PCANet: Pyramid Context-aware Network for Retinal Vessel Segmentation

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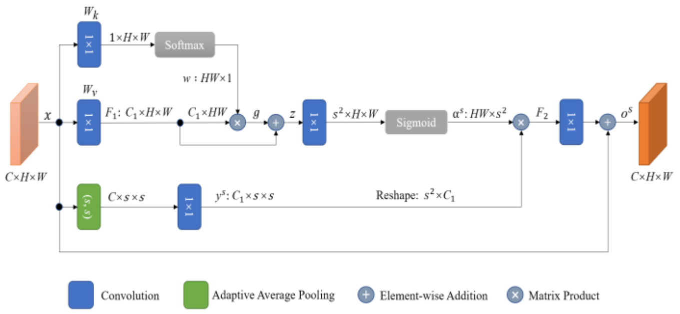
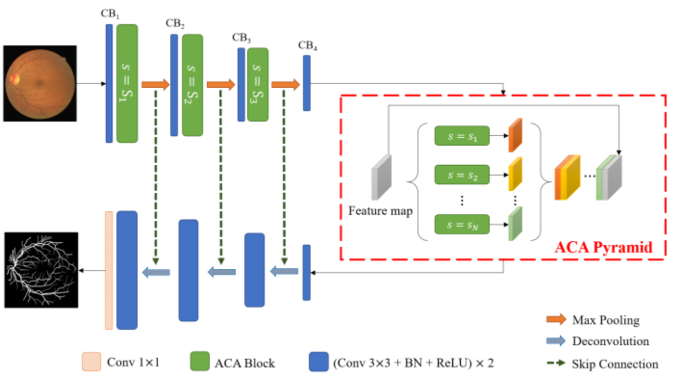
Introduction

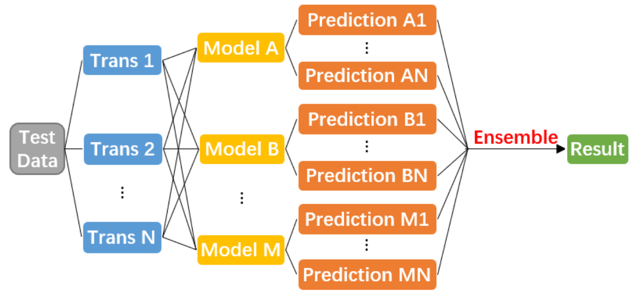
Retinal vessel analysis is an important diagnostic method to detect retinal and systemic diseases, such as diabetes, arteriosclerosis and hypertension. At present, it is the only feasible way to noninvasively examine the vascular system in human body. Retinal vessel segmentation is a prerequisite step of retinal fundus image analysis. In current clinical practice, retinal vessel segmentation is typically achieved by human experts. However, manual segmentation is labor-intensive and time-consuming due to the large image sizes and complex vascular tree structures. Moreover, ophthalmologists often have different experience and limited energy, which may cause incorrect segmentation and even omit some potential symptoms. Therefore, it is necessary to develop computerized methods to reduce the workload of ophthalmologists and make the analysis more accurate.

Method



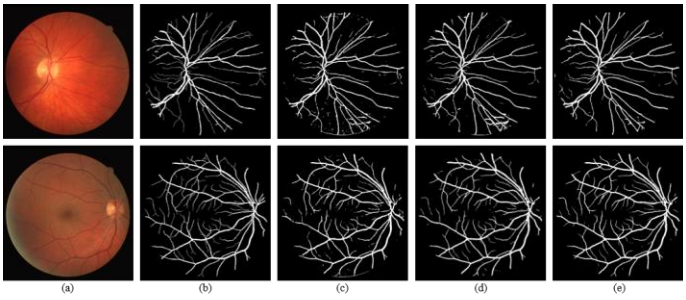


We propose Adaptive Context-aware (ACA) block, which can obtain adaptive context-aware features by utilizing both global context and local information. Furthermore, we propose Pyramid Context-aware Network (PCANet), which exploits ACA Pyramid and imports ACA blocks in different levels of encoding path to obtain better and stronger multi-scale contextual information.



We propose integrated test-time augmentation method, which aggregates all predictions from multiple models and different transformations together during testing to enhance model's robustness and obtain better result.

Results



Visualization of segmentation results with different methods. (a) Raw image. (b) Ground truth. (c) Jin et al. (d) Li et al. (e) PCANet. The results are evaluated on the testing set of DRIVE dataset.

We compare the proposed method with other state-of-the-art methods. In principle, it is simple to generate a high Se or Sp because they focus more on one category than the other. However, other metrics such as F1 Score, AUC and ACC are based on two categories to evaluate the model performance. Therefore, these three indicators demonstrate the robustness of the proposed algorithm, particularly in the case with a highly imbalanced ratio of the vessel and nonvessel pixels amount. It is observed that the proposed PCANet generates the highest F1 Score, AUC, ACC on STARE dataset, and also achieves the highest F1 Score and Se on DRIVE dataset. Therefore, the proposed PCANet exhibits state-of-the-art performance in retinal vessel segmentation task.

References

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[2] D. Li, D. A. Dharmawan, B. P. Ng, and S. Rahardja, "Residual U-Net for retinal vessel segmentation," in International Conference on Image Processing, 2019, pp. 1425-1429.