TOWARD OPEN-SET FACE RECOGNITION

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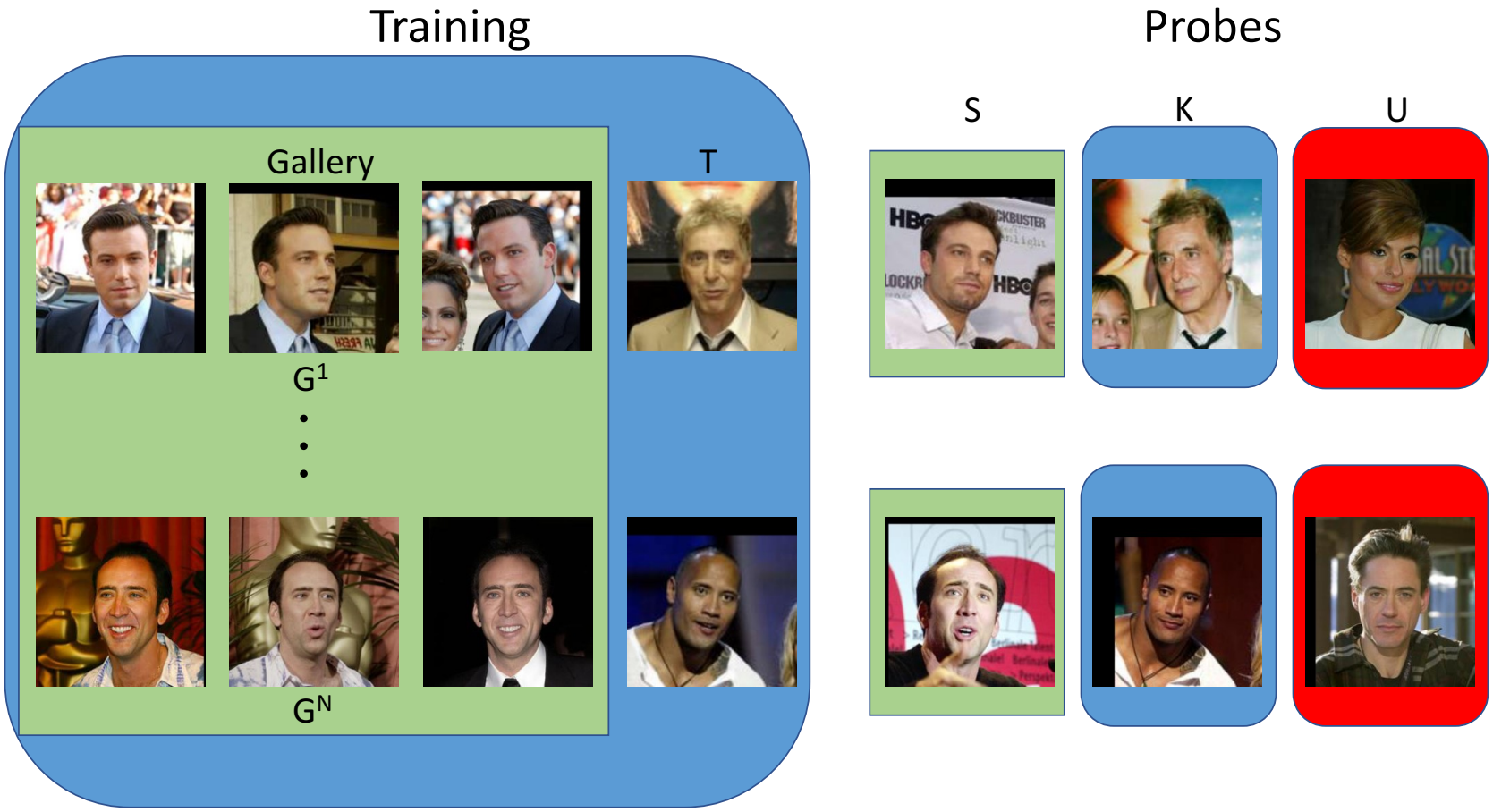
Why Does This Matter?

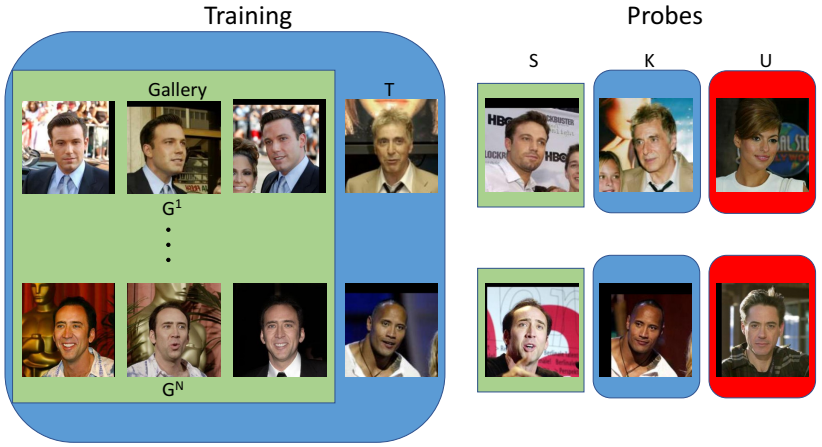
Known Unknowns

Open-Set Face Recognition



Our Protocol

- Labeled Faces in the Wild (LFW)



Identities	Images per Subject	# of Images	Category
610	>3	6733	Known ($\boldsymbol{S}$)
1070	2 or 3	2431	Known Unknown ($\boldsymbol{K}$)
4069	1	4069	Unknown Unknown ($\boldsymbol{U}$)
5749	**-**	**13233**	$\boldsymbol{S} \cup \boldsymbol{K} \cup \boldsymbol{U}$

EXPERIMENTS

- VGG
  - Feature dimension: 4096
  - Removed last layer including ReLU
  - Used funneled LFW images

- http://www.robots.ox.ac.uk/~vgg/software/vgg_face/

Cosine Similarity

- Use as baseline measurement

$$s_{\text{avg}}(\bar{G}^g, P) = \cos\left(\bar{G}^g, P\right)$$

$$\bar{G}^g = \frac{1}{3} \sum_{i \in \{0,1,2\}} G_i^g$$

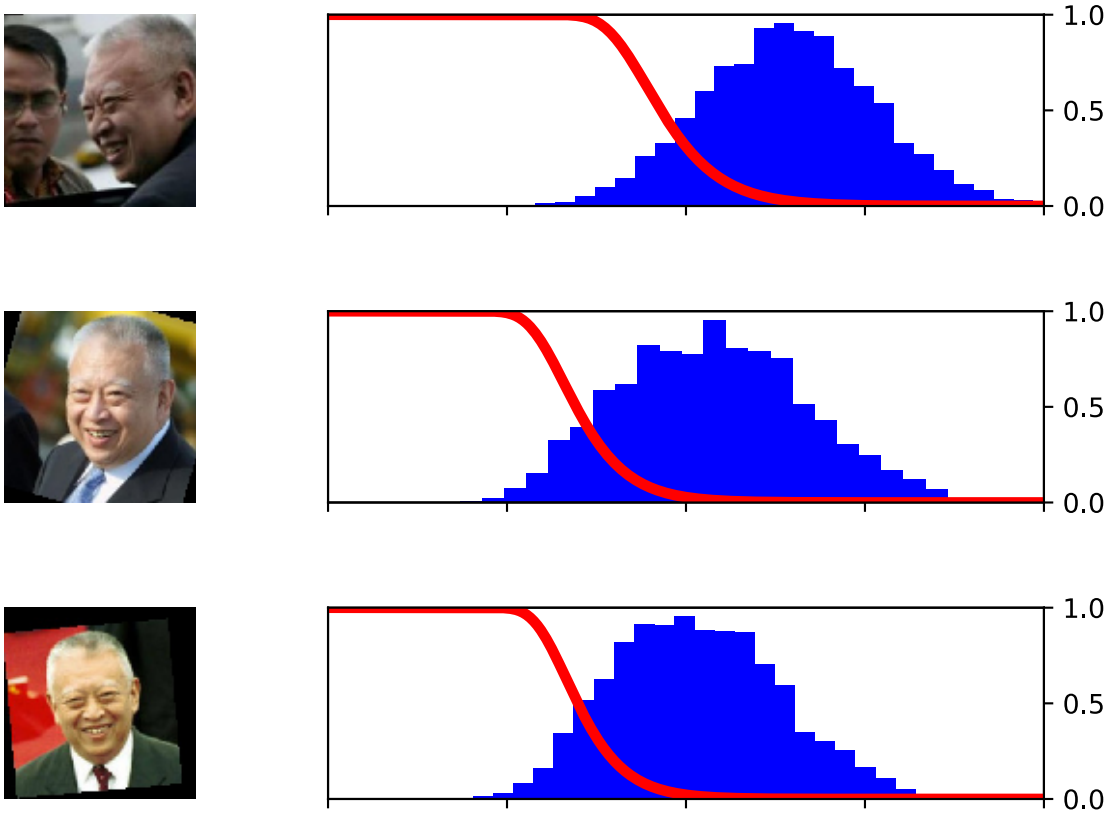
$$s_{\max}(G^g, P) = \max_{i \in \{0,1,2\}} \cos\left(G_i^g, P\right)$$

Linear Discriminant Analysis (LDA)

$$y_{G_i^g} = W^T G_i^g \qquad y_{\bar{G}^g} = W^T \bar{G}^g \qquad y_P = W^T P$$

$$s_{\max}\left(y_{G_i^g}, y_P\right) \qquad\qquad s_{\text{avg}}\left(y_{\bar{G}^g}, y_P\right)$$

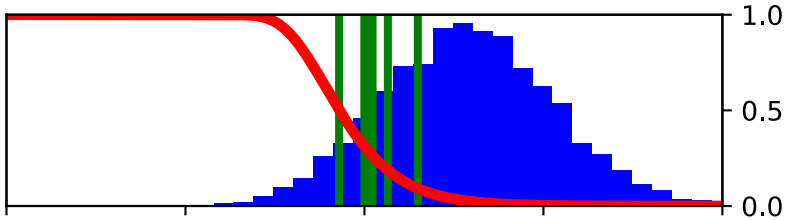
Extreme Value Machine (EVM)

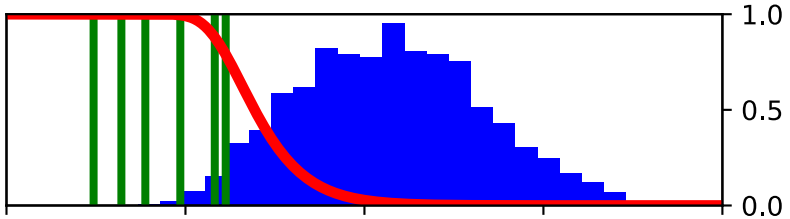


$$\Psi(G_i^g, P; \kappa_i^g, \lambda_i^g) = \exp^{-\left(\frac{d(G_i^g, P)}{\lambda_i^g}\right)^{\kappa_i^g}}$$

$$s_{\max}(G^g, P) = \max_{i \in \{0,1,2\}} \Psi(G_i^g, P, \kappa_i^g, \lambda_i^g)$$

$$s_{\text{avg}}(G^g, P) = \Psi(\bar{G}^g, P, \bar{\kappa}^g, \bar{\lambda}^g)$$


1.0
0.5
0.0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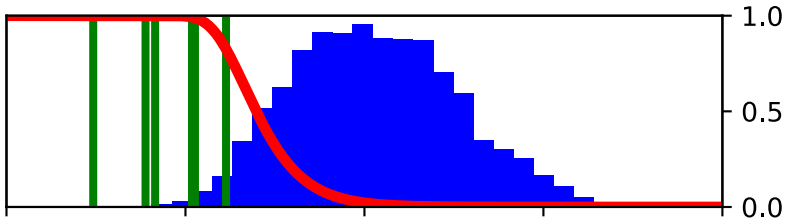
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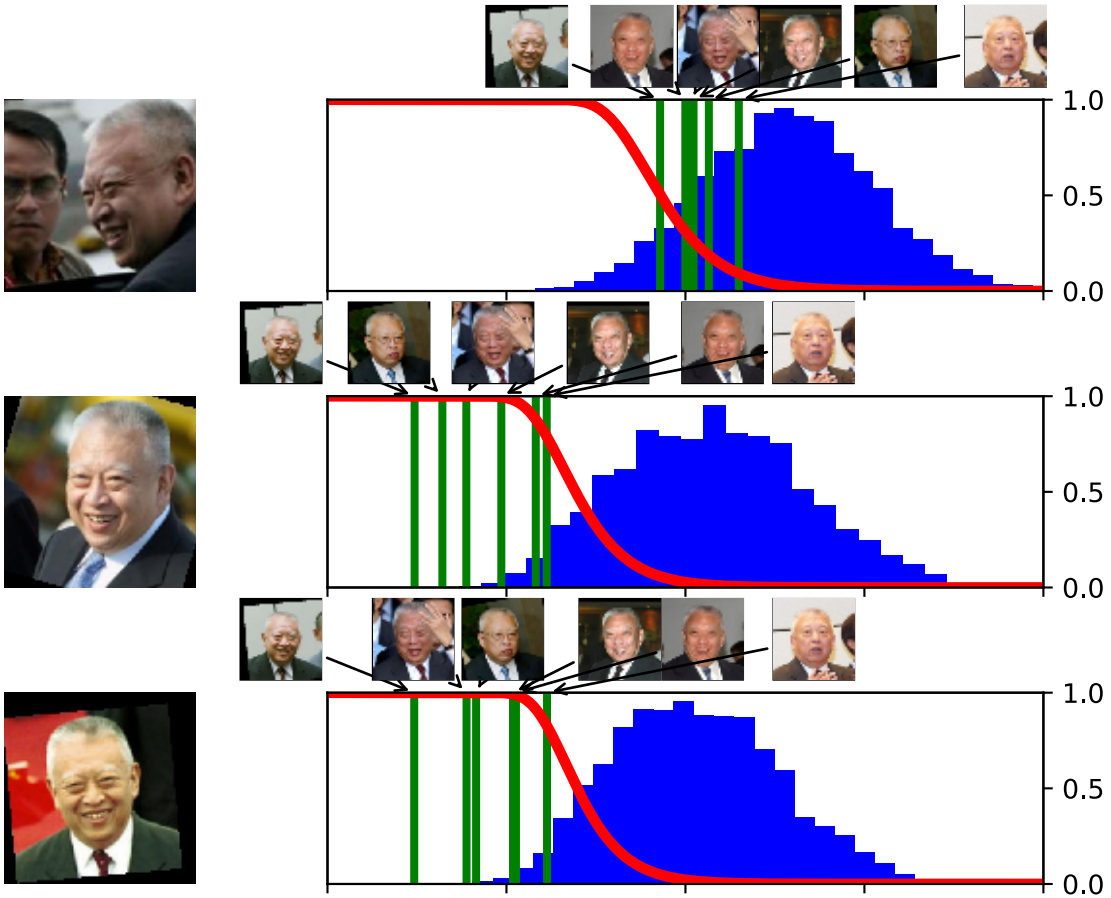
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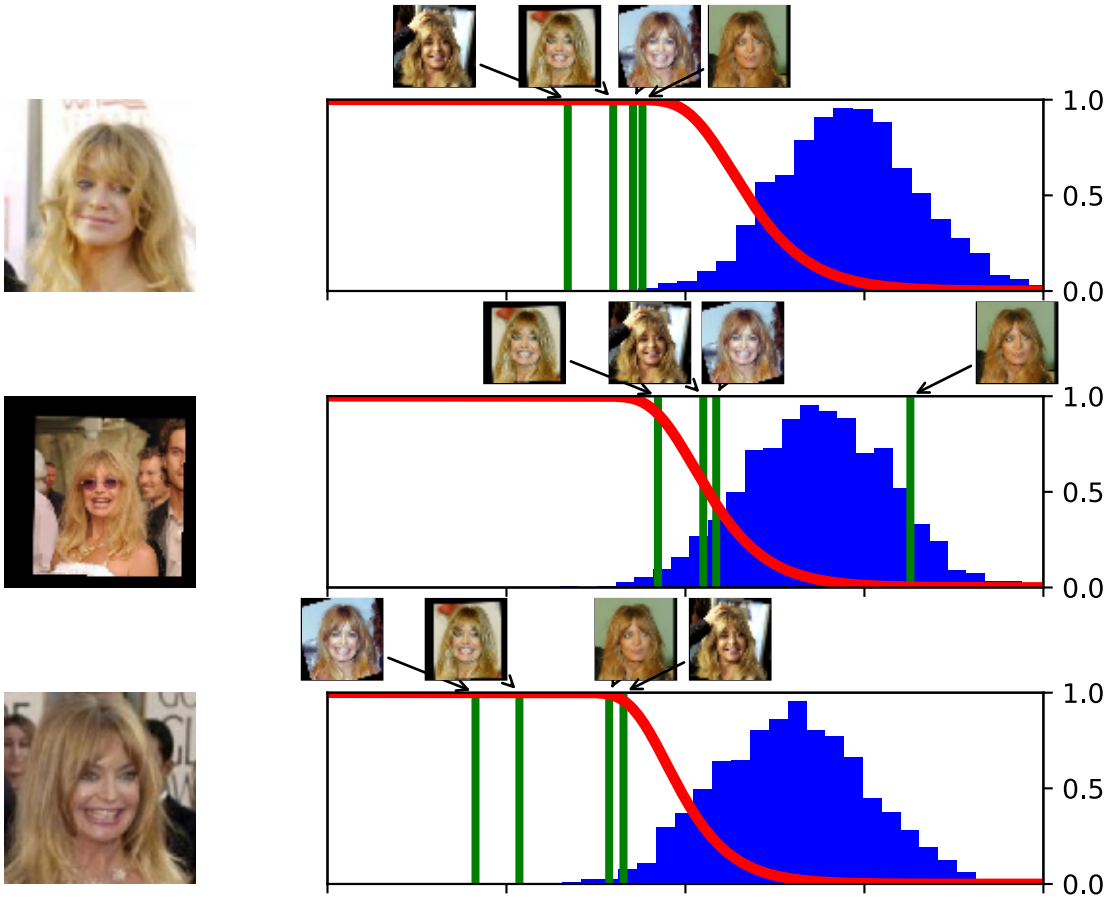
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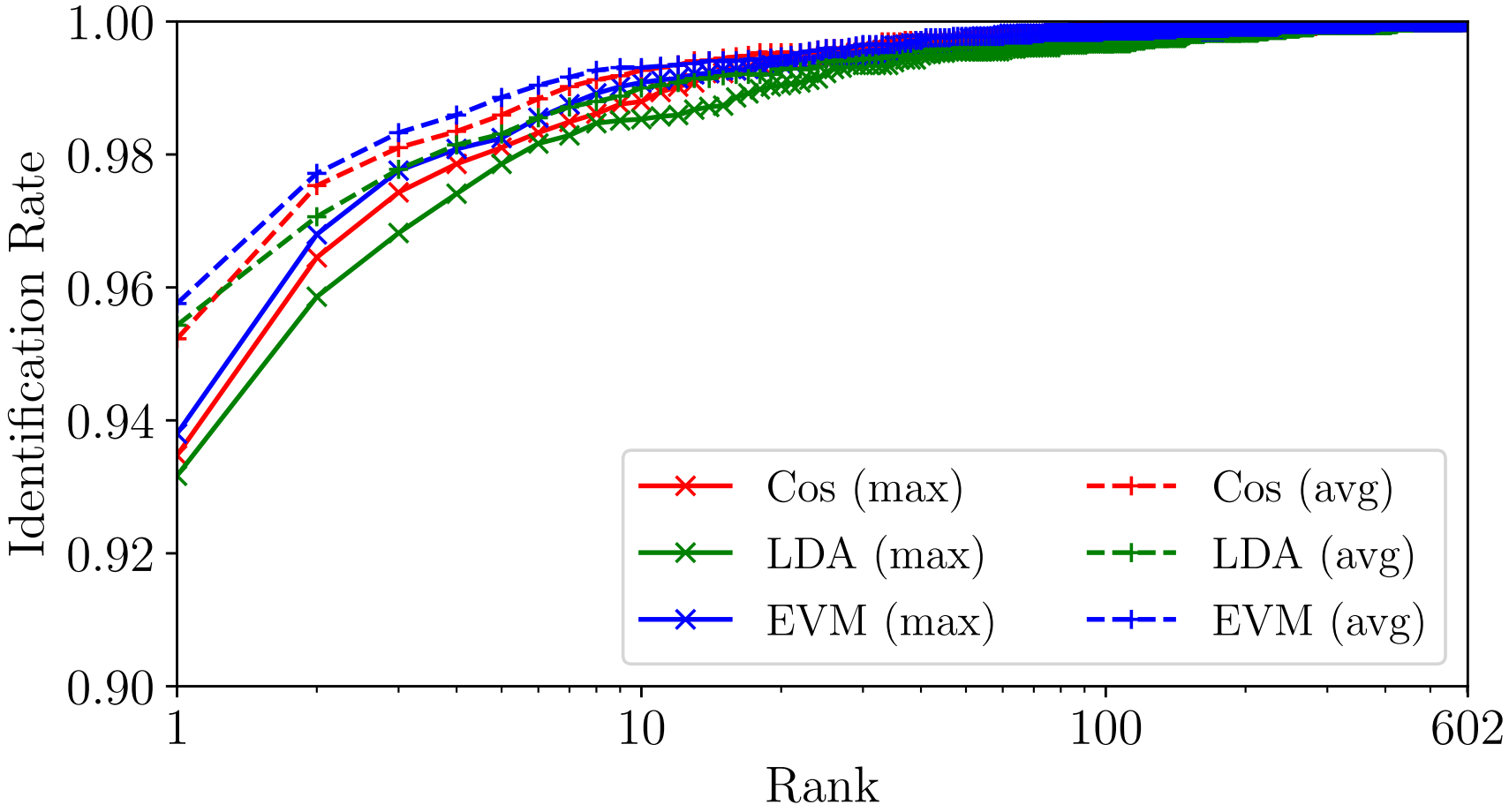
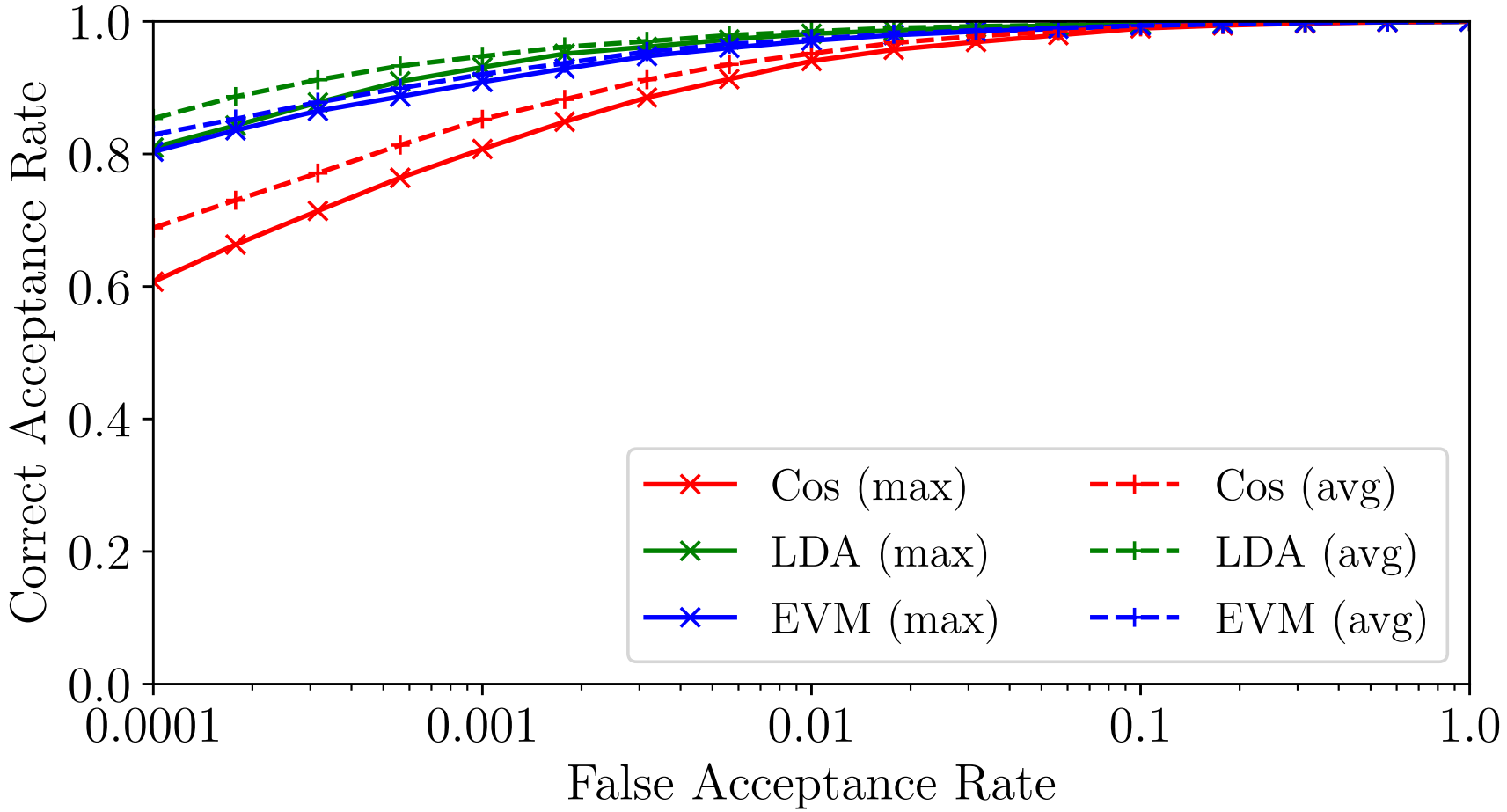
RESULTS

Closed-set identification



RESULTS

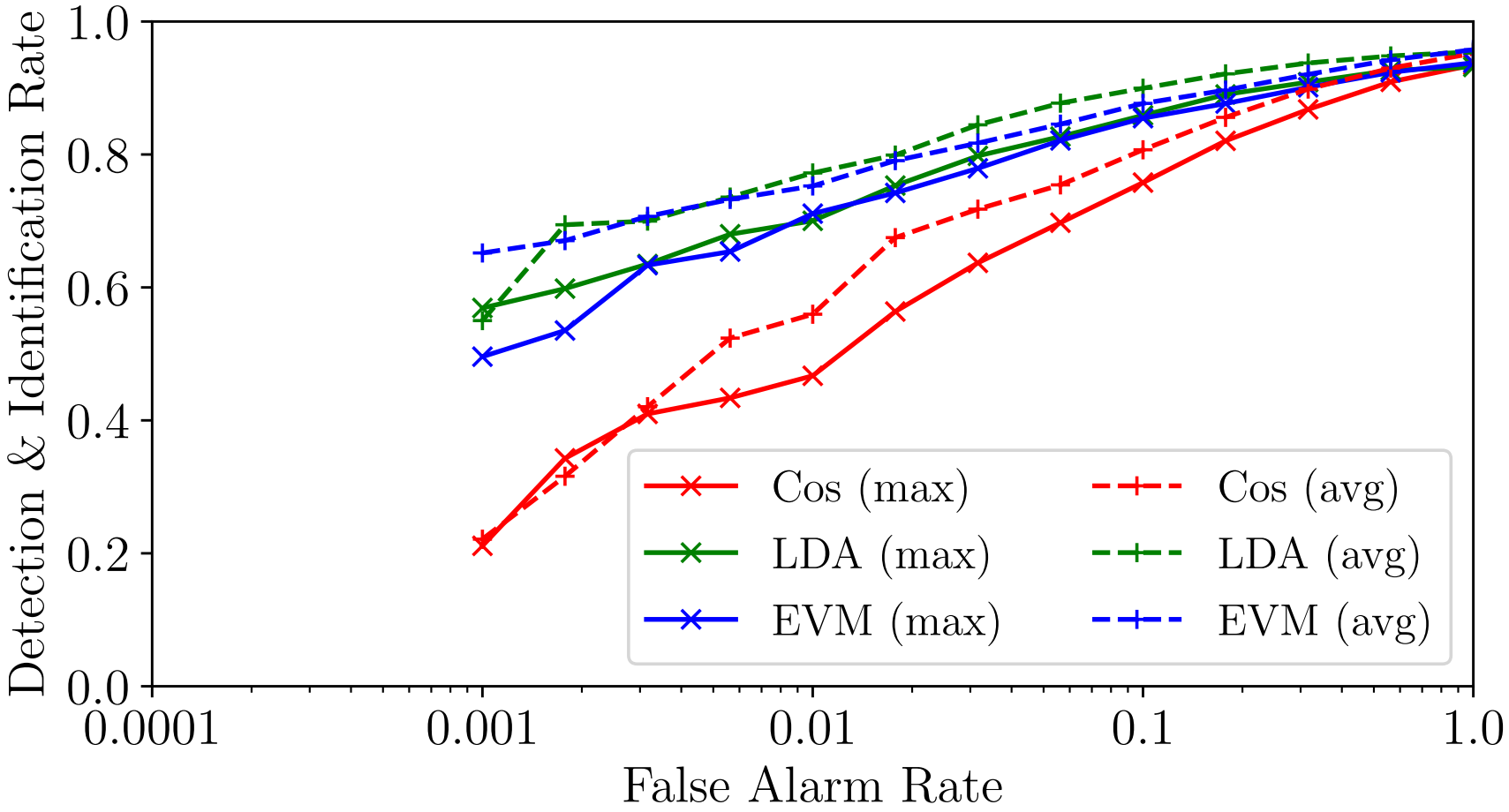
Closed-set verification



- False Alarm Rate (FAR)
  - Computed on unknowns ($\boldsymbol{K}$ + $\boldsymbol{U}$)
  - 1 similarity over threshold
- Detection and Identification Rate (DIR)
  - Computed on the knowns ($\boldsymbol{S}$)
  - Most similar in gallery and over threshold
- Increase threshold
  - Decrease FAR
  - Decrease DIR

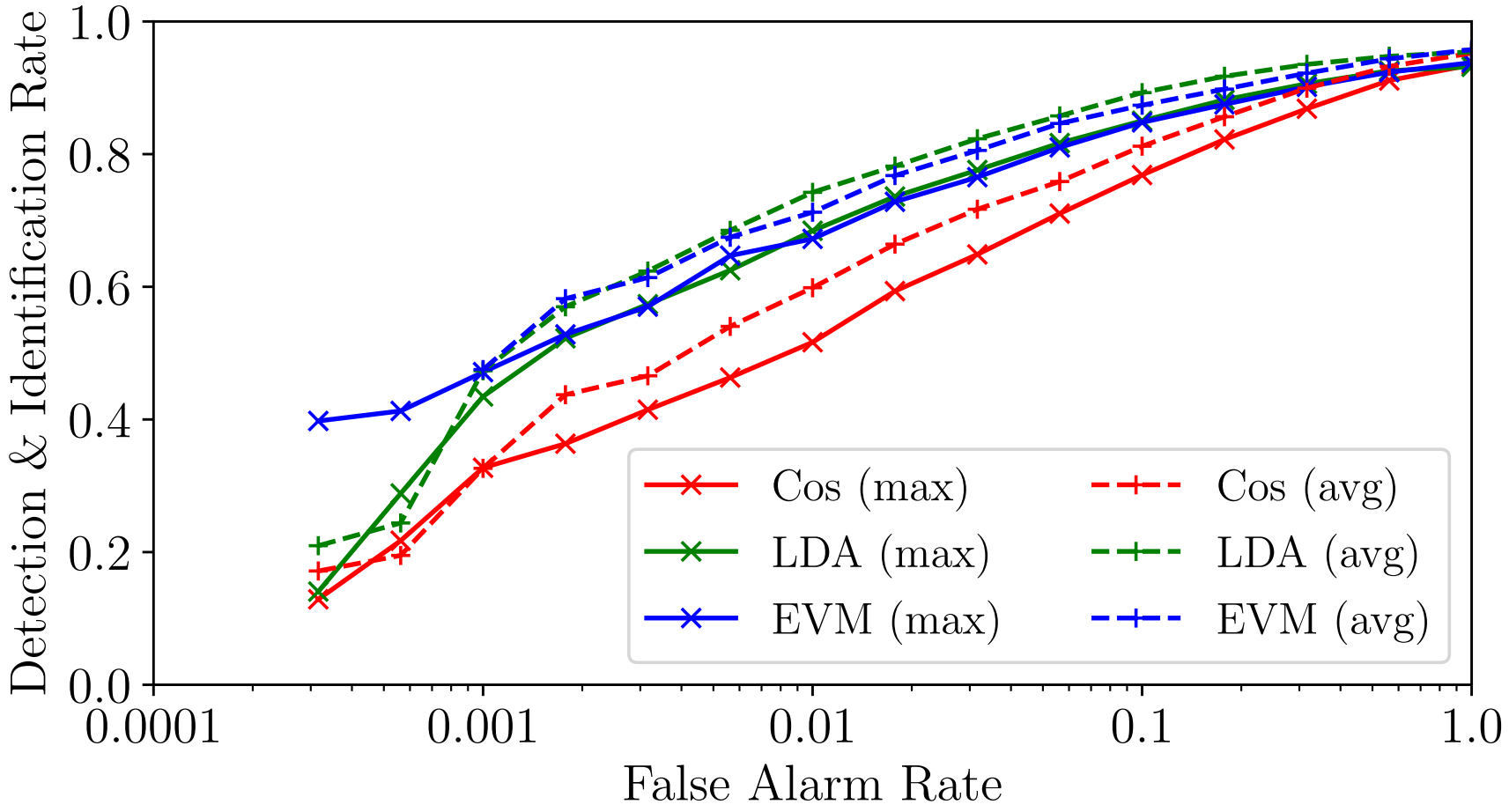
RESULTS

Open-set identification with known unknowns (K)



RESULTS

Open-set identification with unknown unknowns (U)



Conclusion

- Introduced open-set protocol for LFW
  - Known (S)
  - Known unknowns (K)
  - Unknown unknowns (U)

- Closed-set solved for LFW?
- Open-set unsolved!

- Evaluated EVM
  - Open-set by design
  - Step Toward Open-Set Face Recognition