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Activity Results Report:
"Study of Deep Learning algorithms for adverse weather conditions"

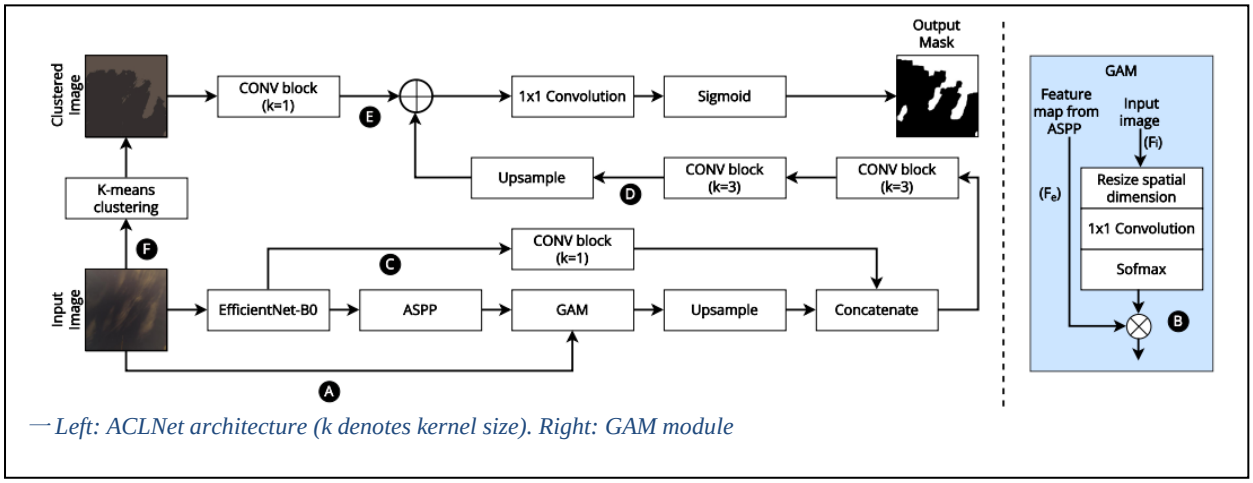
Cloud classification and Segmentation:

a novel deep learning model named ACLNet, for cloud segmentation from ground images. ACLNet uses both deep neural network and machine learning (ML) algorithm to extract complementary features. Specifically, it uses EfficientNet-B0 as the backbone, "atrous spatial pyramid pooling" (ASPP) to learn at multiple receptive fields, and "global attention module" (GAM) to extract fine-grained details from the image. ACLNet also uses K-means clustering to extract cloud boundaries more precisely. ACLNet is effective for both daytime and nighttime images. It provides lower error rate, higher recall, and F1-score predictive performance than state-of-art cloud segmentation models.

ACLNet has a model size of ~31MB and requires only 7.57 million floating-point operations. Further, ACLNet has lowest error rate, higher recall and F1-score than the state-of-art models, for daytime, nighttime, and day+nighttime images (corresponding to SWIMSEG, SWINSEG and SWINySEG datasets, respectively). The main contributions are:

· An interpretable and accurate framework targeted for cloud segmentation from both daytime and nighttime images.

· We introduce an ML algorithm in our DNN to bring their best together and more effectively segment the clouds.



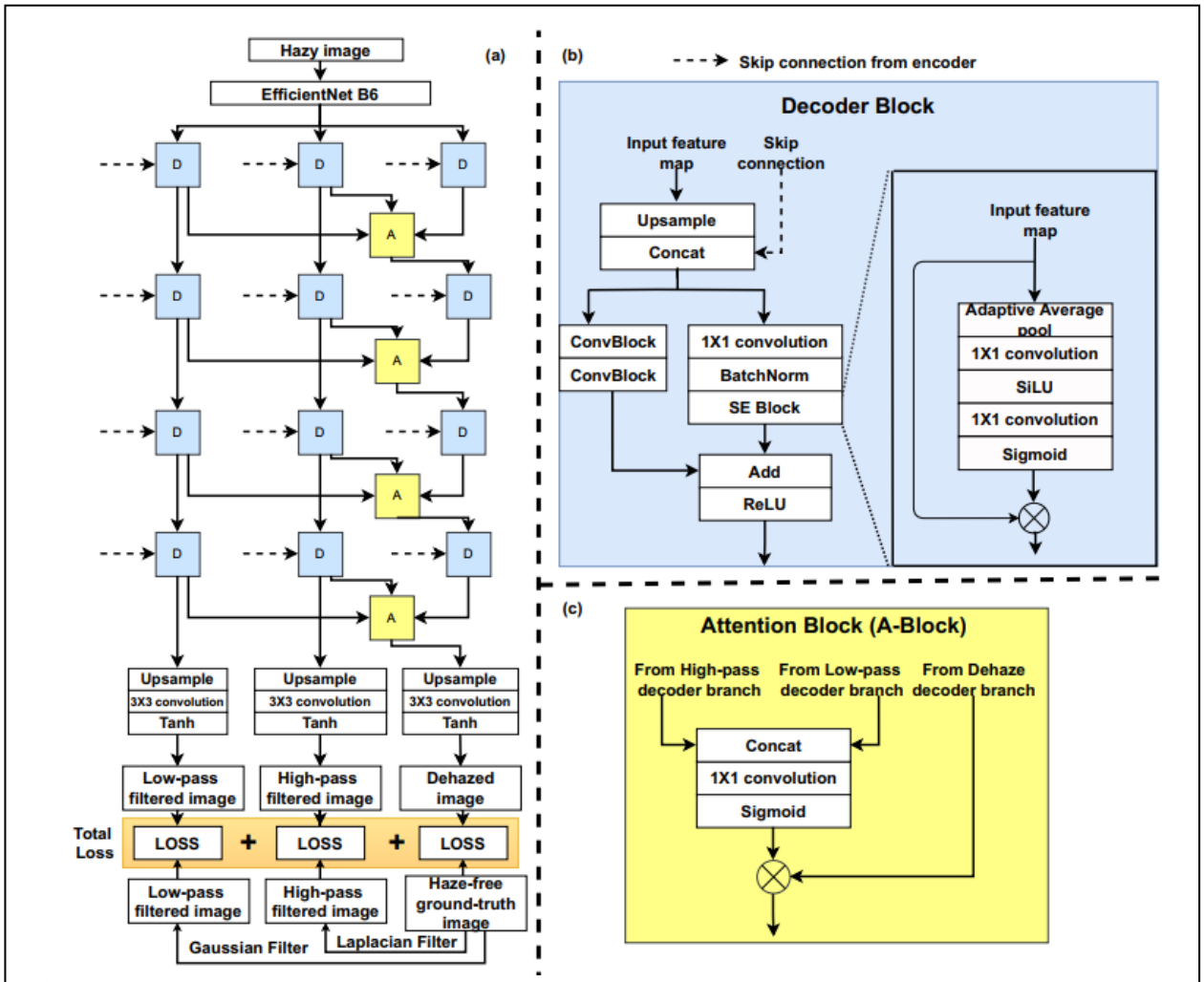
— Left: ACLNet architecture (k denotes kernel size). Right: GAM module

Scene analysis in adverse weather conditions- Image dehazing:

Dehazing refers to removing the haze and restoring the details from hazy images. ClarifyNet, a novel, end-to-end trainable, convolutional neural network architecture for single image dehazing. We comprehensively evaluate ClarifyNet on I-HAZE, O-HAZE, Dense-Haze, and NH-HAZE datasets using PSNR and SSIM metrics and compare them with previous works. On Dense-Haze and NH-HAZE datasets, ClarifyNet achieves the highest PSNR and SSIM. For I-HAZE and O-HAZE, ClarifyNet achieves the highest PSNR and remains within the top three techniques on the SSIM metric.

Contributions:

1. In this paper, we propose ClarifyNet, a novel, end-to-end trainable, CNN architecture for single image dehazing. ClarifyNet is a single-encoder, multi-decoder attention-based network. The encoder uses EfficientNet-B6 backbone, which is pre-trained on ImageNet to extract image features. ClarifyNet network uses several architectural primitives such as attention and squeeze-and-excitation blocks to achieve high predictive performance.
2. We observe that a high-pass filter detects sharp edges, texture, and other fine details present in the image, and a low-pass filter detects color and contrast information. Based on this, our key idea and novelty is to train our network on not only the haze-free ground-truth image but also on the “low-pass filtered” and the “high-pass filtered” images. Thus, ClarifyNet performs dehazing by focusing on color, edge, contrast, texture information and other fine details present in the image. This leads to high reconstruction quality. The decoder has three branches corresponding to the “low-pass filtered” image, “high-pass filtered” image and haze-free image. For each decoder branch, the sum of L1 loss and SSIM loss (LSSIM) is computed, and summation of this value for all three branches is used as the final loss function for training ClarifyNet. Since L1 loss and LSSIM loss are complementary, the use of both helps preserve both pixel-level and structural similarity.
3. We evaluate ClarifyNet on four well-known datasets: I-HAZE, O-HAZE, Dense-Haze, and NH-HAZE. We compare our results with several recent techniques on two metrics, namely peak signal to noise ratio (PSNR) and structural similarity (SSIM). We report the results on both RGB color format and YCbCr color format since they provide the best results on different datasets. On Dense-Haze and NH-HAZE datasets, ClarifyNet achieves the highest PSNR and SSIM. For I-HAZE and O-HAZE, ClarifyNet achieves the highest PSNR and remains within the top three techniques on the SSIM metric. Also, for dehazing a 3996×4096 image on a NVIDIA GeForce RTX 2080Ti GPU, ClarifyNet takes only 1.5 seconds. Further, ClarifyNet has a model size of only 71 MB.



二 *(a) Overall architecture of ClarifyNet (b) Decoder block (SE = squeeze and excitation) (c) Attention block*

Problem/constraints:

- Due to COVID-9 we were unable to procure nowcasting dataset, so we have exhaustively worked on cloud classification/segmentation and image dehazing.

Research Output:

- ACLNet: An Attention and Clustering-based Cloud Segmentation Network- Accepted, Remote Sensing Letters, Taylor & Francis Online, 2.583 (2020) Impact Factor (DOI Assigned: https://doi.org/10.1080/2150704X.2022.2097031)
- ClarifyNet: A High-Pass and Low-Pass Filtering Based CNN for Single Image Dehazing- Under review, Journal of Systems Architecture, Science Direct, 3.77 Impact Factor

Human Capital Development:

- Two PhD Students
- Five undergraduate students