Endoscopic Artifact Inpainting for Improved Endoscopic Image Segmentation

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FREQTY 频泰科技

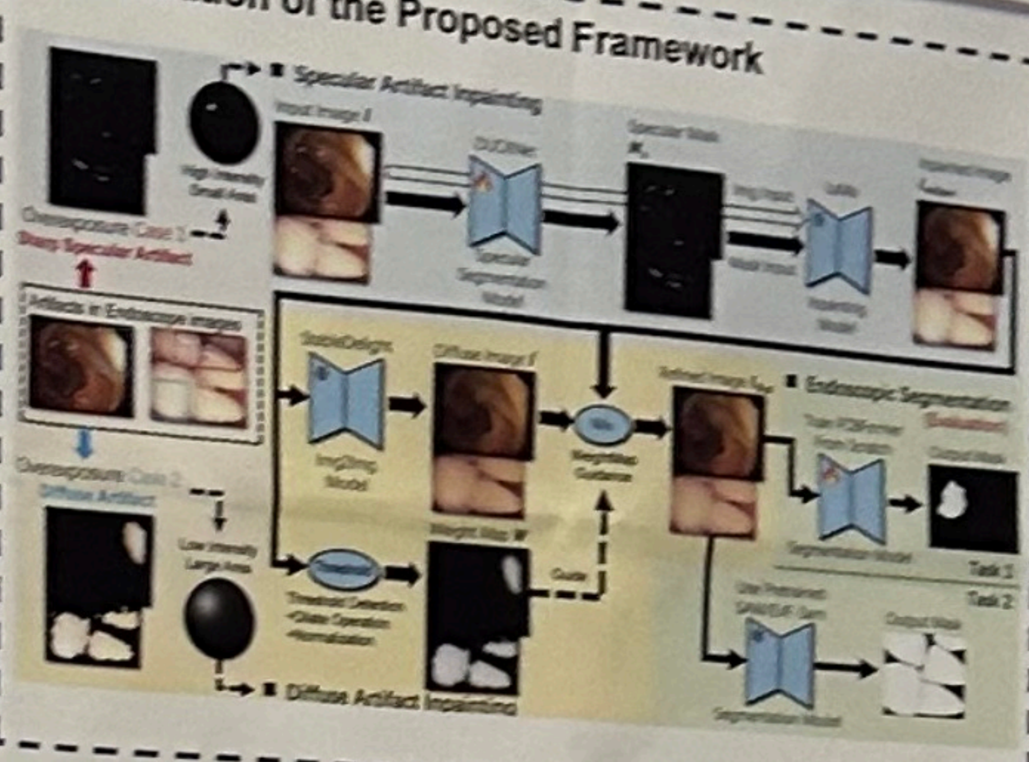
Introduction

Endoscopic imaging plays a crucial role in modern diagnostics and minimally invasive procedures. However, artifacts caused by specular and diffuse reflections present significant challenges, particularly in tasks such as endoscopic image segmentation. Existing methods tackling endoscopic artifacts typically address only one type of reflection, failing to fully account for the non-Lambertian reflectance of endoscopic tissue structures.

Therefore, inspired by the simplified Phong model for endoscopy, we propose a novel artifact inpainting framework. Our work can be summarized as follows:

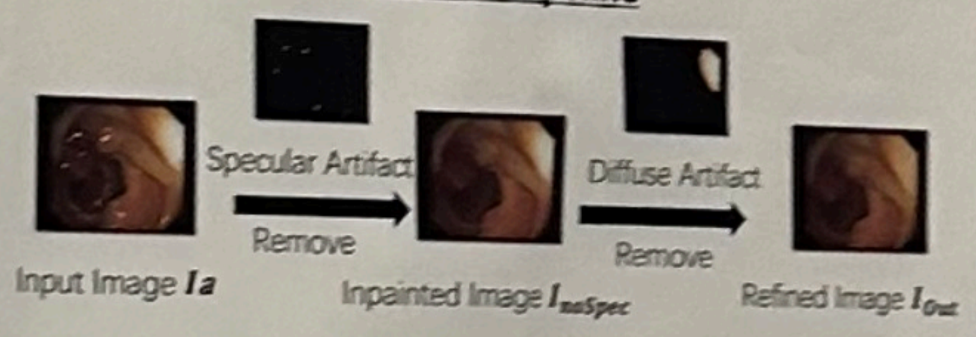
- Propose a two-stage artifact inpainting framework. The first stage suppresses specular artifacts, while the second stage focuses on inpainting diffuse artifacts. Additionally, we introduce a weight map to control the handling of diffuse artifacts, ensuring a more precise enhancement.
- Conduct thorough experiments to compare with SOTA models. The proposed framework can offer better artifact inpainting quality and robustly improve the segmentation performance of endoscopic images.
- Conduct various ablation studies to evaluate the effectiveness of key components and hyperparameter settings in our proposed framework.

Illustration of the Proposed Framework

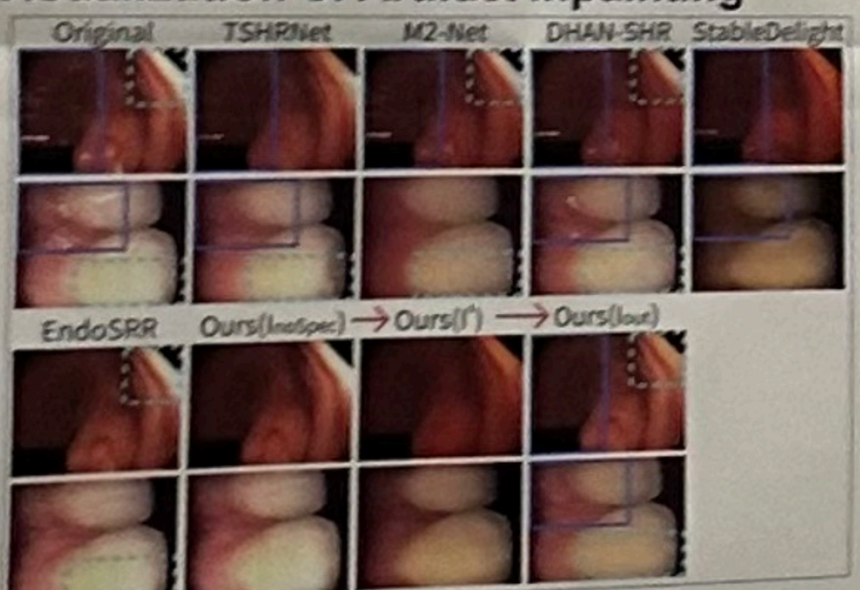


Phong Model

Process Pipeline



Visualization of Artifact Inpainting



Visualization of Endoscopic Image Segmentation

Quantitative comparison for segmentation performance enhancement

Methods	Polyp Datasets								Tooth Dataset			
	CVC-ClinicDB		Kavsir-SEG		CVC-ColonDB		ETIS		Teeth(Point)		Teeth(Text)	
	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU
Original Image	93.2	88.8	92.0	87.0	77.4	69.0	79.3	71.3	51.5	39.3	84.1	74.0
TSHRNet [10]	93.0	88.4	91.4	86.2	79.0	69.7	73.6	65.2	73.5	62.1	80.6	70.0
M2-Net [11]	93.6	89.4	92.5	87.4	80.9	73.0	78.2	70.9	75.7	65.6	84.6	74.9
DHAN-SHR [27]	93.6	88.5	92.1	87.0	79.4	70.2	77.7	68.6	65.1	52.9	85.1	75.4
EndoSRR [7]	94.1	89.2	92.7	87.6	79.6	70.0	79.5	71.4	95.8	92.5	86.3	77.3
StableDelight [13]	93.4	89.0	91.3	86.0	76.2	69.0	69.2	62.4	91.4	85.6	77.9	66.8
Ours	**95.0**	**90.6**	**93.3**	**88.3**	**81.5**	**73.4**	**81.0**	**73.2**	**96.1**	**93.0**	**86.8**	**78.0**

Ablation on key components for artifact inpainting

Modules				Datasets											
Specular		Diffuse		CVC-ClinicDB		Kvasir-SEG		CVC-ColonDB		ETIS		Teeth(Point)		Teeth(Text)	
Detect	Inpaint	SD	Guide	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU	mDice	mIoU
×	×	×	×	93.2	88.8	92.0	87.0	77.4	69.0	79.3	71.3	51.5	39.3	84.1	74.0
✓	×	×	×	94.5	89.9	92.3	87.2	78.4	69.5	76.5	68.1	49.5	37.4	83.6	73.2
✓	✓	×	×	94.6	90.0	93.0	88.0	**81.8**	**73.8**	80.0	72.2	95.8	92.7	86.5	77.5
✓	✓	✓	×	94.4	89.6	91.1	86.4	76.8	69.7	77.7	70.5	94.5	90.5	83.4	73.6
✓	✓	✓	✓	**95.0**	**90.6**	**93.3**	**88.3**	81.5	73.4	**81.0**	**73.2**	**96.1**	**93.0**	**86.8**	**78.0**

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