Exploring Geometry-Texture Interactions for Colored Mesh Quality Assessment

Armin Shafiee Sarvestani*, Sheyang Tang*, Zhou Wang

University of Waterloo, Canada
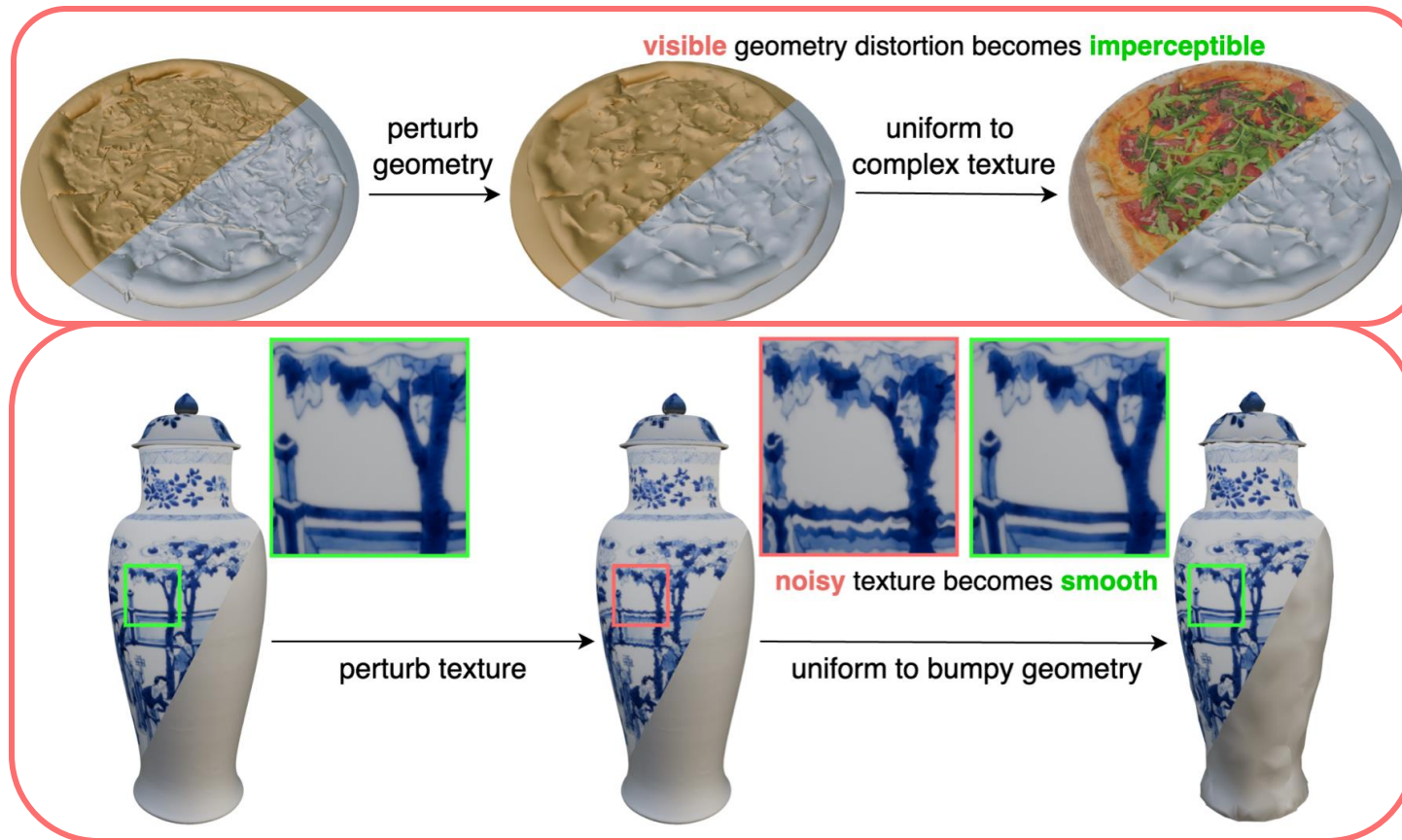

* Equal Contribution

Task:

- Colored meshes are defined by shape (geometry) + color (texture).

- Our task: Evaluate the *visual quality* of a mesh under real-world distortions.

UV mapping + render →

Observation:

- Geometry and Texture *interact* in complex ways that affect mesh's *visual quality*.

visible geometry distortion becomes **imperceptible**

perturb geometry → uniform to complex texture →

noisy texture becomes **smooth**

perturb texture → uniform to bumpy geometry →

Solution:

❌ Existing works ignore such *interactions* and assess either on geometry (model-based) or texture (projection-based)

Pure geometry?
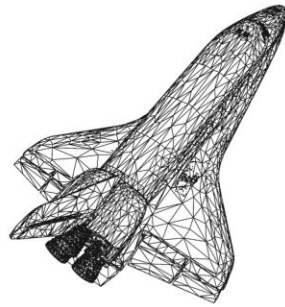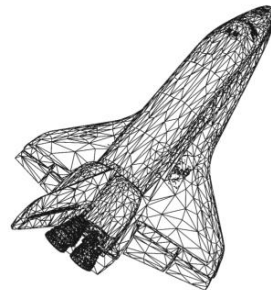
Pure texture?

✅ A *hybrid* method (model- and projection-based) that explores geometry-texture *interactions*
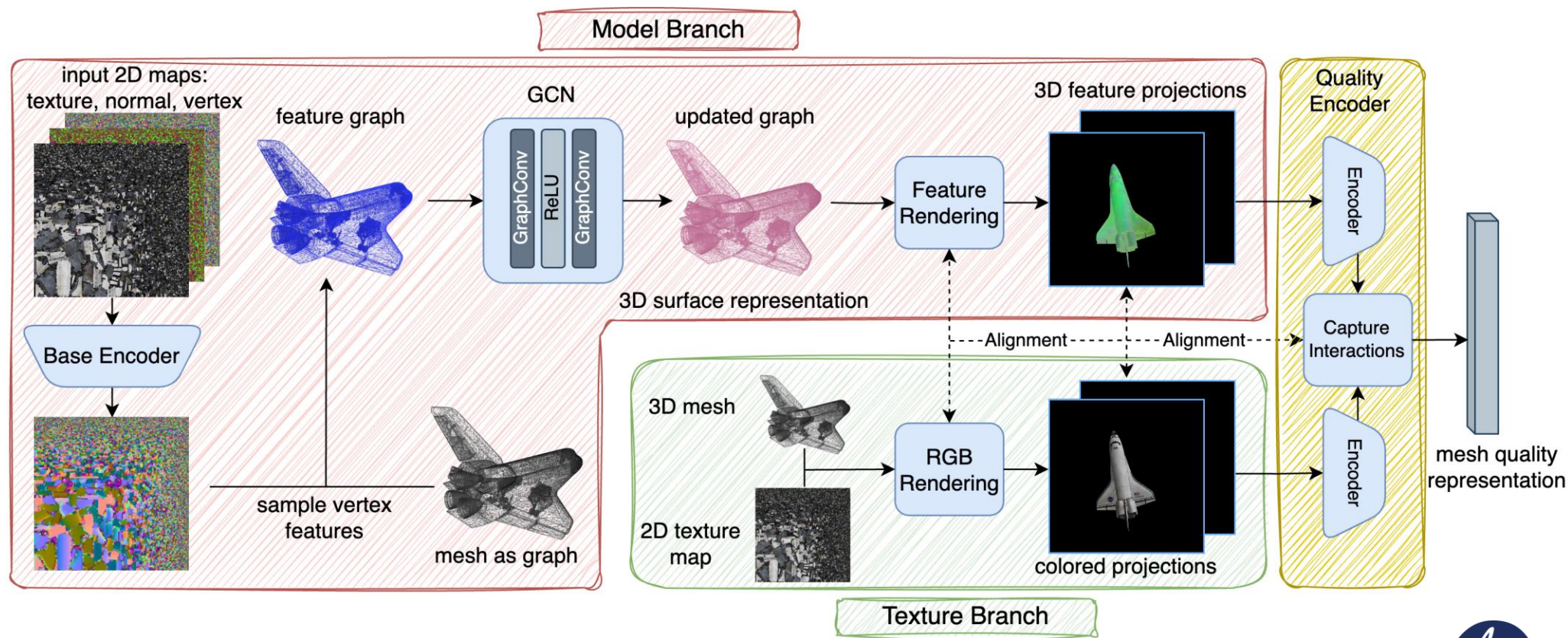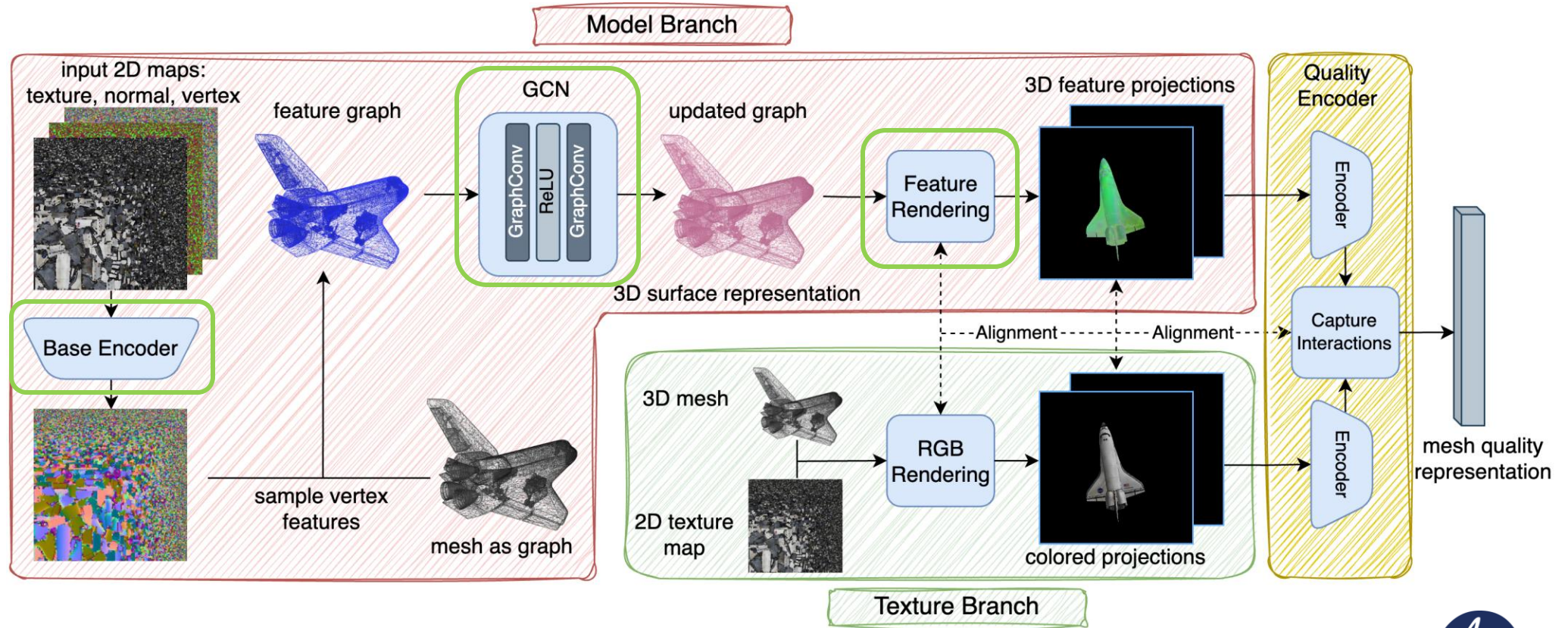
Hybrid!

interaction

HybridMQA Framework:
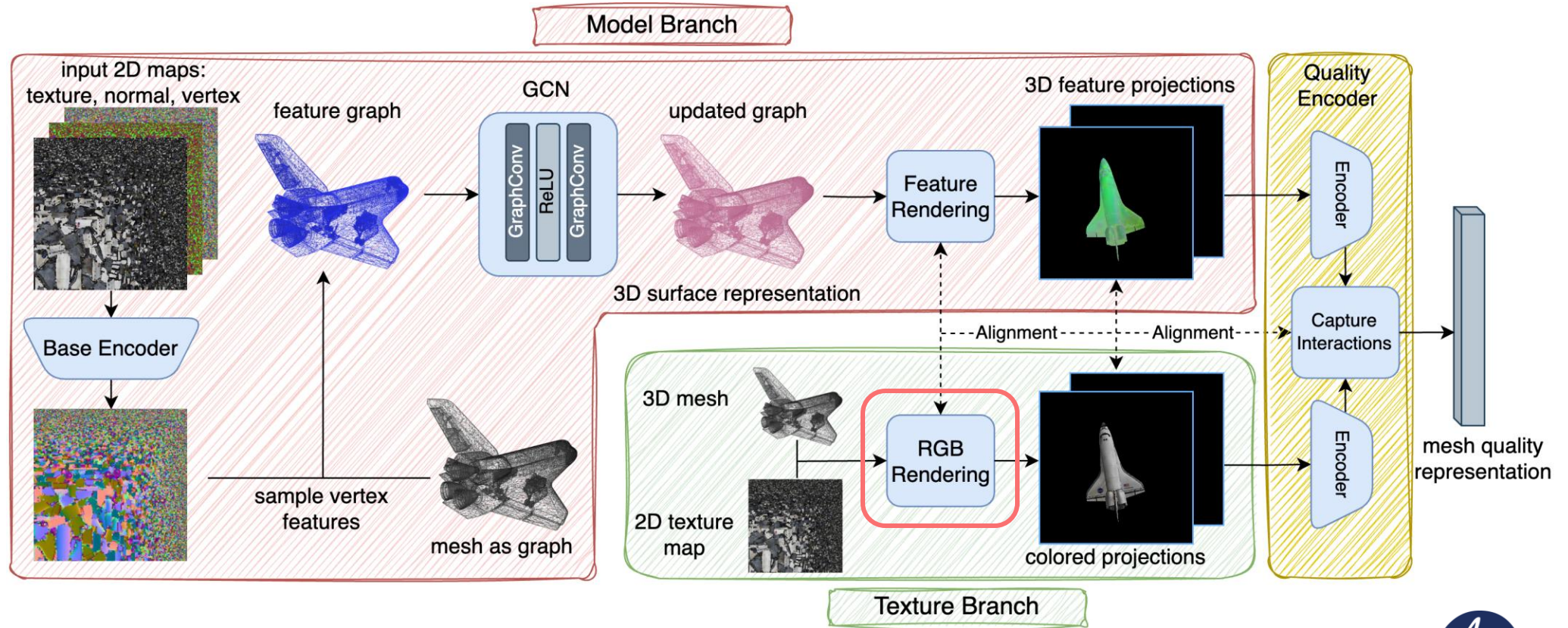
- Model Branch + Texture Branch + Quality Encoder

HybridMQA Framework:

- **Model Branch:** Learn 3D surface representations and render their 2D projections
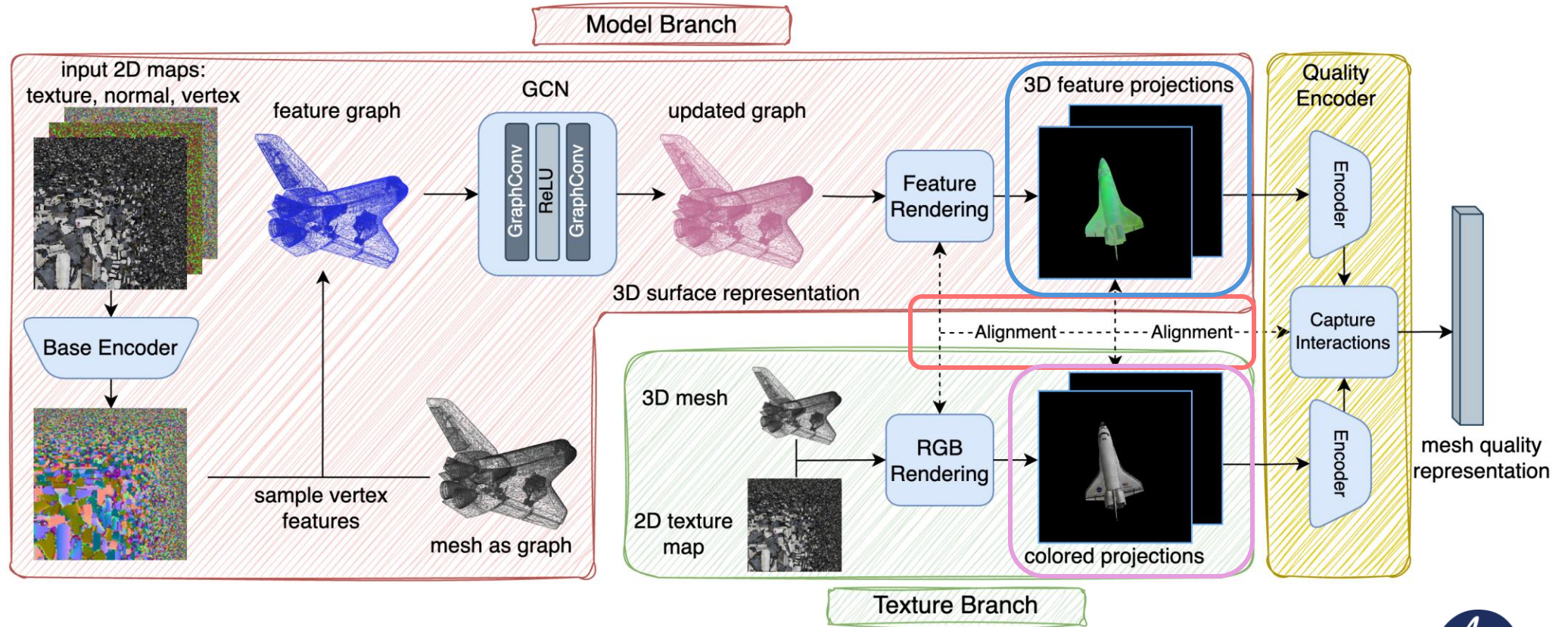
HybridMQA Framework:

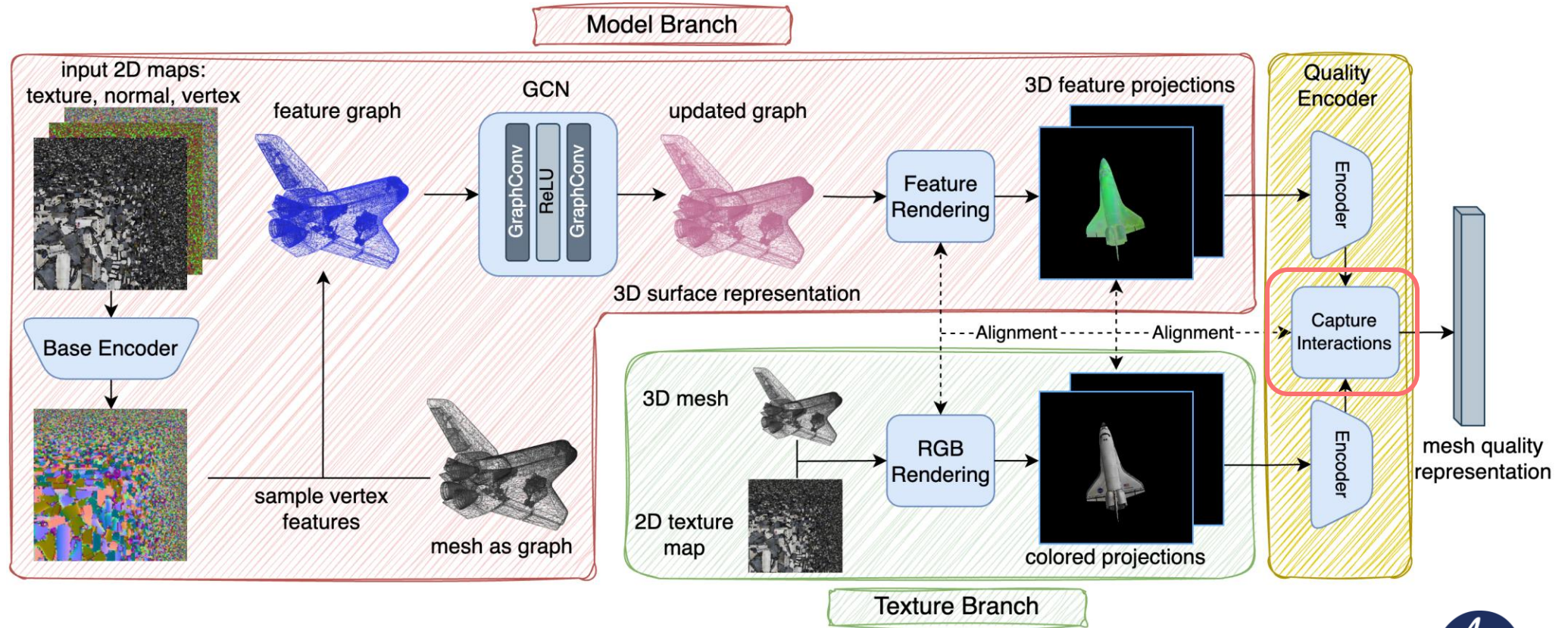- Texture Branch: Render 2D colored projections of the mesh

HybridMQA Framework:

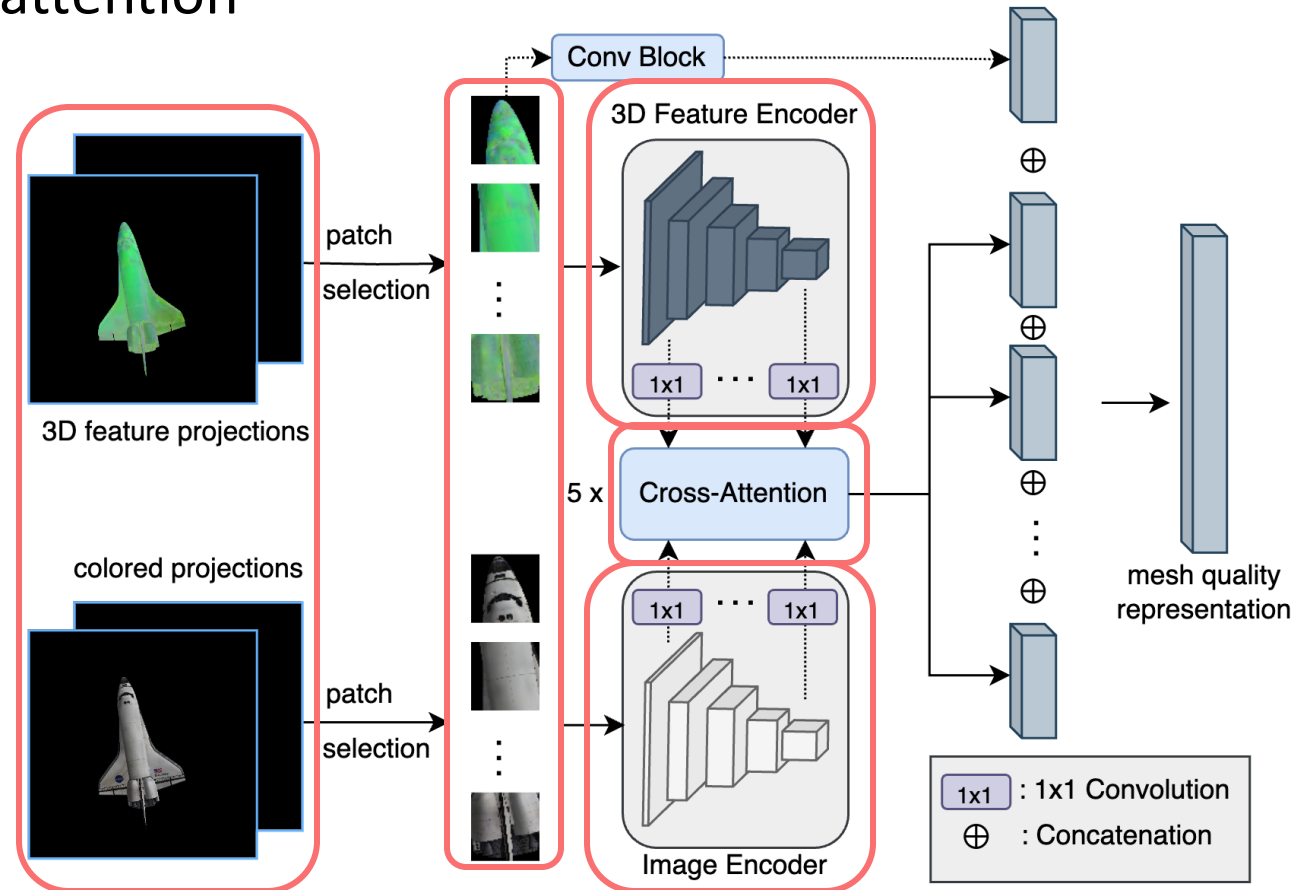- Alignment between geometry and texture repr. for exploring their *interactions*

HybridMQA Framework:

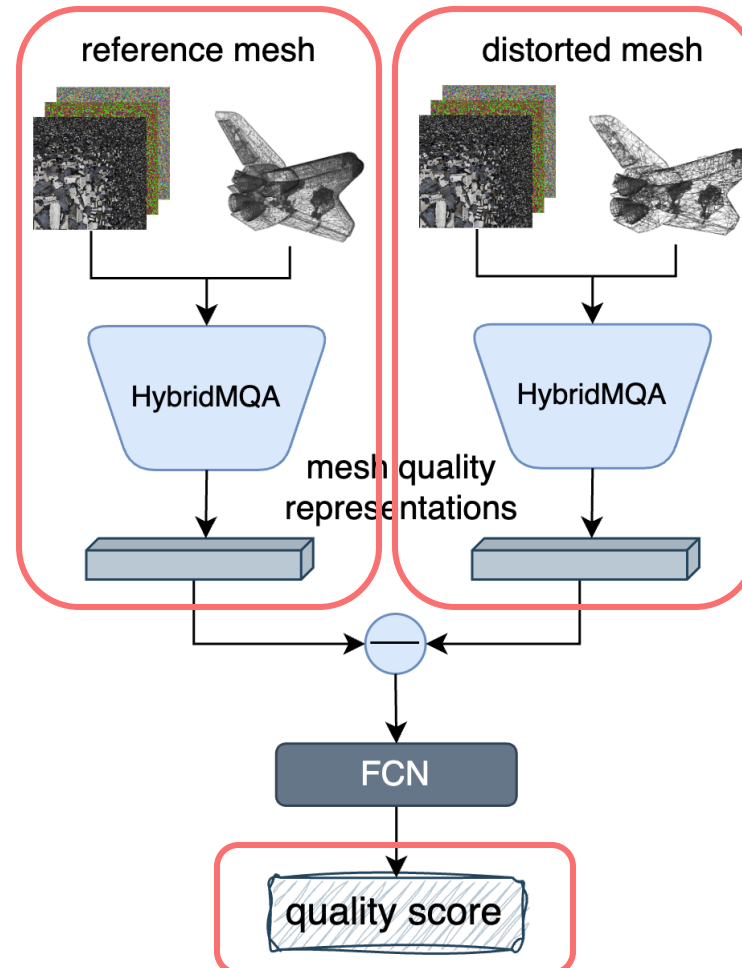- Quality Encoder: Capture *interactions,* and outputs mesh quality representation

HybridMQA Framework:

- **Quality Encoder:** Patchify and encode projections and capture *interactions* through cross-attention

HybridMQA Framework:

- HybridMQA is a full-reference method.

Experiments & Results:

- HybridMQA outperforms all existing works on four public datasets.

Type	Method	Nehmé *et al.* [29]		SJTU-TMQA [7]		TSMD [49]		CMDM [30]	
		SRCC	PLCC	SRCC	PLCC	SRCC	PLCC	SRCC	PLCC
Model-based	HD [4]	0.107	0.175	0.060	0.140	0.446	0.462	0.189	0.210
	MSDM2 [19]	0.335	0.344	0.050	0.120	0.045	0.255	0.415	0.517
	FMPD [44]	0.391	0.404	0.156	0.458	0.077	0.218	0.615	0.623
	GeodesicPSIM [50]	–	–	–	–	0.820	0.820	–	–
	Fu *et al.* [9]	0.688	0.696	–	–	–	–	–	–
Projection-based	PSNR [45]	0.353	0.375	0.299	0.287	0.714	0.711	0.830	0.839
	SSIM [47]	0.210	0.226	0.394	0.289	0.673	0.674	0.852	0.861
	VIF [36]	0.538	0.557	0.450	0.422	<u>0.851</u>	<u>0.846</u>	0.827	0.837
	LPIPS [54]	0.672	0.676	0.718	0.717	0.710	0.712	<u>0.865</u>	0.918
	Graphics-LPIPS [29]	0.722	0.746	0.790	0.762	0.834	0.812	0.859	<u>0.925</u>
	3D-PSSIM [20]	<u>0.882</u>	<u>0.842</u>	<u>0.842</u>	<u>0.832</u>	–	–	0.855	0.854
Hybrid	**HybridMQA**	**0.892**	**0.897**	**0.887**	**0.896**	**0.912**	**0.919**	**0.897**	**0.927**

Experiments & Results:

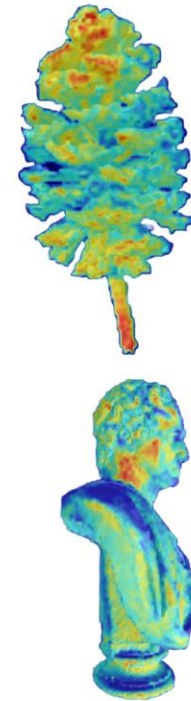- HybridMQA understands 3D geometry and attends to regions with geometric distortions.
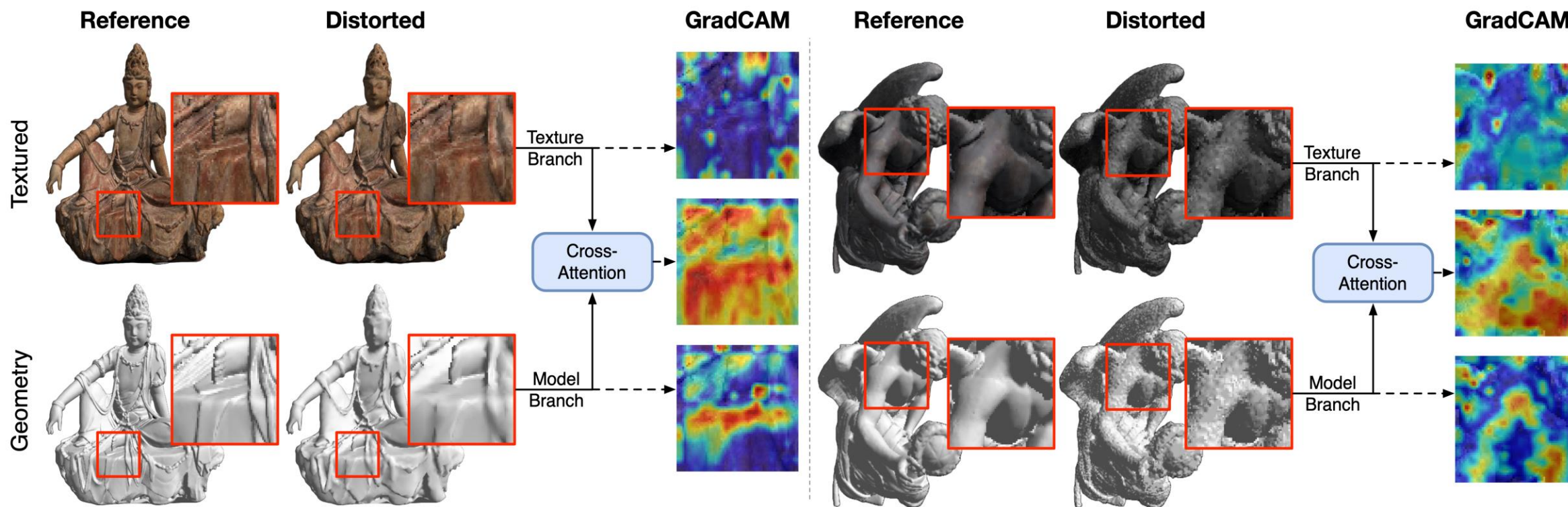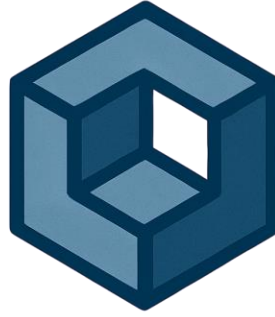
Experiments & Results:

- Cross-attention attends to perceptually important regions through geometry-texture interactions.

HybridMQA

Check out our webpage for more results, poster, code, and pre-trained checkpoints

arshafiee.github.io/hybridmqa