**Technical Paper Review: Tan Chun Wee**

**Questions**

1. In 400 words or less, describe the problem the authors are trying to solve, the solution(s) proposed by the author, and their main considerations.

Prior to Zero-DCE, existing methods of low-light image enhancement fail to cope with extreme back lights or will generate colour artifacts.

The authors’ solution to the problem was to propose a lightweight deep learning model, Zero-DCE, that does not train on paired or unpaired data, thus avoiding overfitting and also creates a model that generalises well to various lighting conditions. This is new to the field as existing models are trained by either paired or unpaired data. Zero-reference training is done through the use of specially designed non-reference loss functions. An image-specific curve was designed to approximate pixel-wise and higher-order curves by iteratively applying itself, thus the curve is able to map to a wide dynamic range.

One of the main considerations of the authors was Zero-DCE has to be competitive with other current HE-based, CNN-based or GAN-based models in terms of performance. Another consideration was Zero-DCE has to be lightweight. Lastly, Zero-DCE’s network should be able to produce more robust and accurate dynamic range adjustments through approximating higher-order curves iteratively.

2. The paper claims to perform better than other methods. What quality assessment metric were used in this paper? Describe in 400 words or less the quality metric used for evaluation and how they were computed.

Two kinds of metrics were used in this paper, qualitative and quantitative.

For qualitative metrics, User Study (US) and Non-reference Perceptual Index (PI) were used.

For US, 15 trained subjects scored the visual quality of the enhanced images. Each image was given a score of 1 to 5, with 5 representing the best quality . The scores were averaged and reported.

Non-reference PI quantifies the quality of image based on how natural it looks. A low score for PI is indicates better quality.

Four quantitative metrics were used in this study. They are Peak Signal to Noise Ratio (PSNR), Structural Similarity (SSIM), Mean Absolute Error (MAE), and Runtime.

PSNR measures the quality of enhanced image to the original. A higher PSNR value indicates a closer similarity to the original image. The formula for PSNR is: ,where MSE is the average squared difference between each corresponding pixel in the original and processed images.

SSIM measures the similarity of two images (enhanced vs original), according to their brightness and structural information (e.g. edges, textures, patterns). SSIM values range from -1 to 1, where 1 indicates a perfect similarity.

MAE measures the overall dissimilarity between two images. A higher MAE value represents a higher dissimilarity. MAE is calculated by taking the average magnitude of difference between corresponding pixels between the original image and the processed image.

Runtime is calculated for the different methods by averaging the the amount of time it takes to process 32 images of size 1200x900x3. Runtimes were mostly measured on the same CPUs and GPUs (Intel i7 6700 CPU and Nvidia GTX 2080Ti GPU), with the exception of Wang et al. who used a Nvidia GTX 1080Ti GPU.

3. Describe in 400 words or less a possible use-case for HomeTeam departments that would require the technology presented in this paper.

A possible use case would be for surveillance using CCTV cameras, especially in rural areas of Singapore where lighting may not be as good as the urban areas after the sun sets, effectively setting a “blind spot” where CCTV footage from such areas are not as helpful.

Possible light sources in rural areas can include moonlight, street lamps, or even electronic devices (e.g. phones), which can provide the small amount of light needed for Zero-DCE to work.

With Zero-DCE, any low-light frames cut from video feeds from CCTV cameras can be enhanced to provide a clearer picture to feed into other detection models (e.g. facial detection models, number plate recognition). Of course, just purely using Zero-DCE may be insufficient as CCTV footage may be of too low resolution for detection models to produce accurate results, perhaps due to the distance of the subject. Hence the enhanced image from Zero-DCE may be used in conjunction with other image processing methods (e.g. Super-Resolution, Noise Reduction).

Theoretical scenario:

Person A murders Person B and dumps body of B in the countryside at night. The body of B is discovered and the police are called to investigate. With the help of forensic evidence, the date and time of B’s death can be estimated, and nearby CCTV records from this time period can be obtained. With the help of Zero-DCE, low-light frames that contain any individuals can be brightened and individuals can be identified as suspects. More evidence can thus be gathered to convict A.