Multiscale deep desmoking for laparoscopic surgery

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MOTIVATION

- **Image quality can be severely degraded by surgical smoke**
  - Introduces errors for the image processing algorithms (used in image guided surgery)
  - Reduces the visibility of the observed organs and tissues
- **Smoke removal methods**
  - Mechanical solutions
  - Image processing based approaches

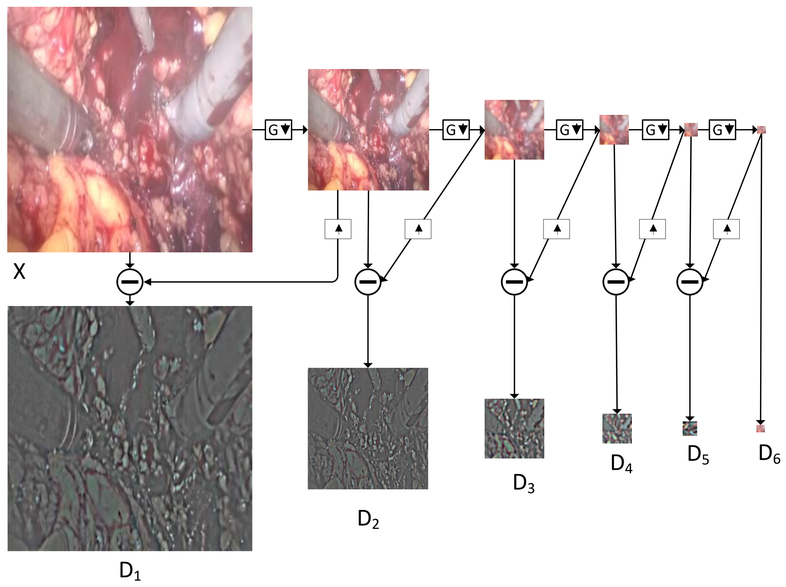
Aim:
Automatic and real-time image processing based smoke removal method.

CONTRIBUTIONS

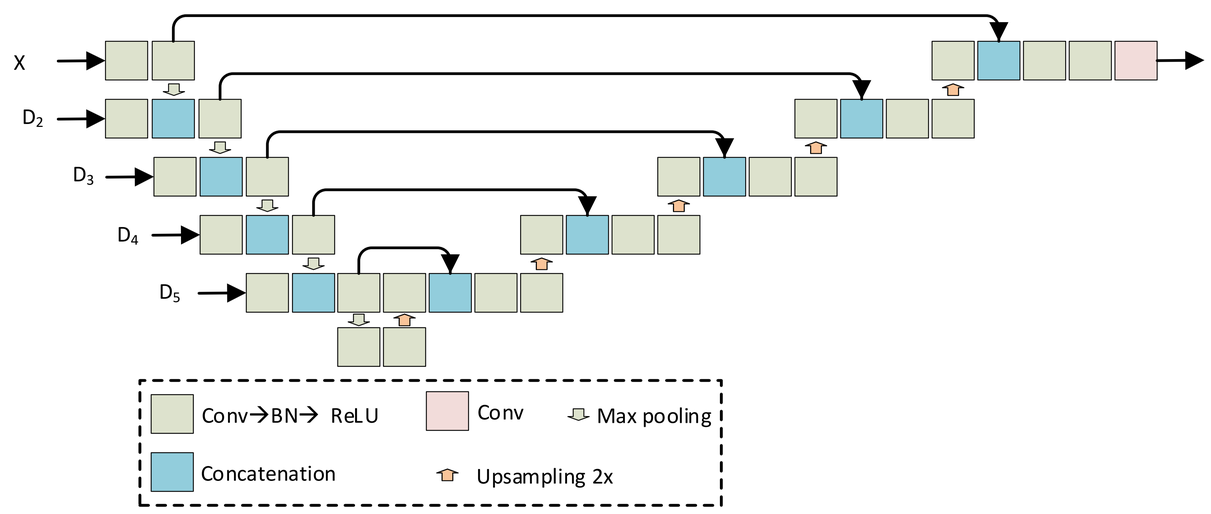
- A CNN based srugical smoke removal approach.
- Although trained on only synthesized dataset, the proposed method can eliminate smoke effectively while preserving the original colors.
- Processing speed reaches 26 fps for a video of size 512x512 on a single NVIDIA 12GB Titan X GPU.

METHOD

1. Image Pyramid Decomposition



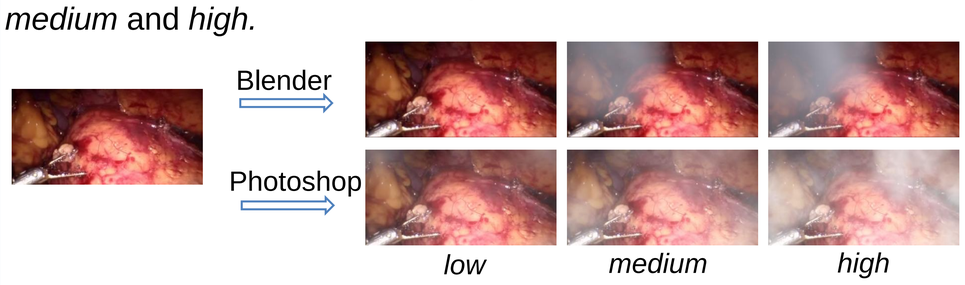
2. Network Structure



RESULTS

Training Dataset [1]

Manually selected 7553 smoke free images, synthesized smoke images via Blender and Adobe Photoshop with three smoke densities: *low*, *medium* and *high.*



Quantitative evaluation on synthetic dataset

Tab. 1. Average and standard deviation results for evaluation metrics.

		Smoke images	DCP[2]	R-DCP[3]	EVID[4]	VAR[5]	U-Net[6]	**Proposed**
PSNR	*low*	15.87 ± 1.17	15.25 ± 1.52	18.59 ± 1.60	20.90 ± 1.50	16.90 ± 2.08	28.29±1.92	**28.58 ± 1.84**
	medium	12.14 ± 1.03	16.08 ± 1.55	17.32 ± 1.14	20.63 ± 1.65	16.71 ± 1.83	27.56±1.80	**27.91 ± 1.69**
	high	9.81 ± 1.21	17.00 ± 1.53	15.53 ± 1.33	18.26 ± 2.07	15.72 ± 1.70	26.54±1.72	**26.92 ± 1.65**
SSIM	*low*	0.88 ± 0.03	0.85 ± 0.04	0.76 ± 0.03	0.92 ± 0.03	0.90 ± 0.03	0.98±0.01	**0.99 ± 0.01**
	medium	0.77 ± 0.04	0.86 ± 0.05	0.68 ± 0.03	0.93 ± 0.03	0.88 ± 0.04	0.98±0.01	**0.98 ± 0.01**
	high	0.65 ± 0.07	0.87 ± 0.05	0.58 ± 0.05	0.91 ± 0.04	0.83 ± 0.06	0.97±0.01	**0.98 ± 0.01**

Qualitative evaluation

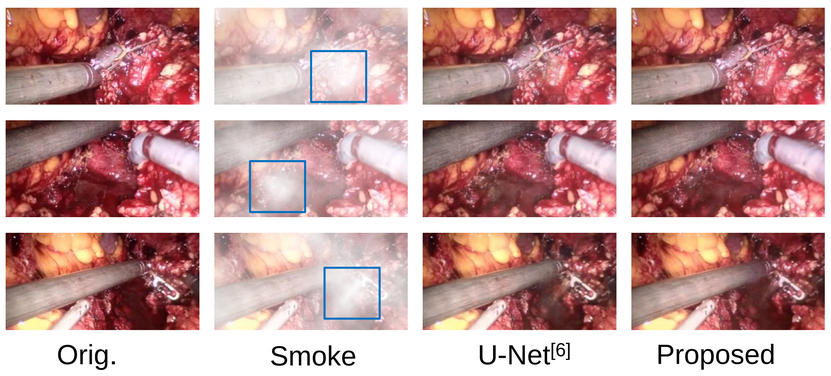


Fig. 1. Subjective results of synthetic dataset

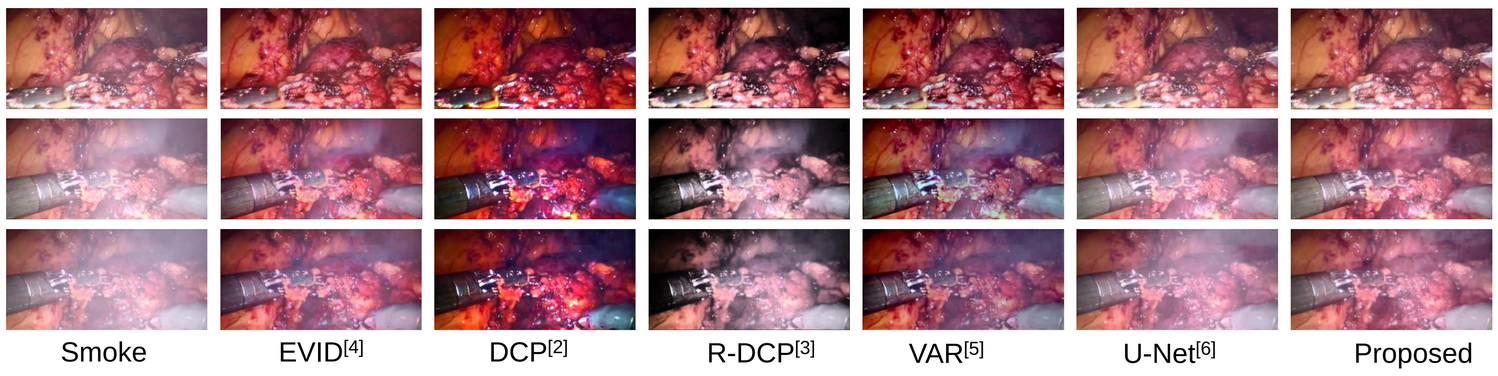


Fig. 2. Subjective results of real smoke images

DISCUSSION

- Proposed method provides very good results on synthized images, but the performance degrades on real dense smoke images.
- Simulation of more realistic training dataset to improve the results is necessary.

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