Weakly-Supervised Simultaneous Evidence Identification and Segmentation for Automated Glaucoma Diagnosis

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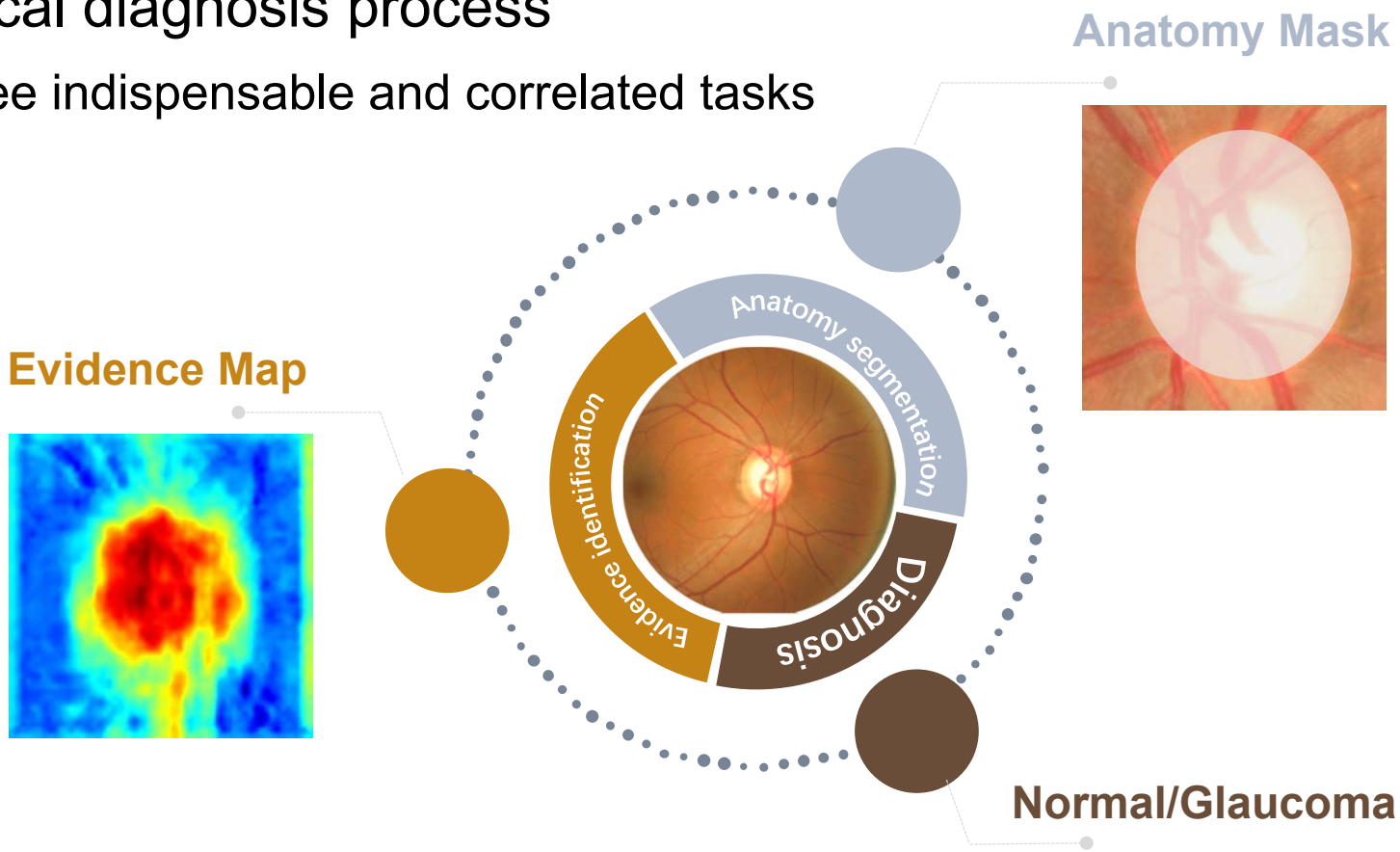
Background

The clinical diagnosis process

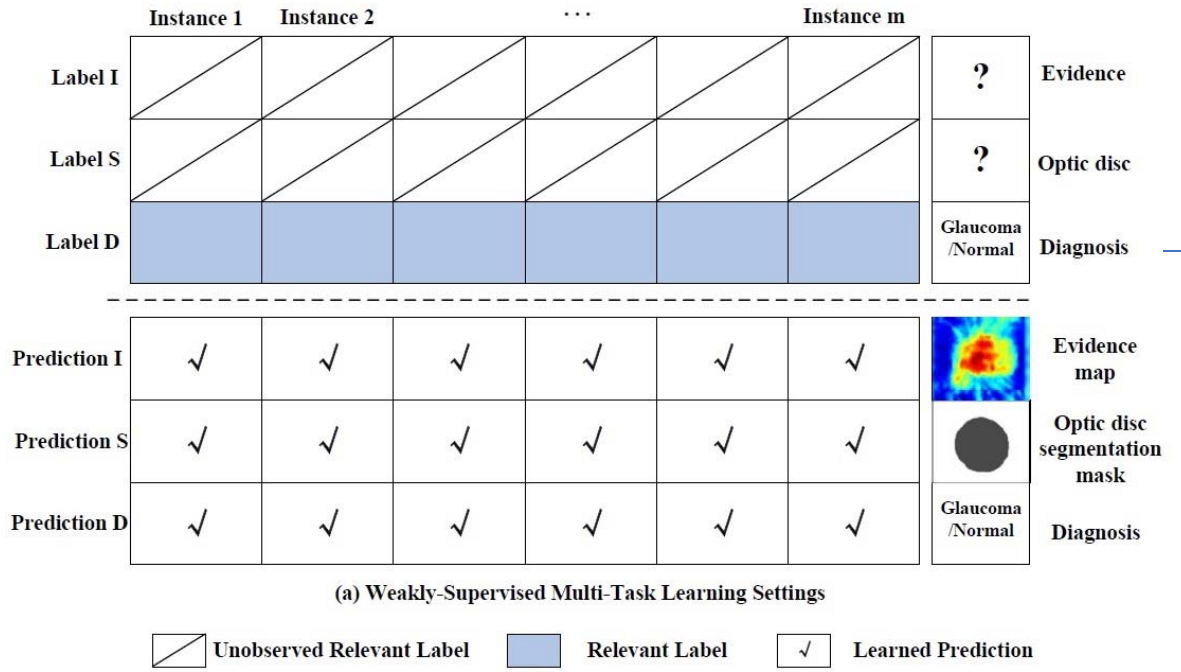
- ✓ Three indispensable and correlated tasks



Overview

Task: Simultaneous delivering the three tasks in a unified framework

Challenges: Classical multi-task learning is unavailable due to unobserved labels

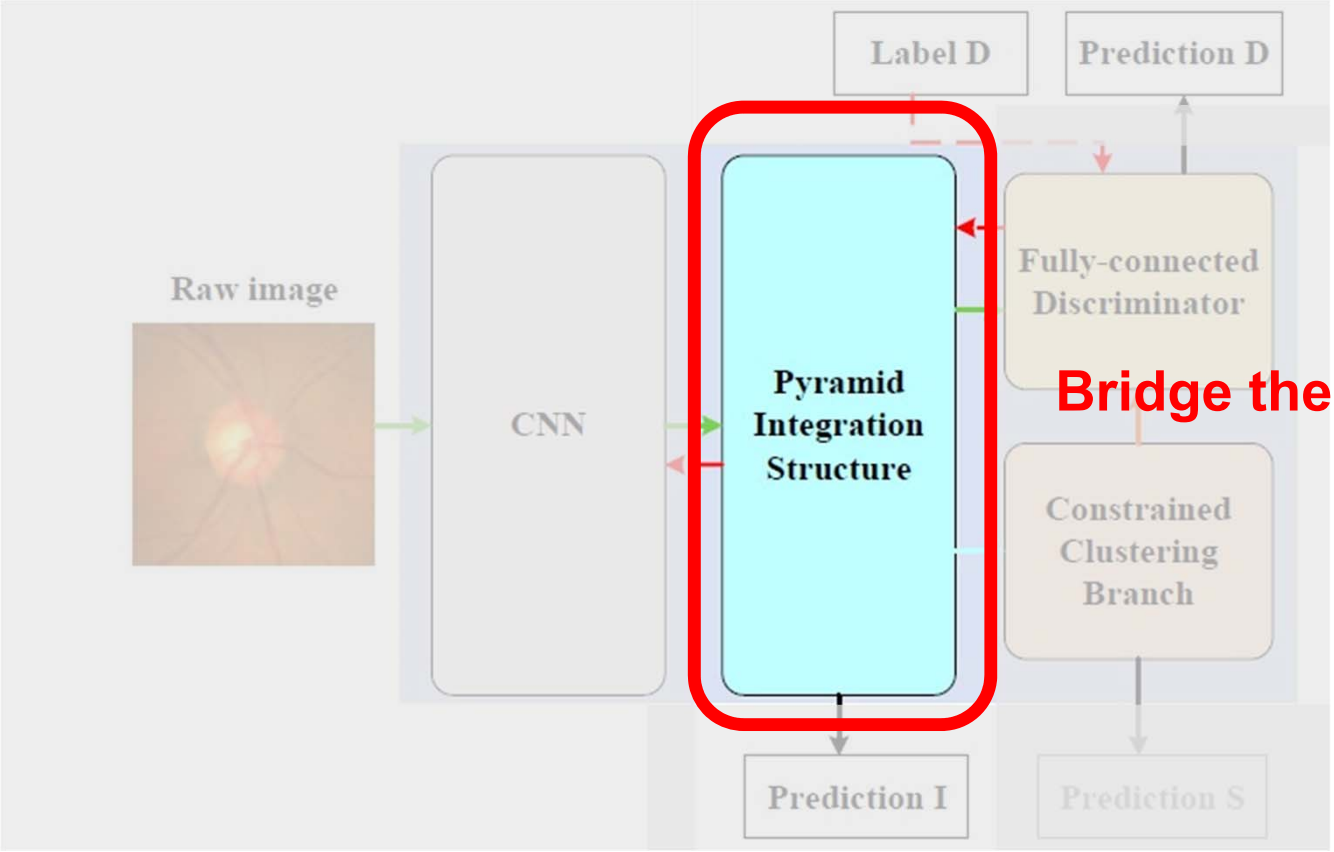


Hard to obtain the pixel-level labels

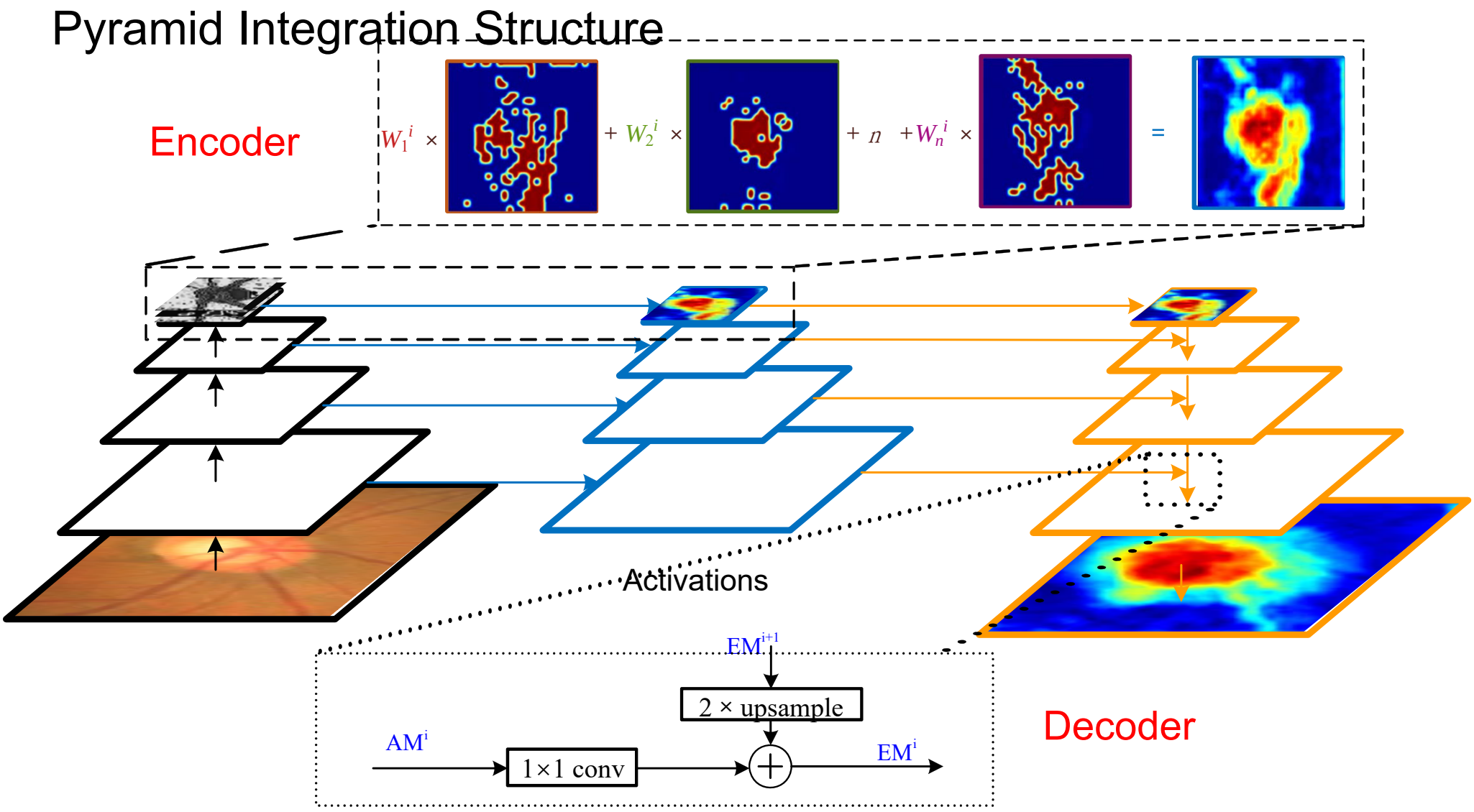
diagnostic labels are readily available

Our Approach

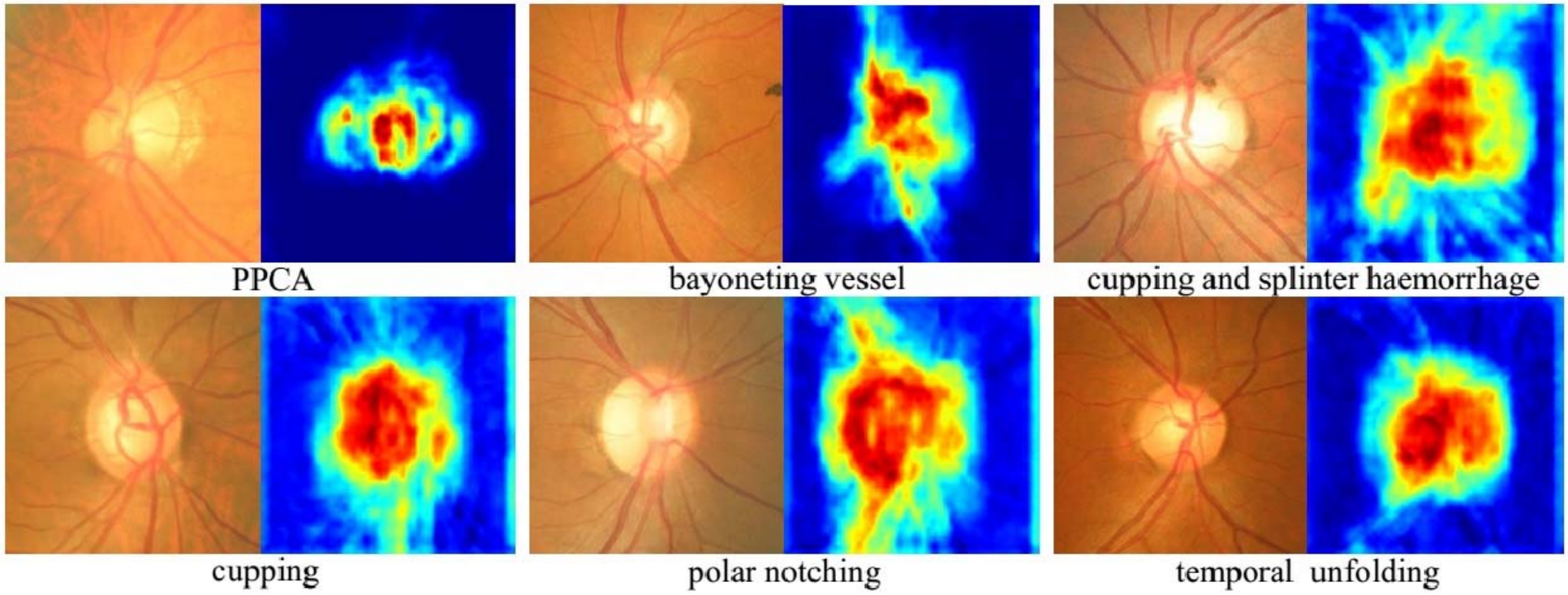
Weakly-Supervised Multi-Task Learning (WSMTL) framework



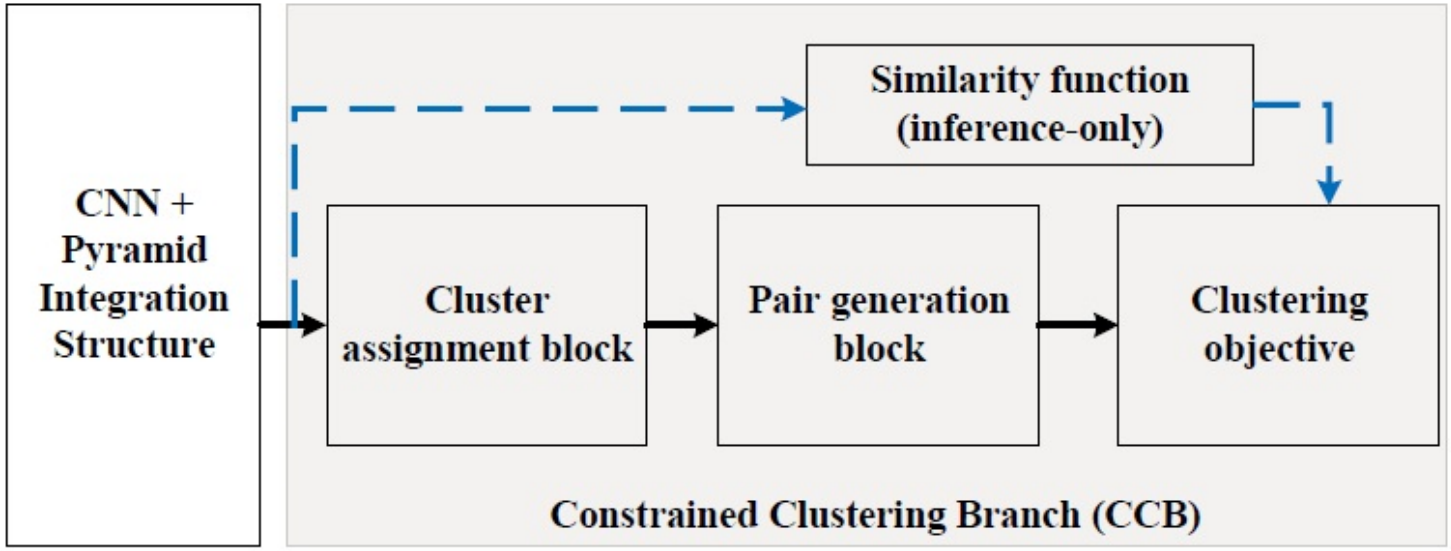
Bridge the gap among the three tasks


Pyramid Integration Structure
Encoder
W_1^i ×
+ W_2^i ×
+ n
+ W_n^i ×
=
Activations
EM^{i+1}
2 × upsample
AM^i
1×1 conv
EM^i
Decoder

Evidence Identification

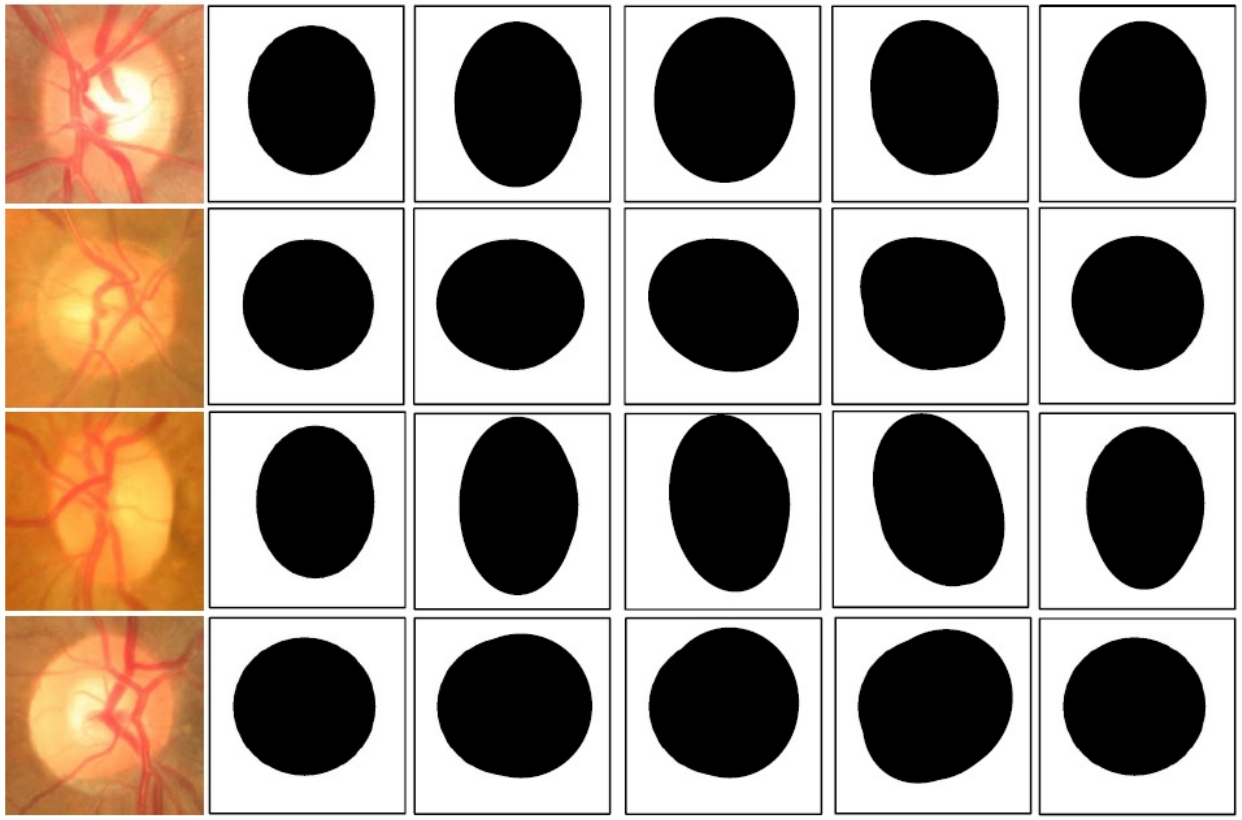


Constrained Clustering Branch for Segmentation



Generating optic disc mask by using the constrained clustering network with predictive pairwise similarity.

Optic disc segmentation



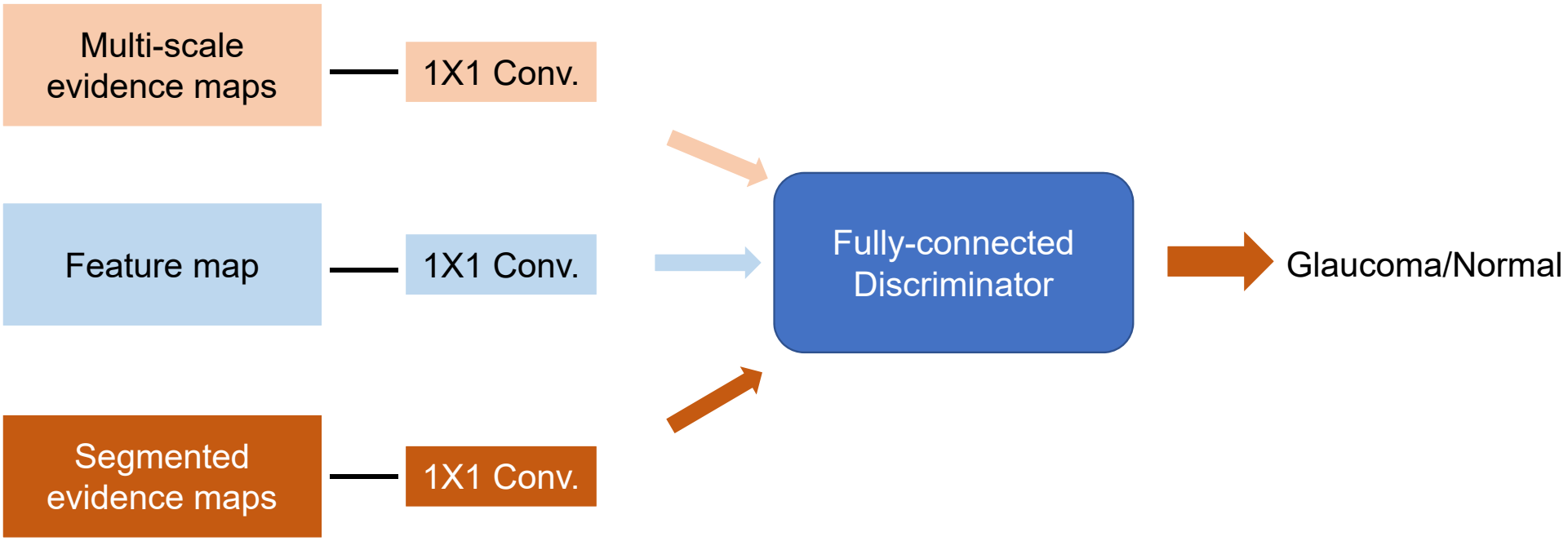
Raw image, ground truth (GT), Unet, DRIU, VAE and our proposed method

Optic disc segmentation

Method	Dice	TP Dice*	AUC
Fully-supervised			
U-Net(Ronneberger, Fischer, and Brox 2015)	**0.87±0.09**	0.85±0.10	-
DRIU(Maninis et al. 2016)	0.82±0.09	0.81±0.11	-
Semi-supervised			
VAE(Sedai et al. 2017)	0.87±0.06	0.84±0.09	-
Our weakly-supervised			
1-layer MGP w/ APM	0.82±0.08	0.83±0.07	0.89
2-layers MGP w/ APM	0.85±0.07	0.86±0.05	0.91
3-layers MGP w/ APM	**0.87±0.06**	**0.89±0.04**	**0.92**
4-layers MGP w/ APM	0.86±0.07	0.88±0.06	0.92
3-layers MGP w/o APM	0.82±0.12	0.83±0.09	0.90

* TP Dice = Dice coefficient over truly detected glaucomatous images.

Glaucoma diagnosis



Glaucoma diagnosis based on feature aggregation

Glaucoma diagnosis

Method	Fu et al. 2018	Fu et al. 2018	Cheng et al. 2013	Zhao et al. 2017	Our
AUC	0.9183	0.8508	0.8269	0.7684	**0.924**
Improve	**0.62%**	**8.60%**	**11.79%**	**20.2%**	

Ensemble classification stagey outperforms naïve diagnosis network

Conclusions

1. A unified framework is proposed to simultaneously deliver three indispensable parts of clinical practice: evidence identification, anatomy segmentation and glaucoma diagnosis.
2. The weakly-supervised multi-task learning (WSMTL) is proposed to endow the model with the ability to discover the evidence regions, obtain the optic disc mask and complete diagnosis learning from weak-label data.

Thanks & Questions