Exploring Object Recognition and Image Denoising in Demanding Unreal and Virtual Environments

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GitHub Repo: https://github.com/ppremdas3/Object-Detection-and-Image-denoisign-in-demanding-Unreal-and-Real-Environment.git

Motivation

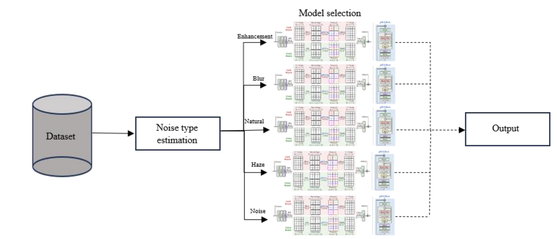
- The necessity for a robust image denoising and enhancement algorithm for various real and unreal challenging noise types in the field of computer vision and image processing is the motivation behind the project.

Methodology

- In this study, we pursued a comprehensive understanding of denoising and enhancement algorithm robustness under different challenging conditions.
- Five distinct datasets with a variety of noise characteristics were chosen, namely CURE-OR, CURE-TSR, CURE-TSD, SIDD and Set-12.
- The figure below illustrates the pipeline of the MAXIM and object detection framework:

1. **Improved adaptive gamma correction**: This algorithm perform an adaptive exposure estimation by analyzing the intensity distribution using histogram and CDF before applying non-linear gamma correction.
2. **Anisotropic diffusion**: It is an edge preserving denoising algorithm mostly used in medical image processing. We employs the Perona-Malik diffusion equation.
3. **Multi-Axis MLP**: This is an efficient and flexible U-Net architecture based image denoising and enhancement algorithm.
4. **Object detecion**: Object detection was done using YOLOv8x model and the Object recogonization in VURE-TSR and CURE-TSD was done using a fine-tuned model on YOLOv8.

MAXIM



Object Detection

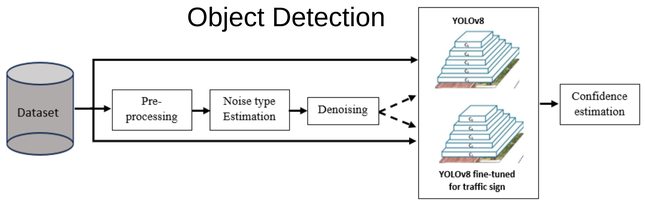
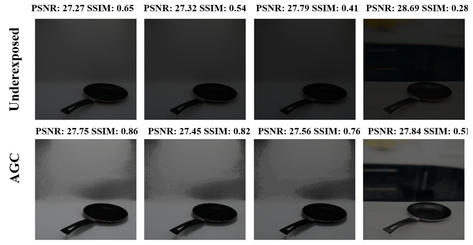
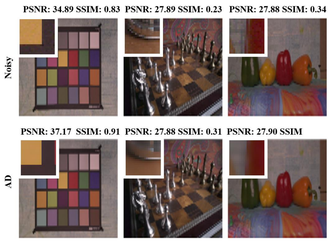


Image Denoising/Enhancement result



Evaluation of AGC on level 1-4 of underexposed images from CURE-OR dataset

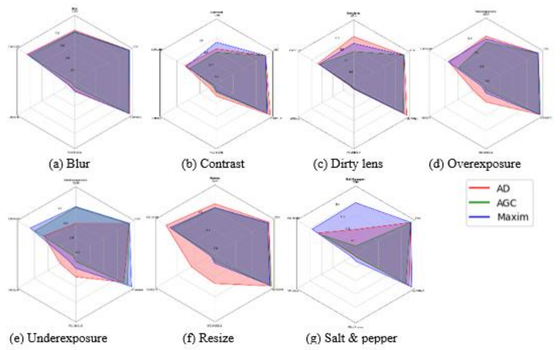
Evaluation of MAXIM on darkened, Gaussian blur, rain, haze and noisy images from CURE-TSD dataset



Evaluation of noise reduction using AD on 3 test image from the SSID dataset

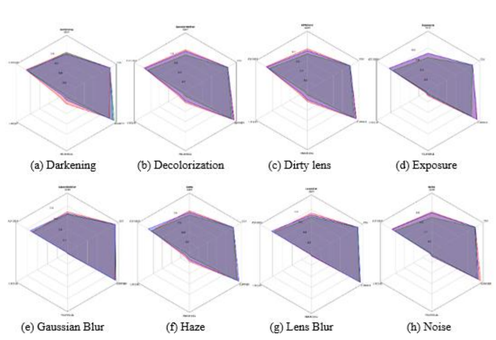
Results

CURE-OR



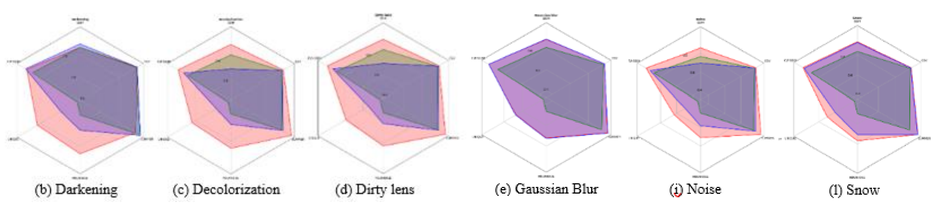
AD performs on texture noise, AGC performs on underexposure but fails in overexposure, and is MAXIM is very robust

CURE-TSR



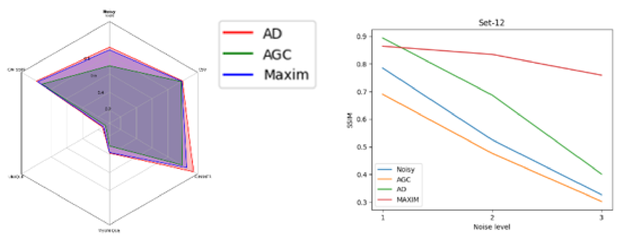
No significant improvement due to vast variation in size in the dataset and highly complex noise conditions

CURE-TSD



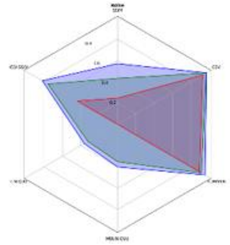
AD is very robust and flexible. AGC perform well in exposure or darkening and MAXIM fails on random noise due to noise characteristics.

Set-12



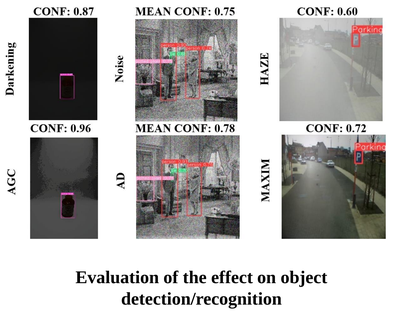
AD performs well on low level noise but MAXIM has better performance in complex noise

SIDD



AD and MAXIM have comparable performance but AGC fails due to random noise type

Object Detection



Evaluation of the effect on object detection/recognition

Conclusion

Noise Type	AGC	AD	MAXIM MLP
Texture	No	Yes	Yes
Exposure	Yes	No	Yes
Compression	No	Yes	No
Weather	No	Varies	Yes
Noise	No	Yes	Yes
Blur	No	No	Yes

In conclusion, every denoising and enhancement algorithm has its strengths and weaknesses. But, it is to be noted that Anisotropic diffusion is a very robust method for denoising which can be further improved by either combining with other denoising methods or by performing multiscale diffusion. Furthermore, MAXIM provides a very good architechture to further develop denoising model for machine vision and image processing application.