Improving Aerial Instance Segmentation in the Dark with Self-Supervised Low Light Enhancement

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1. Problem

Aerial Computer Vision methods are biased towards clean datasets, and do not include any mechanism to deal with low light conditions. Low light is an inevitable part of aerial images, due to capturing in:

1. Extreme weather conditions
2. Night time
3. Poor capturing techniques
4. Low contrast conditions

Thus, key UAV applications such as remote sensing cannot be performed effectively.

2. Contributions

For robustness, we not only expose the method to low light aerial images, but also introduce a light enhancement module.
Our major contributions are:

1. Proposal of a self-supervised enhancement network capable of performing instance segmentation.
2. Generation of a new low light aerial image dataset having segmentation annotations.
3. Validation of the network's performance both qualitatively & quantitatively

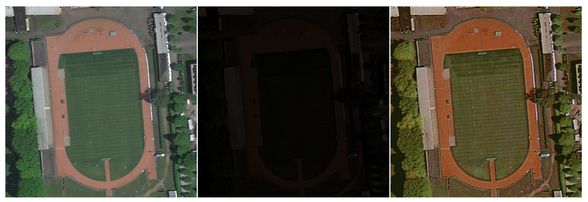
3. Dataset Generation

Method	Type	AP	AP_{50}	AP_{75}
HTC	Box	41.7	61.8	46
	Segm	34.3	57.6	35.8

Performance of HTC on clear images of iSAID when trained with dark images only

We utilise the iSAID and the LOw-Light dataset (LOL) to translate the low light attribute. The translation is processed using the cycle consistency loss of CycleGAN. We generate 18528 low light aerial images for the training set that match with real time conditions.

4. Brightness Restoration



This stage is based on the Maximum Entropy-based Retinex Model, wherein the histogram distribution of the enhanced & original images is compared. This approach eliminates the requirement of paired examples, and the loss function is constructed using low-light images only. Following is the loss function:

$$Z = \|S - R \cdot I\| + \lambda_1 \left\| \max_{c \in R,G,B} R^c - F\left(\max_{c \in R,G,B} S^c \right) \right\|$$

$$+ \lambda_2 \|\Delta I \cdot \lambda exp(-\lambda_3 \Delta R)\| + \lambda_4 \|\Delta R\|$$

This equation is solved by a CNN which breaks image into illuminance and reflectance.

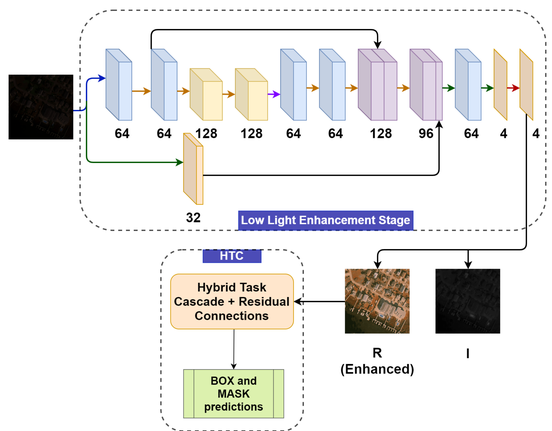
6. Results

Method	Type	AP	AP_{50}	AP_{75}
Original HTC	Box	38	55.9	42.1
	Segm	31.3	51.9	32.7
Our Method	Box	38.9	57.5	43.1
	Segm	32.2	53.8	33.9

Training data	Type	AP	AP_{50}	AP_{75}
iSAID	Box	17.5	25.5	19.8
	Segm	15.2	24.7	15.9
low light	Box	38	55.9	42.1
	Segm	31.3	51.9	32.7

Figure 1: Enhancement of synthetic low light images using the self-supervised light enhancement module

5. Network Description



- The light enhancement CNN breaks an input image into R & I and consists of simple convolutions. It is fast, efficient, lightweight (2 MB).
- HTC is utilised for performing instance segmentation. Skip connections in the mask pipeline efficiently segment tiny objects in images.
- The light enhancement module & HTC complement each other during the end-to-end training, and losses from both phases contribute to the global loss.

6. Conclusion

We propose a new method for robust feature extraction from low-light aerial images, by efficiently restoring the brightness in the image. In addition, we generate a synthetic dataset consisting of low light aerial images having annotations for performing instance segmentation.

References

[1] Wei, C.; et al. 2018. Deep Retinex Decomposition for Low-Light Enhancement. In British Machine Vision Conference.
[2] Zamir, W.; et al. 2019. isaid:A large-scale dataset for instance segmentation in aerial images. In Proceedings of the IEEE CVPR Workshops, 28–37.