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Thermal Image Enhancement using Generative Adversarial Network for Pedestrian Detection

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Introduction

Motivation:

- Infrared cameras often suffer from low-contrast, low-resolution and blurred details.
- These problems could limit the feasibility of different infrared imaging applications.

Objective: To enhance the visual quality of thermal images in order to improve the pedestrian detection performance.

State-of-the-art:

- Traditional methods based on Histogram Equalization (HE) and Contrast Limited Adaptive(CLAHE)
- Deep Learning methods (VDSR, SRCNN, TEN, CDN-MRF)
- Adversarial Learning methods(SRGAN, DCGAN)

Proposed Thermal Image Enhancement Architecture

- New Thermal Enhancement-GAN (TE-GAN) architecture basically inspired from EnlightenGAN [1] and DnCNN[2].
- The proposed architecture is composed of two modules with a post-processing step to cover different limitations of thermal images.
- Training TE-GAN architecture according to an overall loss function that combines perceptual, content, global and local losses

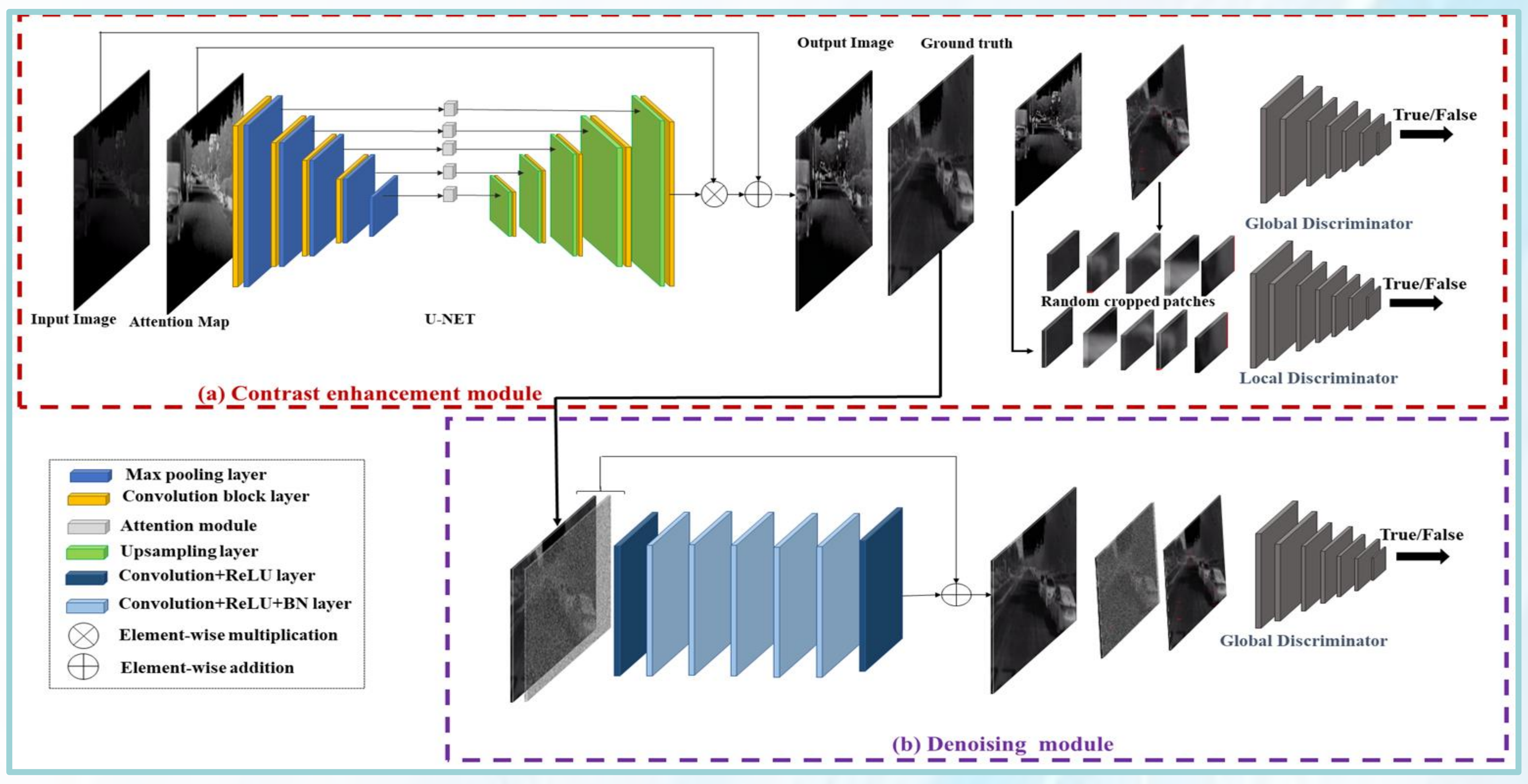

Fig.1 :The proposed TE-GAN architecture composed of two modules:(a) contrast enhancement and (b) denoising.

1.Contrast Enhancement Module

To improve the contrast using U-NET generator, global and local discriminators.

❑ **Perceptual Loss**

To compute the distance between the output image and the ground-truth based on high-level representations extracted from VGG pre-trained model.

2. Denoising Module

To remove the noise level by a CNN generator and a global discriminator.

❑ **Content Loss**

To minimize the low-level content errors between the noisy image and the denoised generated image using Pixel-wise MSE,.

3. Post-processing Module

To highlight the edges and decrease the visual blur effects by means of a convolutional edge enhancement filter

Dataset

KAIST dataset [3].

Total number of frames(RGB and thermal): 95k
Training set : 7601 thermal images
Testing set : 2252 thermal images

Fig.2: Examples of thermal images from KAIST datatset.

Experiments & Results

1.Visual quality evaluation in terms of:

- *The Peak Signal to Noise Ratio (PSNR)*
- *The Structural Similarity Index Metric (SSIM)*

	HE	CLAHE	TE-GAN
PSNR	7.81	11.92	13.92
SSIM	0.34	0.37	0.50

Tab.1: Comparison of the TE-GAN architecture to HE and CLAHE.

Fig.3: Qualitative results of our proposed architecture TE-GAN compared to other enhancement methods.

2. Detection results with and without enhancement in terms:

- *The mean Average Precision (mAP)*
- *The Log Average Miss Rate (LAMR)*

Testing conditions	Metric	Without enhancement	With enhancement
Day	mAP	0.61	0.63
	LAMR	0.41	0.40
Night	mAP	0.66	0.73
	LAMR	0.26	0.20
All	mAP	0.62	0.65
	LAMR	0.45	0.43

Tab.2: Comparison of the detection performance of YOLOv3 detector with and without TE-GAN enhancement.

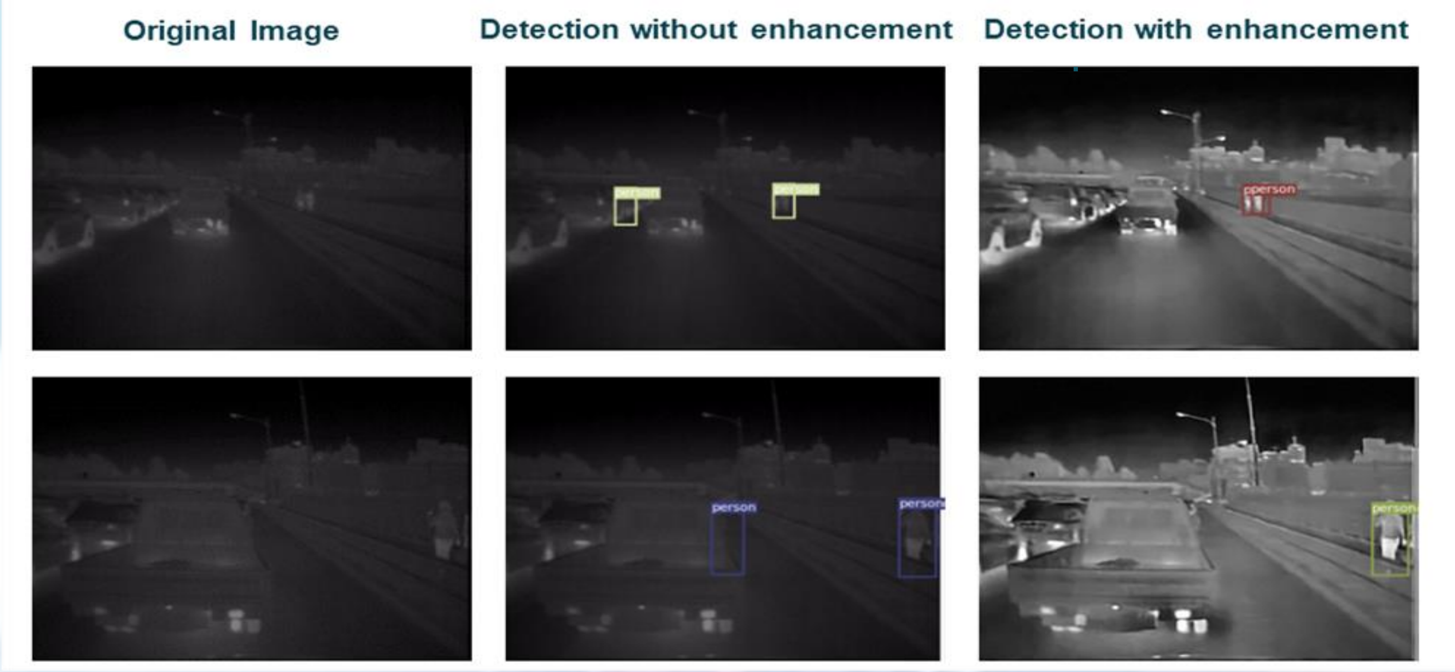

Fig.4:Some results of pedestrian detection using YOLOv3 on thermal images from KAIST dataset with and without TE-GAN enhancement.

Conclusion & Future work

- The effectiveness of the proposed TE-GAN architecture is proven by obtaining better quantitative and qualitative results compared to the original thermal images and to other existing enhancement methods.
- The detection results using YOLOv3 detector are improved by means of TE-GAN architecture with a significant margin.
- Extension of the proposed TE-GAN architecture to incorporate a super-resolution module.
- Extend the proposed approach to other applications such as people tracking and activity recognition.

References

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[2] Zhang, Kai, et al. "Beyond a gaussian denoiser: Residual learning of deep cnn for image denoising." IEEE Transactions on Image Processing 26.7 (2017): 3142-3155.
[3] Hwang, Soonmin, et al. "Multispectral pedestrian detection: Benchmark dataset and baseline." Proceedings of the IEEE conference on computer vision and pattern recognition. 2015.

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