THE STATE OF AUTOMATED FACE RECOGNITION AND BIAS: "SEPARATING FACT FROM FICTION!"

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Collaborative research effort with
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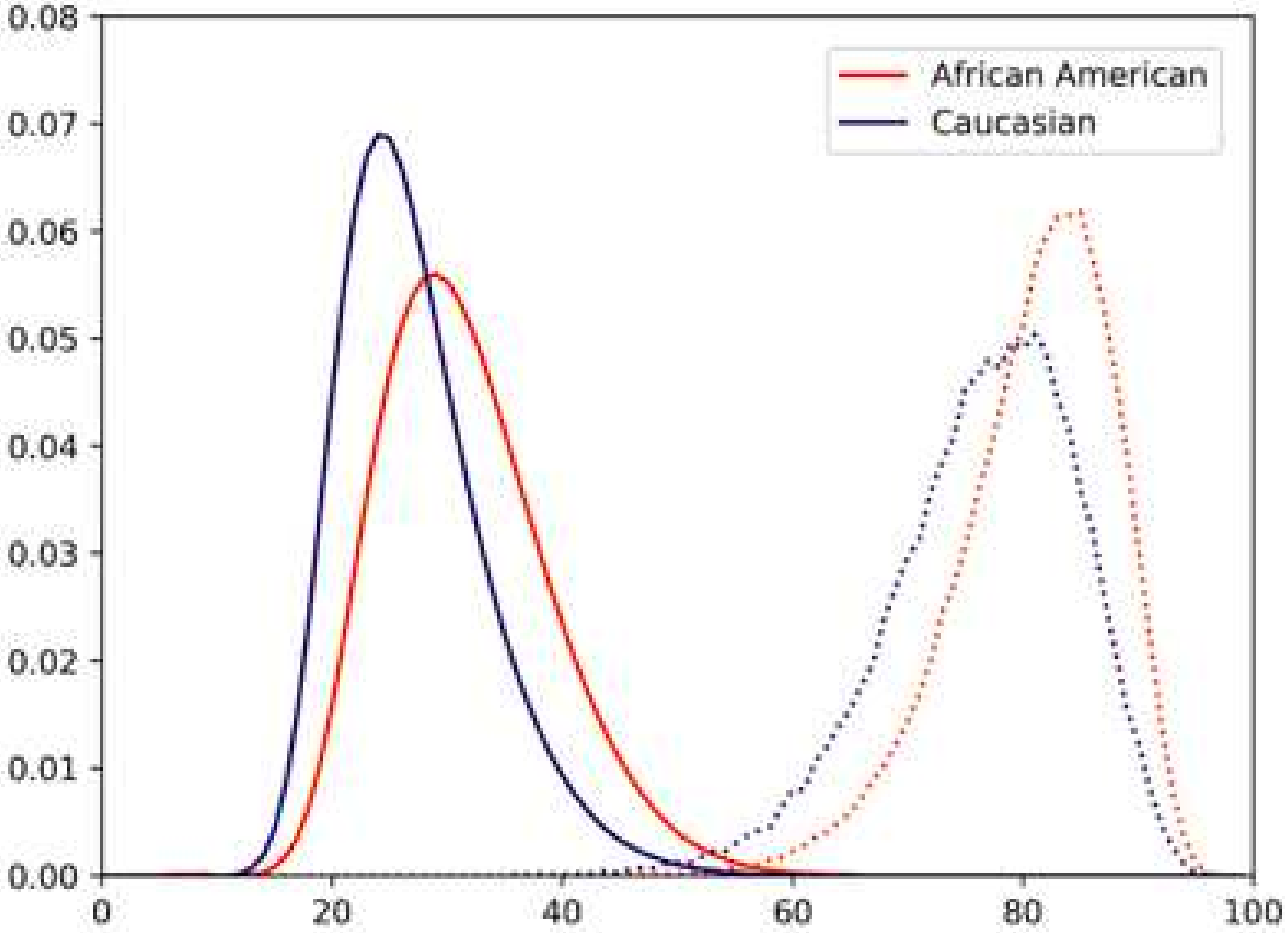
Project Objectives (ongoing work)

- **What differences in face recognition accuracy really exist between groups?**
- **Why do these differences exist?**
- What might be done to mitigate these differences?

ResNet Impostor & Authentic Distributions

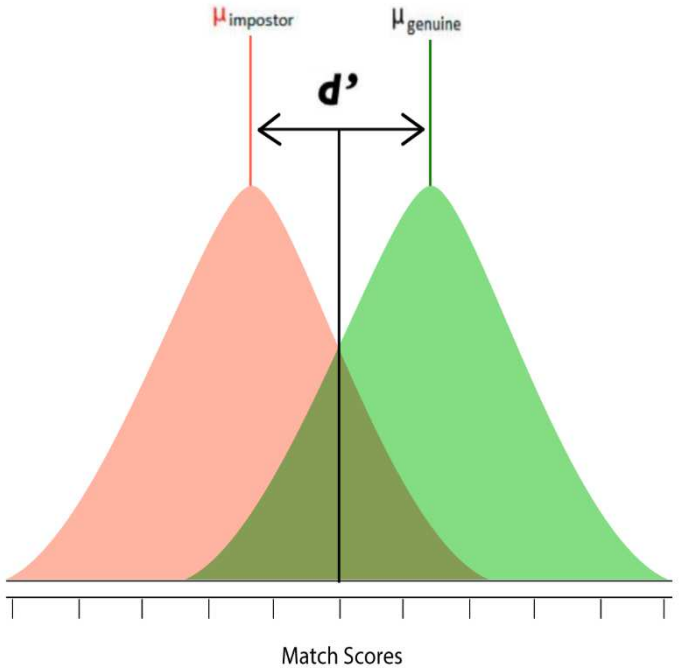


African-American Impostor and Authentic distributions are both shifted to higher similarity scores.

D-Prime Statistic

The d-prime value (*d'*) measures the separation between the means of the genuine and impostor probability distributions in standard deviation units, and is defined as:

$$d' = \frac{\sqrt{2}\,|\,\mu_1 - \mu_0\,|}{\sqrt{\sigma_1^2 + \sigma_0^2}}$$



where μ1: mean of genuine score distribution

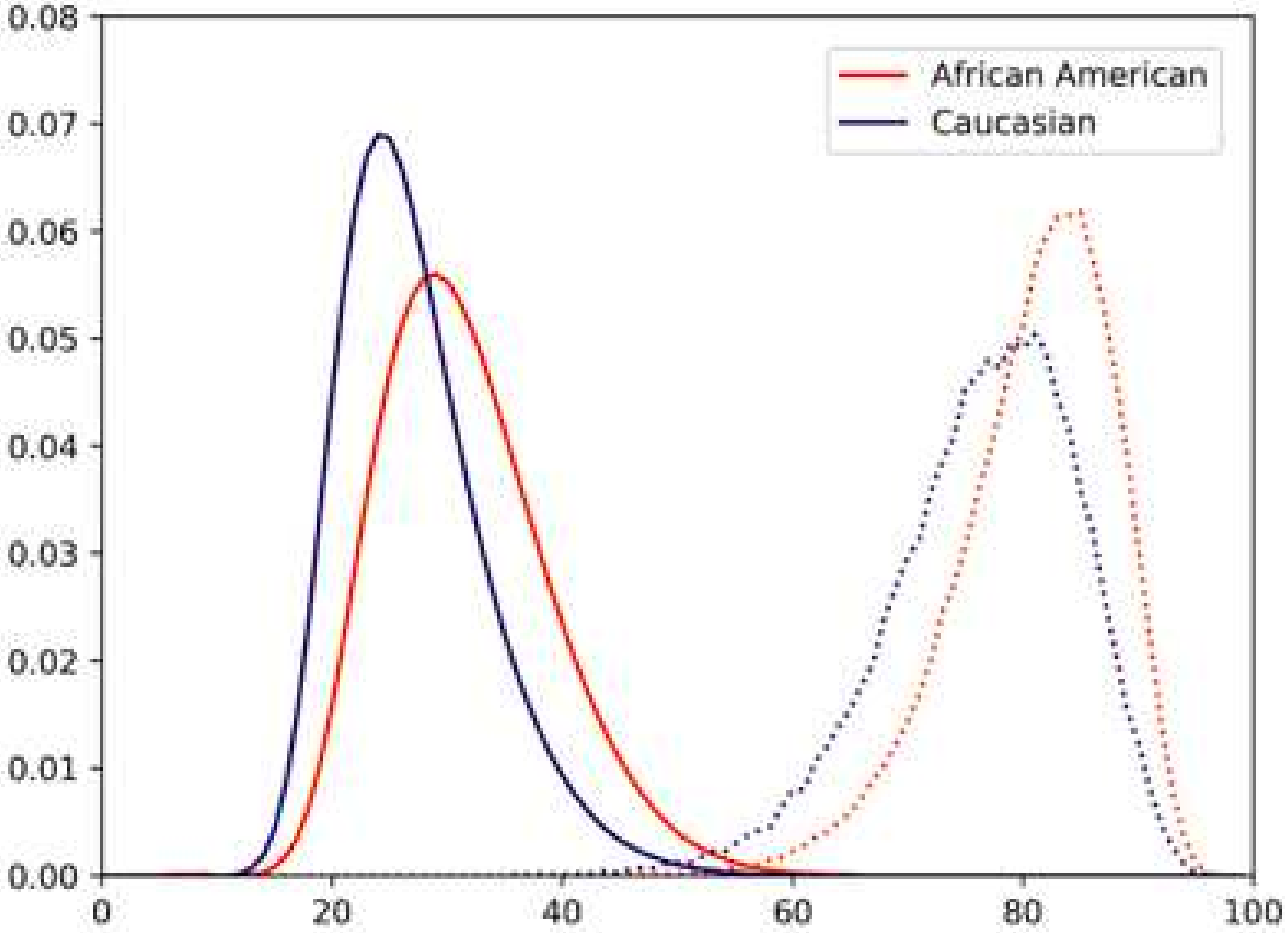
μ0: mean of impostor score distribution

σ1: standard deviation of genuine score distribution

σ0: standard deviation of impostor score distribution

Higher d-prime value indicates better performance.

ResNet Impostor & Authentic Distributions



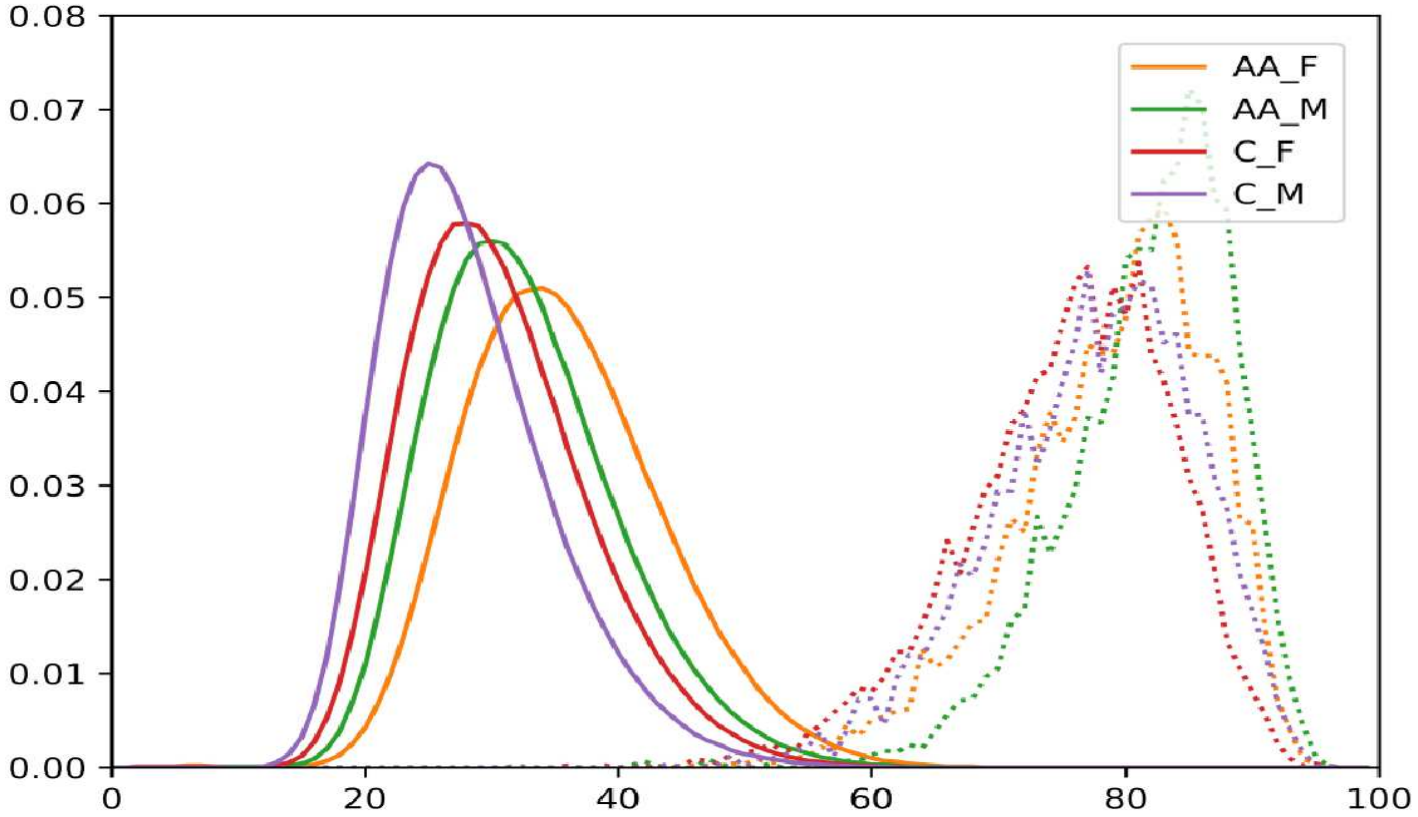
	d-prime values
	ResNet
African-American	6.69
Caucasian	6.59

African-American Impostor and Authentic distributions are both shifted to higher similarity scores.

The Consistent Accuracy Difference

- The consistent difference is that, at a given decision threshold, African-American images have a higher FMR (error) and a higher TPR (accuracy) compared to Caucasian images.
- The African-American impostor and authentic distributions are both shifted to higher similarity scores.

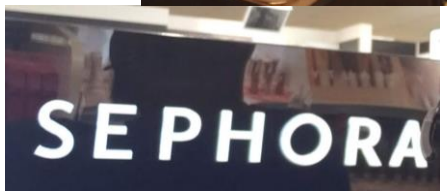
ResNet Impostor & Authentic Distributions



	d-prime values
	ResNet
African-American Male	6.65
African-American Female	5.36
Caucasian Male	6.49
Caucasian Female	5.55

- AA (M/F) Impostor and Authentic distributions shifted to higher similarity scores relative to C.
- Female (AA/C) distributions shift closer relative to male.

What's My Skin Tone?



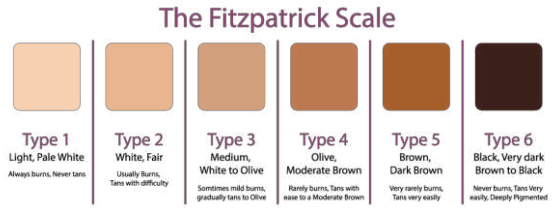
Color: 10-Walnut (Sephora)
"deep with neutral undertones"
Clarksburg, WV;
September 29th, 2019

Lancôme, Chicago, Il; October 26th, 2019

Skin Type Classification Schemes

Fitzpatrick Scale

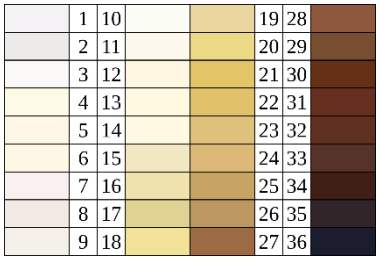
The Fitzpatrick skin typing system was developed as a tool for classifying skin type in terms of reaction to ultraviolet radiation and is widely used in dermatology.



https://hairport1.com.au/laser-hair-removal/fitzpatrick-skin-type-scale_219892/

Von Luschan scale

The von Luschan scale was used to establish racial classifications of populations according to skin color; but in many instances it produced inconsistent results.



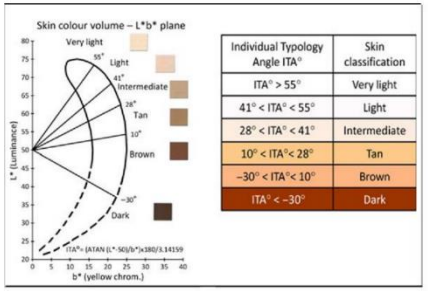
Studies mapped von Luschan 36 colors to Fitzpatrick band.

https://en.wikipedia.org/wiki/Von_Luschan%27s_chromatic_scale/

Individual Typology Angle

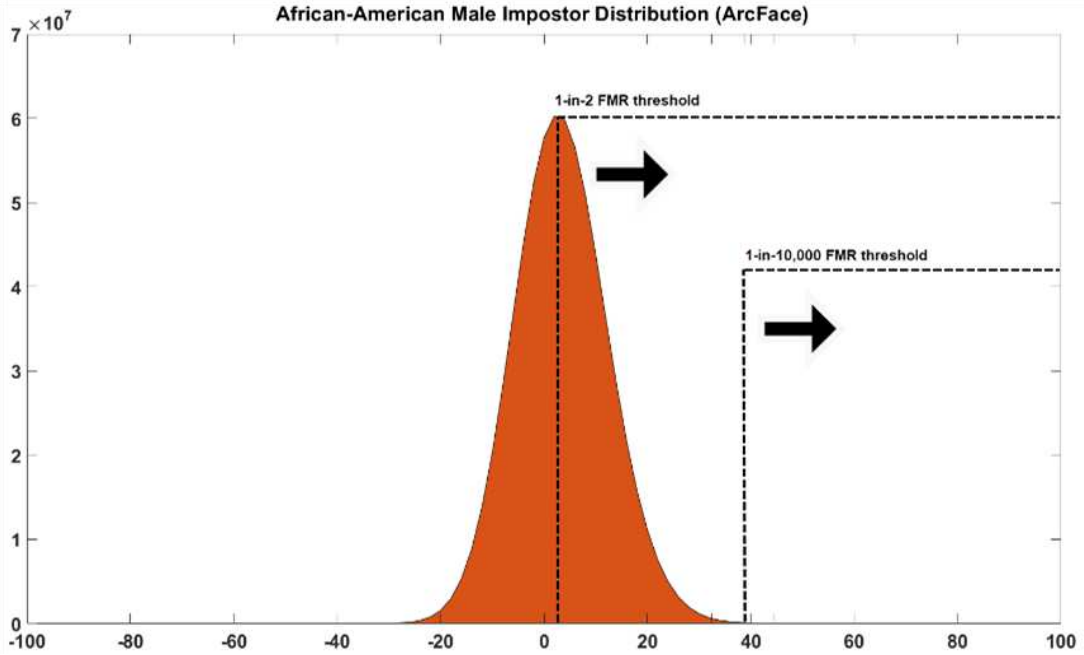
The individual typology angle (ITA) allows skin color classification into six groups, from very light to dark skin. It is calculated as:

$$IndividualTypologyAngle(ITA) = \frac{arctan(\frac{(L-50)}{b} * 100}{\pi}$$



https://www.kentimaging.com/wp-content/uploads/2019/04/Training%20Deck%20201%20FINAL.pdf

Influence of Skin Tone on FMR



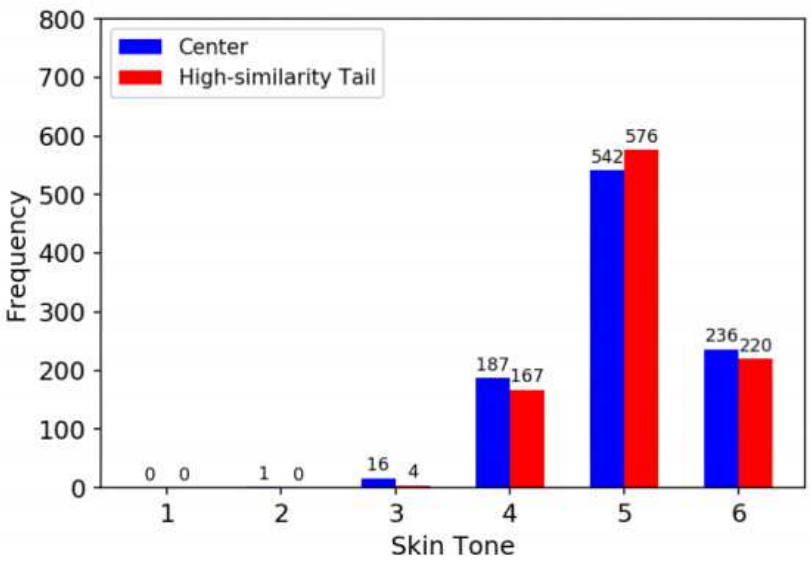
The basic premise of this experimental work is simple -

Are the images or image pairs in the high-similarity tail of the impostor distribution (false match region) different in any significant way from in the rest of the distribution?

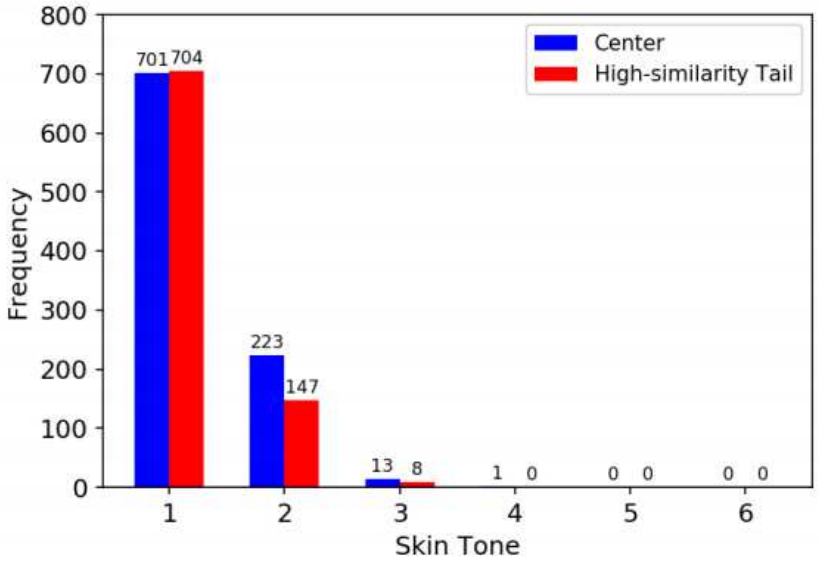
Human-based Fitzpatrick Rating

Distribution of Fitzpatrick skin tone ratings for false matches sampled from African-American male and Caucasian male impostor distributions.

- 500 image pairs from 1-in-2 FMR threshold region **(center or no-false-match region)**
- 500 image pairs from 1-in-10,000 FMR threshold region **(high-similarity tail or high-likelihood-false-match region)**



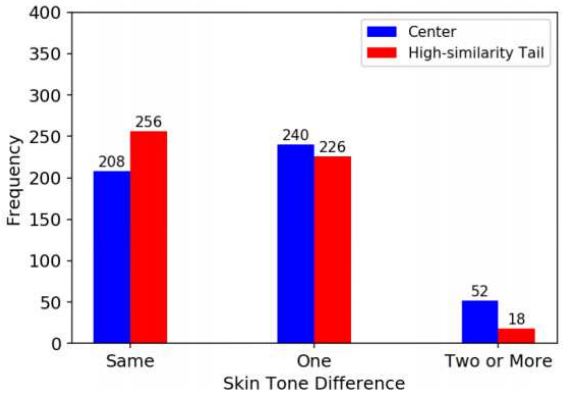
African-American Male



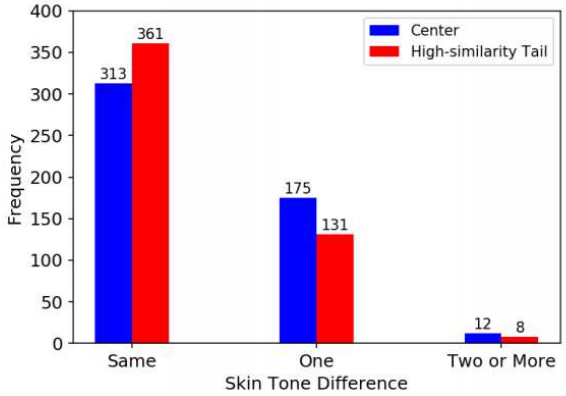
Caucasian Male

Human-based Fitzpatrick Rating

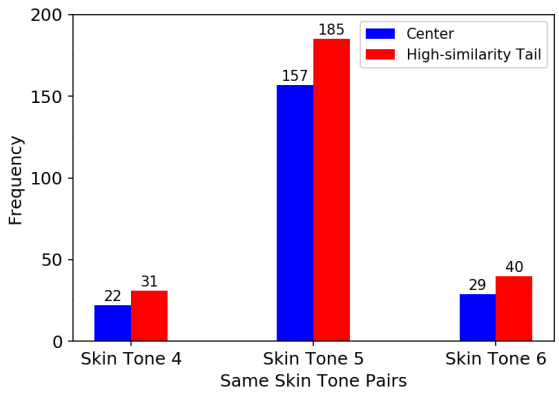
A false match is a result obtained for a pair, rather than a single image. This motivates examining the frequency of image pairs where both are rated as darker skin-tone.



African-American Male



Caucasian Male



African-American Male

Same-skin-tone pairs occur more frequently in the high-similarity tail of the distribution.

No clear evidence to support a general conclusion that darker skin tone, in and of itself, causes an increased FMR

Major Takeaways

- **Use of human raters, untrained or trained, results in skin tone ratings that can often be subjective and inaccurate.**

I I II IV V VI VI

Example Fitzpatrick skin tone outliers found in the IJB-C dataset.

- **Efforts to automate the process of skin tone labeling from images show that this is a challenging task, and mislabeling can occur due to variations in lighting, shadows, occlusions, and low resolution.**

ITA = -80 ITA = -75 ITA = -40 ITA = -85 ITA = -51 ITA = -58 ITA = -62

Example Fitzpatrick skin tone outliers found in the DiF dataset. The ITA skin tone annotations given in the metadata for all images above are Fitzpatrick skin type VI.

Publicity about face recognition “bias”

engadget

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The New York Times

TECHNOLOGY | Wrongfully Accused by an Algorithm

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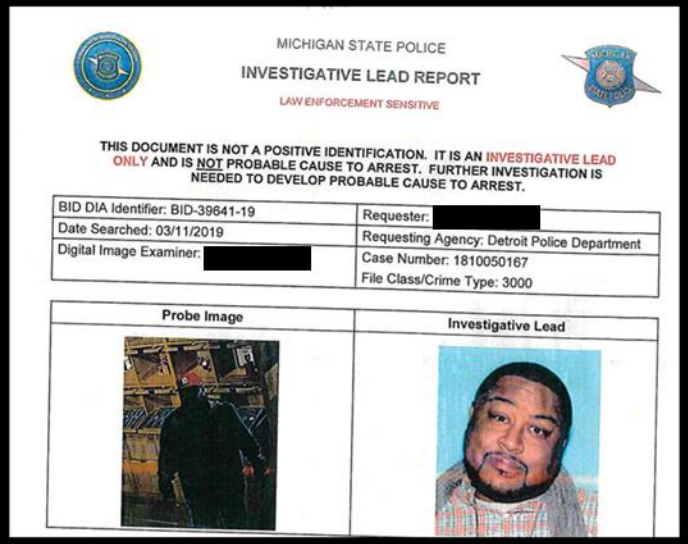
Wrongfully Accused by an Algorithm

In what may be the first known case of its kind, a faulty facial recognition match led to a Michigan man's arrest for a crime he did not commit.



MICHIGAN STATE POLICE

INVESTIGATIVE LEAD REPORT

LAW ENFORCEMENT SENSITIVE

THIS DOCUMENT IS NOT A POSITIVE IDENTIFICATION. IT IS AN INVESTIGATIVE LEAD ONLY AND IS NOT PROBABLE CAUSE TO ARREST. FURTHER INVESTIGATION IS NEEDED TO DEVELOP PROBABLE CAUSE TO ARREST.

BID DIA Identifier: BID-39641-19	Requester: [redacted]
Date Searched: 03/11/2019	Requesting Agency: Detroit Police Department
Digital Image Examiner: [redacted]	Case Number: 1810050167
	File Class/Crime Type: 3000

Probe Image	Investigative Lead

any visible on the person in the video. When Oliver's attorney took photos of him to the victim and an assistant prosecutor, they agreed Oliver had been misidentified. A judge later dismissed the case.

Publications

- K. S. Krishnapriya, Kushal Vangara, Michael C. King, Vitor Albiero and Kevin Bowyer. “Characterizing the Variability in Face Recognition Accuracy Relative to Race”, 2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW) (2019).

- K. S. Krishnapriya, V. Albiero, K. Vangara, M. C. King and K. W. Bowyer, “Issues Related to Face Recognition Accuracy Varying Based on Race and Skin Tone”, in IEEE Transactions on Technology and Society, vol. 1, no.1, pp. 8-20, March 2020.

- Albiero, Vitor, Krishnapriya KS, Kushal Vangara, Kai Zhang, Michael C. King, and Kevin W. Bowyer. “Analysis of gender inequality in face recognition accuracy”, In Proceedings of the IEEE Winter Conference on Applications of Computer Vision Workshops, pp. 81-89. 2020.

- V. Albiero, K. W. Bowyer, K. Vangara, and M. C. King. “Does face recognition accuracy get better with age? Deep face matchers say no. In Winter Conference on Applications of Computer Vision (WACV), 2020.

Thank you for your attention.

Questions ?

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