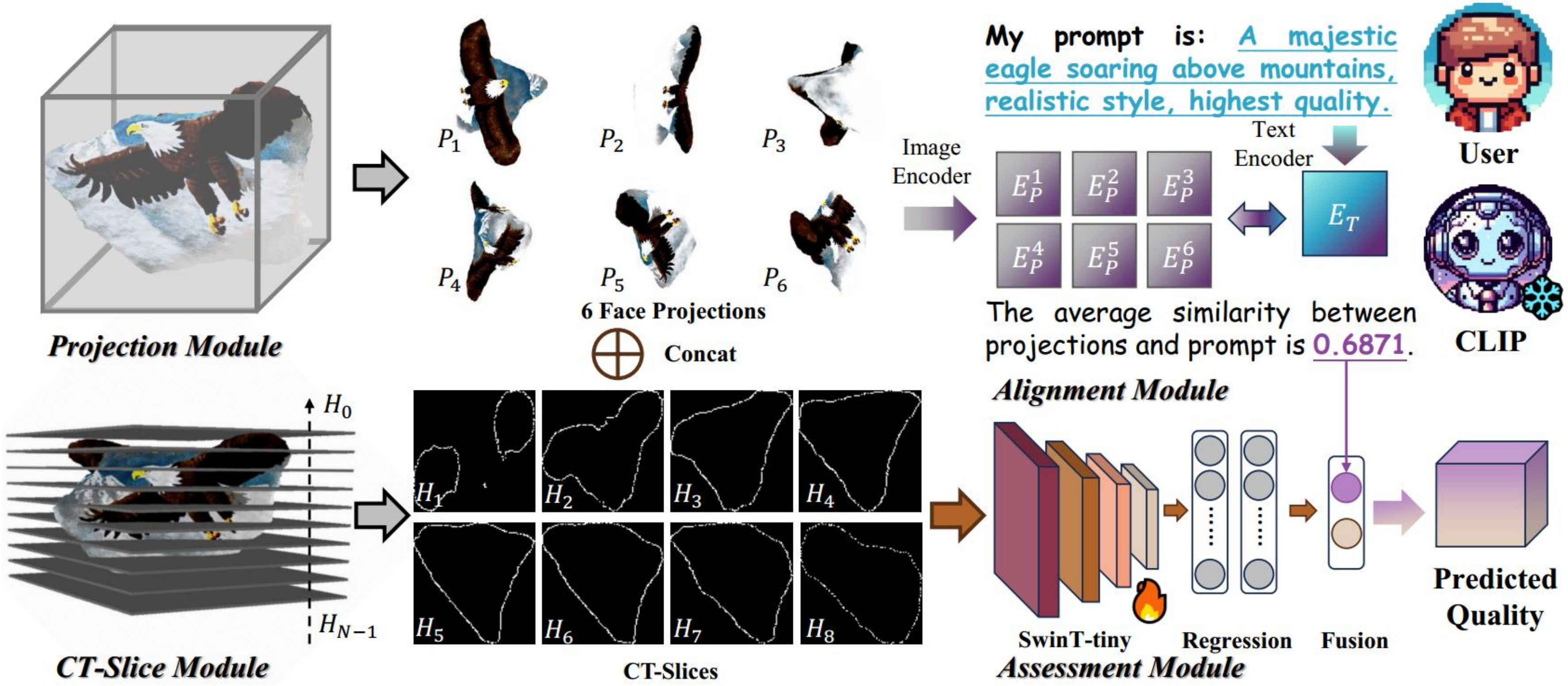


Fig.2. Illustration of common distortions occurred in 3DGCs

CAP: An No-Reference QA for 3DAIGC Meshes



The CAP framework comprises four distinct modules. The Projection Module, CT-Slice Module, and Alignment Module are designed to assess distinct aspects of GM quality, focusing on external quality information, internal structural features, and prompt alignment, respectively. The Assessment Module integrates these insights by performing feature extraction, regression, and fusion to produce the final predicted quality score of the GM.

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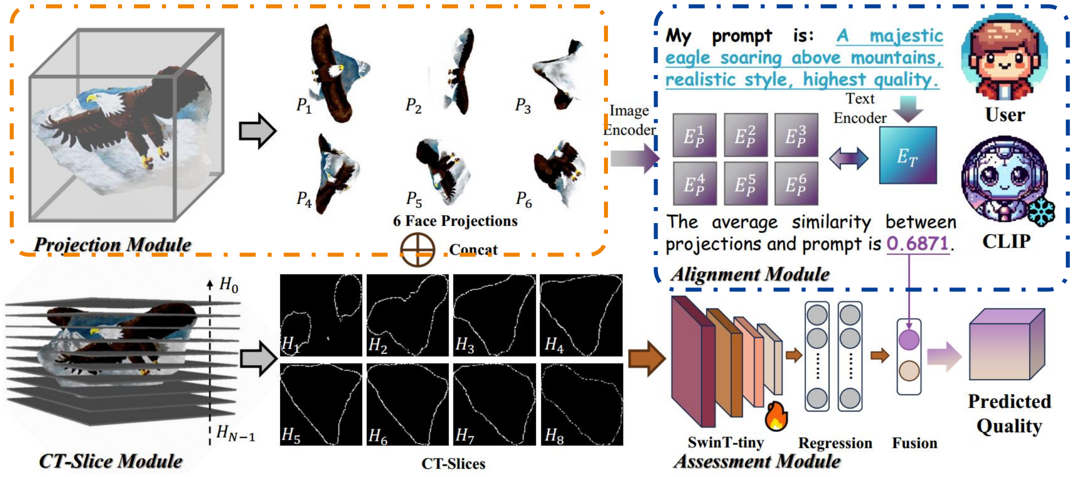
Projection Module

- Projection is a common preprocessing technique in 3DQA, enabling the transformation of complex 3D models into 2D images using virtual cameras.
- This approach effectively reduces dimensionality and computational overhead.
- Given the visually complex distortions often present in GMs, the six-face projection employed in CAP provides a more comprehensive visualization of a GM's external features.



Alignment Module

- Computes the similarity between the six-face projection embedding and the prompt embedding using CLIP

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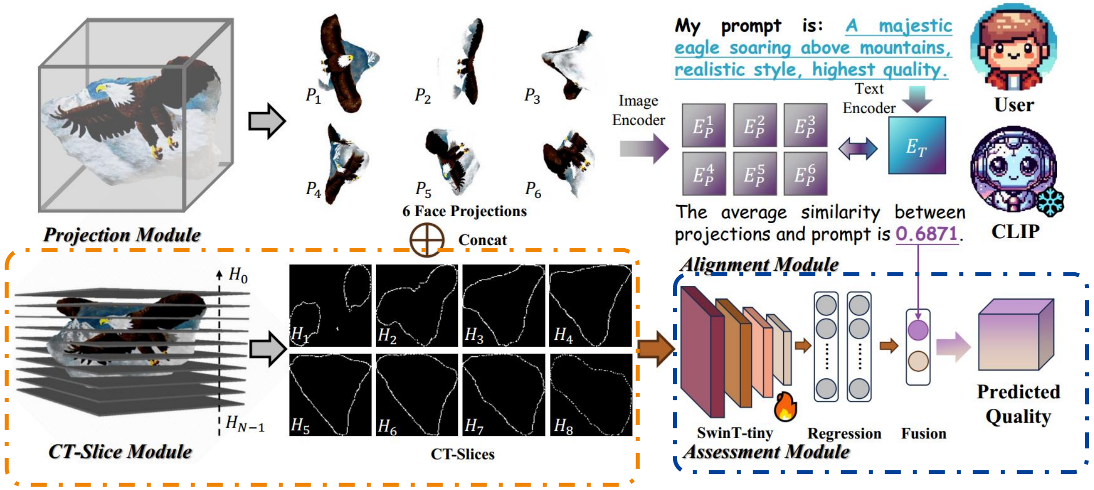
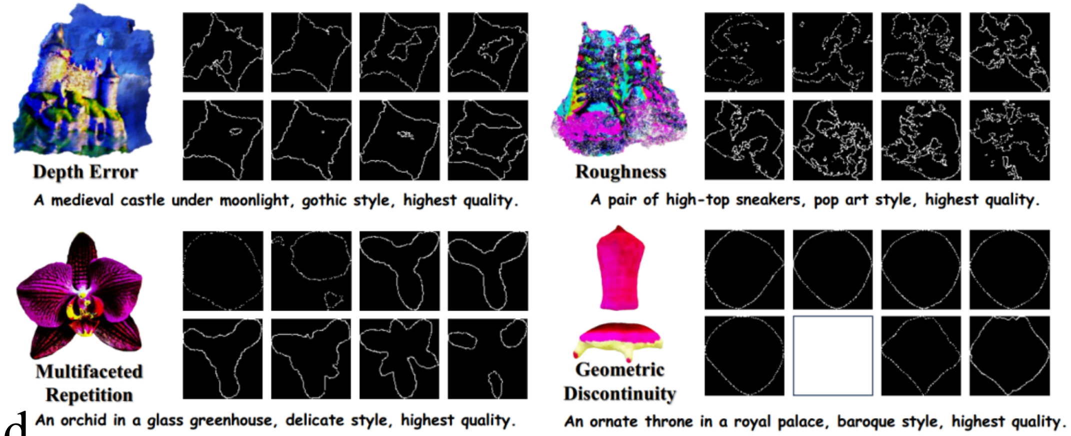
CT-Slice Module

- To address this potential for deceptive visualizations, it is crucial to perform CT slicing on the GM to capture its internal structural information.
- First identify the highest and lowest vertices and compute the height H and the slicing interval I of the GM.
- Keep all but the highest and lowest slices because they pass through only a few vertices

Assessment Module

- Employ Swin-T tiny for further feature extraction.
- Two fully connected layers are used as quality regressors to predict the quality of the GM.
- Using an additional FC layer to weigh the average and the predicted quality from the FC layers before.





Performance

Analysis

- The proposed CAP method achieves state-of-the-art (SOTA) performance, outperforming all other methods with a substantial margin (+5% SRCC).
- Methods relying on manually extracted features generally perform poorly, indicating that quality assessment algorithms designed for natural scene images (NSIs) are unsuitable for generative content. This disparity arises from the significant differences in prior distributions between generative content and NSIs.
- While existing deep learning based methods exhibit better performance, their primary limitation is the exclusive focus on external visual information of GMs.

TABLE I
PERFORMANCE COMPARISON OF DIFFERENT METHODS ON 3DGCQA DATABASE. BEST IN **RED**, SECOND IN **BLUE**.

Type	Method	SRCC↑	PLCC↑	KRCC↑	RMSE↓
Hand-crafted Based	BRISQUE [39]	0.2091	0.3347	0.1444	0.7414
	CPBD [40]	0.2099	0.4797	0.1335	0.7217
	IL-NIQE [41]	0.1481	0.1573	0.1131	0.6600
	NFERM [42]	0.2797	0.4062	0.1999	0.7222
	NFSDM [43]	0.3189	0.4468	0.2235	0.6935
	NIQE [44]	0.2079	0.2594	0.1413	0.8050
Deep-learning Based	DBCNN [35]	0.5381	0.5147	0.3946	0.4700
	StairIQA [36]	0.3813	0.4566	0.2653	0.5802
	ViT-MQA [14]	0.3517	0.3724	0.2609	0.8780
	Dual-PCQA [15]	**0.6583**	**0.6578**	**0.4718**	**0.4549**
	Q-Align [37]	0.0746	0.0764	0.0498	0.8311
	CAP (Ours)	**0.7098**	**0.7566**	**0.5386**	**0.4245**

Thanks!

Welcome to add my Wechat for further discussion and cooperation!

林夕

广东 深圳