Assessing Learned Models for Phase-only Hologram Compression

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Problem

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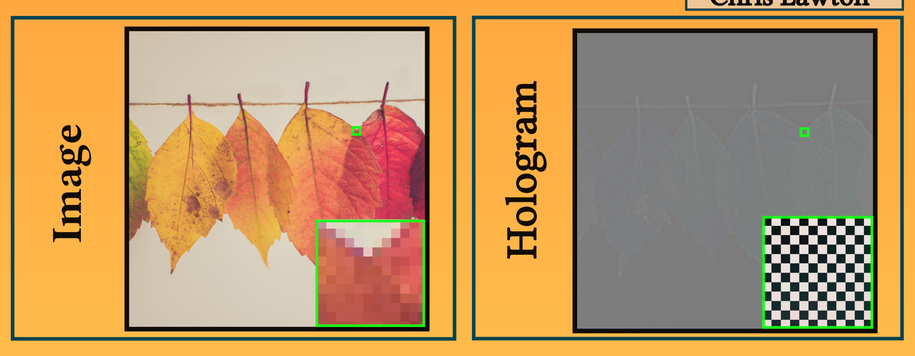
Unlike natural images, holograms contain **high-frequency content**, which presents unique challenges for **compression and reconstruction**, leading to degraded image quality.

Sample source: Chris Lawton



Aims

2

Whether learned models can **effectively compress phase-only holograms** and contribute to improved storage and transmission efficiency.

Related Work

3

Vanilla MLP

Foundational INR to image compression.

SIREN

Effective tool to represent complex natural signals and their derivatives.

FilmSIREN

Conditioned SIREN to accelerate training and mitigate computational complexity.

TAESD

A tiny distilled version of Stable Diffusion's VAE , turns full-size images into latent and the decoder then generates new full-size images.

References

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Method

4

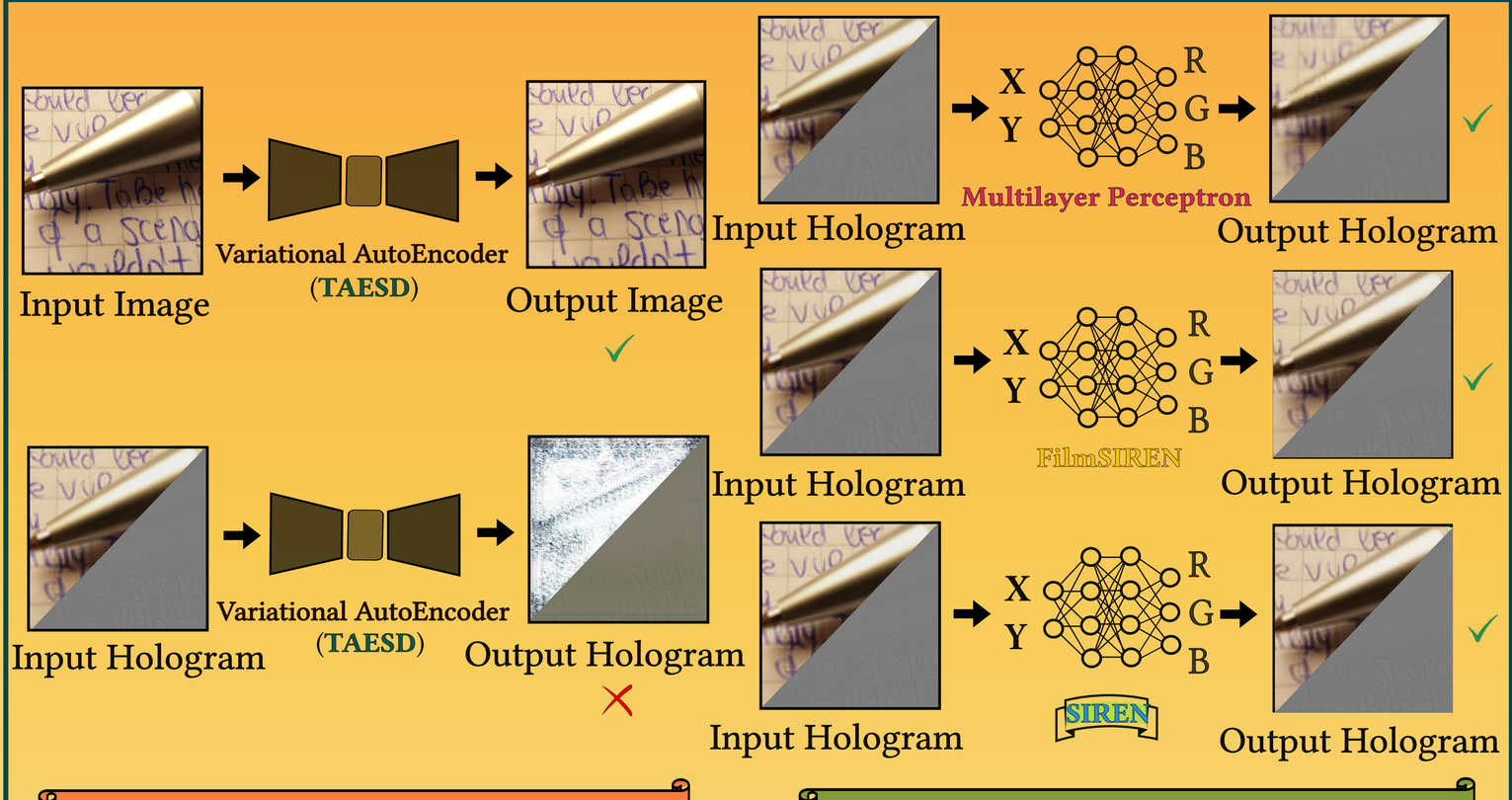
(1) Split phase-only holograms (3×512×512) into high-frequency-focused patches (e.g., 3×64×64);

(2) Train specialized INRs (MLP/SIREN/FilmSIREN) per patch with weight inheritance to ensure consistency and input the holograms into the VAE (TAESD) to obtain its decoded version for comparison;

(3) Reconstruct full hologram, INR achieved 40% compression Visualized in below where VAE fail.

Introduction video source

Sample source: photosteve101



Pretrained VAEs compresses images successfully

Fail to compress holograms.

Implicit Neural Representations (INRs)

Promises high quality hologram compression

Result

5

SIREN achieves peak performance at 3×64×64 patch size: PSNR is 42.29 dB with compression ratio of 40%.

Comparison

Three INRs (MLP/SIREN/FilmSIREN) methond can effectively compress hologram at compression ratio of 40%, and significantly outperform TAESD which fails to compress.

Limitations

Degrades ~5 dB at larger patches (160×160). The 40 min/hologram training is slower than conventional encoders.

Future work

Explore state-of-the-art models and adaptive patch sizing to balance throughput and quality.

Table 1: Patch based hologram quality comparison between vanilla MLP, FilmSIREN, and SIREN.

vanilla MLP			
Patch size	PSNR ± Std.	Params	Comp. Ratio
3 × 64 × 64	40.06 ± 2.73	5,059	41%
3 × 96 × 96	**41.50 ± 2.91**	**11, 139**	**40%**
3 × 128 × 128	39.88 ± 2.05	19,459	40%
3 × 160 × 160	40.71 ± 1.89	31,939	41%
FilmSIREN			
Patch size	PSNR ± Std.	Params	Comp. Ratio
3 × 64 × 64	**40.92 ± 2.91**	**4, 869**	**40%**
3 × 96 × 96	40.68 ± 2.58	10,755	39%
3 × 128 × 128	39.70 ± 3.18	19,137	39%
3 × 160 × 160	35.48 ± 2.93	30,357	40%
SIREN			
Patch size	PSNR ± Std.	Params	Comp. Ratio
3 × 64 × 64	**42.29 ± 2.45**	**4, 899**	**40%**
3 × 96 × 96	40.83 ± 2.63	11,171	40%
3 × 128 × 128	39.32 ± 3.08	19,491	40%
3 × 160 × 160	37.51 ± 4.88	31,971	41%

Webpage