# Pathology-Aware Deep Network Visualization and Its Application in Glaucoma Image Synthesis

*Xiaofei Wang, Mai Xu*, Liu Li, Zulin Wang, Zhenyu Guan*

*School of Electronic and Information Engineering, Beihang University (BUAA)*

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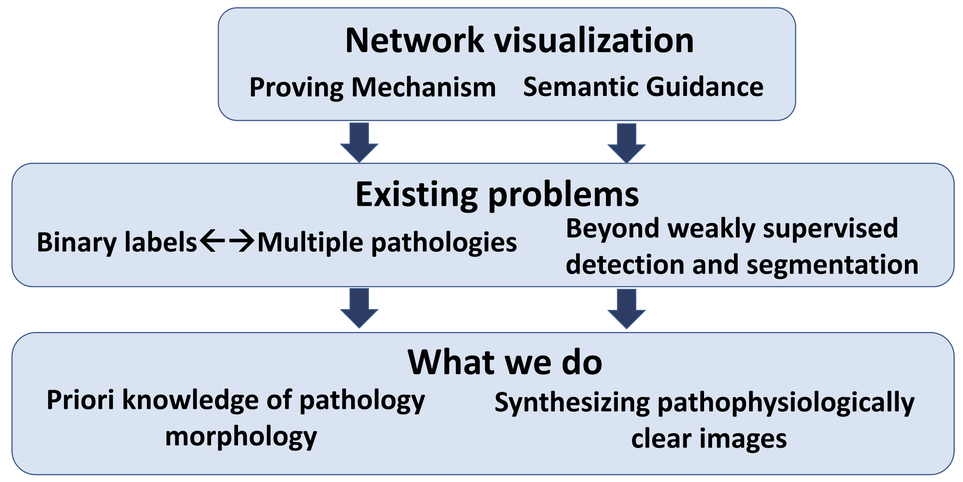
## I. Motivation

### Motivation

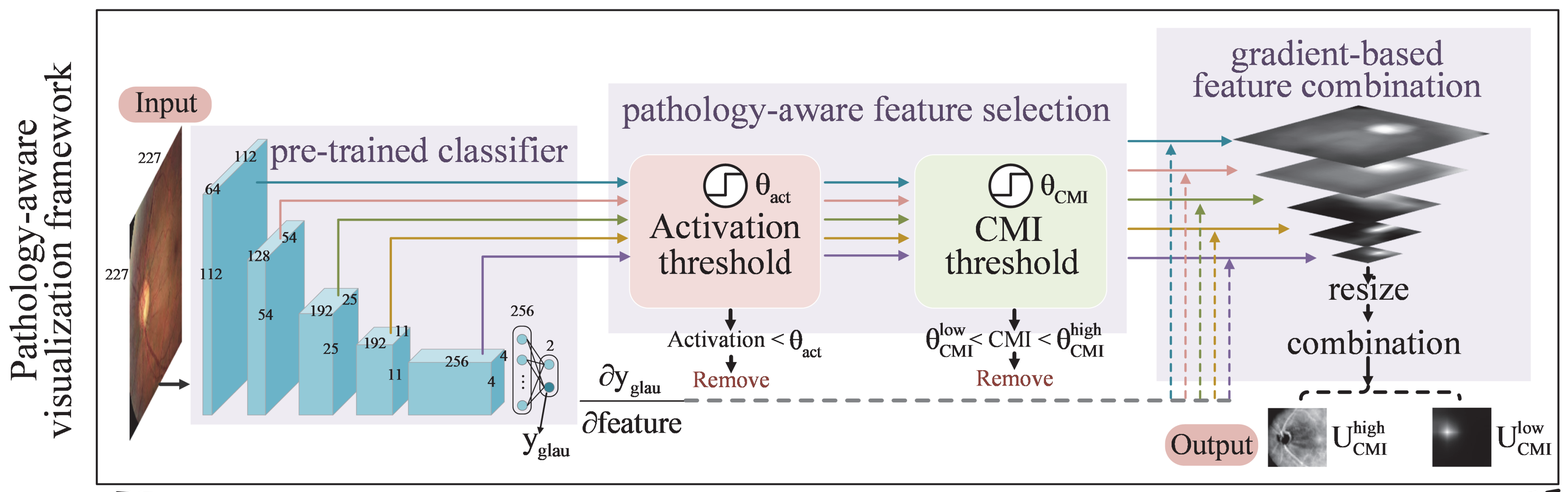
1. When applying network visualization in medical domain, there exists conflicts between multi-pathologies (like RL and RNFLD of glaucoma) and binary annotations (positive or negative glaucoma), which limits the existing visualization methods to pinpoint different pathological evidence hidden behind DNNs.
2. Image synthesis is a popular data augmentation approach in medical image domain. However, the recent synthesis algorithms can not add specific pathology information in it.

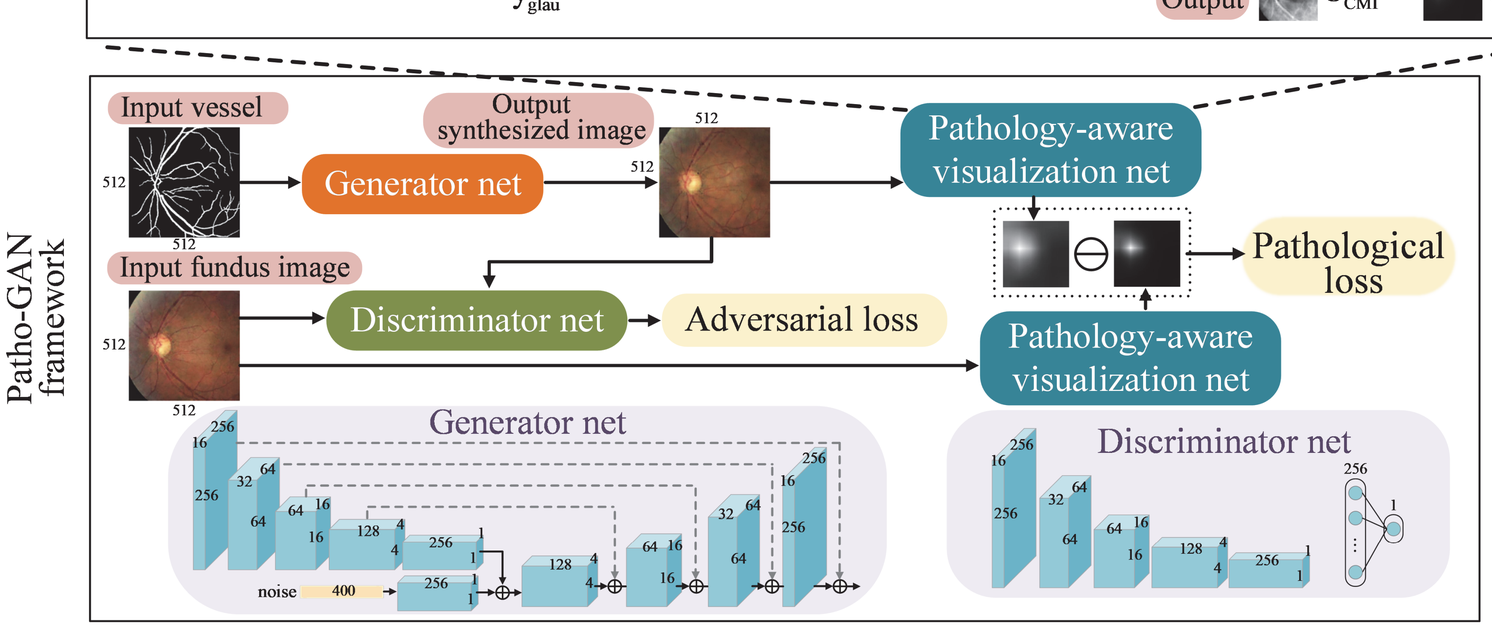
### Contribution

1. We propose a novel pathology-aware visualization method to find different pathological evidence (RL and RNFLD) for glaucoma classification network.
2. We propose Patho-GAN to apply the feature visualization to the glaucoma image synthesis task, thus enhancing RL and RNFLD of the synthesized glaucoma images.




## II. Methodology



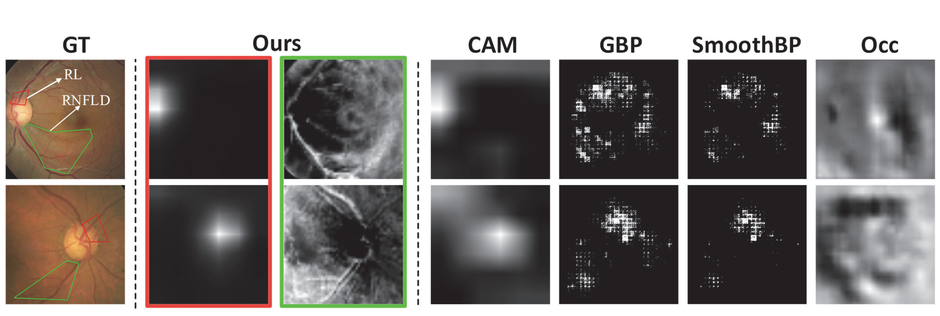

### Pathology-aware network visualization

The pathology-aware network visualization includes three subprocess: (1) The features of a pre-trained classification network are selected by their activation values; (2) the features are further screened and divided into two groups by their centroid-centric moment of inertia (CMI) values; (3) the two groups of features are combined separately in a gradient-based weight and then output the visualization heat maps.

### Patho-GAN for image synthesis

The overall structure of Patho-GAN consists of three subnets: generator net, discriminator net and pathology-aware visualization net. Given the vessel segmentation image (generated by the method proposed in [1]) and a noise code as input, the generator tries to synthesize images, while the discriminator net tries to tell apart the synthesized images from the real ones. The visualization net enforces the synthesized image to have the similar visualization results to the reference image.

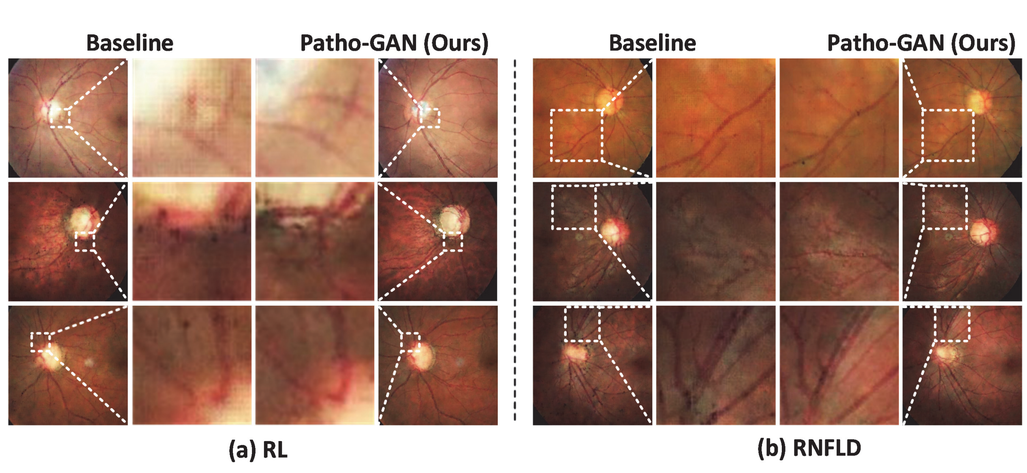
## III. Results




| Accuracy | Ours | CAM | GBP | SmoothBP | Occlusion |
|---|---|---|---|---|---|
| RL | 31.8±0.3 | 21.3±0.2 | 11.2±0.4 | 13.3±0.8 | 4.2±0.2 |
| RNFLD | 41.2±0.5 | 3.8±0.1 | 7.6±0.8 | 6.3±0.7 | 23.6±0.3 |

### Network visualization

As can be seen, our pathology-aware visualization performs better in locating both the RL and RNFLD areas. Besides, CAM creates the heat maps similar to ours but more dispersedly. Occ produces the heat maps highlighting large areas but without any clear emphasis. Although GBP and SmoothBP can show part of the RL and RNFLD, there exists strong noise that makes the pathological regions not be highlighted.




### Image Synthesis

As can be seen, the synthesized images with enhancement in RL can highlight the turning point of blood vessels from the optic cup to the optic disc, and thus the rim is more clear. Moreover, the synthesized images with enhancement in RNFLD show a clearly shading boundary than the baseline, making the RNFLD more evident. The results are verified by the evaluation experiment with the assistance of a professional ophthalmologist.

Reference:

1. Xiancheng, W., Wei, L., Bingyi, M., He, J., Jiang, Z., Xu, W., Ji, Z., Hong, G., Zhaomeng, S.: Retina blood vessel segmentation using a u-net based convolutional neural network. In: ICDS 2018, Beijing, China, 8-9 June 2018 (2018)