Segmentation of blood vessels in retinal fundus images







Normal Retina

Severe Diabetic Retinopathy



Healthy Optic Nerve

Optic Nerve in Eye with Glaucoma



Healthy

Hypertension damage

Ophtalmoscopy



Retinal image Segmentation Automatic segmentation

Simple bar-selective filter: B-COSFIRE



Each point described by:

 σ : Std. deviation of DoG_{σ} ρ : Radius of circle that the point lies on ϕ : Angle

Rotation invariance:



Filter application

- Use a Gaussian for tolerance, $stdq' \exists e_{0}' + \alpha \rho_i$
- Response for one point:

 $S_{\sigma_{i},\rho_{i},\phi_{i}}(x,y) = \max_{x',y'} \{ c_{\sigma_{i}}(x - \Delta x_{i} - x', y - \Delta y_{i} - y') G_{\sigma'}(x',y') \}$

• Multiply the shifted responses -> COSFIRE



Pre-processing



Putting it all together



Tuning parameters B-COSFIRE

- **\mathbf{O}:** DoG_{σ}
- ρ: The largest circle

$$\sigma' = \sigma'_0 + \alpha \rho_i$$

• α

Symmetric: $\sigma = 4.8$, $\rho = 20$, $\sigma_0 = 3$, $\alpha = 0.3$ Assymetric: $\sigma = 4.4$, $\rho = 36$, $\sigma_0 = 1$, $\alpha = 0.1$



Segmentation performance

	Classifier: Vessel	Classifier: Non-Vessel
GT: Vessel	TP	FN
GT: Non-Vessel	FP	TN

 $MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}} \in [-1, 1]$



∀^{tt} **₮₽₨₨₱₱**



IOSTAR



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Machine learning approaches



Deep neural network

B-COSFIRE



AUC: .9720

 $\boldsymbol{\mathsf{N}}$

AUC: .9614

Thank you.