Bias in 2D Face Matching vs. 3D Face Matching

Independent testing has shown that face biometrics that use data captured from 2D cameras within the visible light wavelengths (e.g., on selfie cameras and webcams) have lower accuracy when the static face images are collected from users with darker skin tones, females, and younger people.

The vast majority of people who work in the biometrics industry do not understand that bias in their systems is, in part, the result of the camera collecting less data for some users than others. Thus, the algorithms have less data to consider when making Liveness, matching, and age predictions for users with dark skin tones, females, and younger people than for lighter-skinned users and older males.

Algorithms ultimately rely on data received from reflected photons that enter a 2D camera lens and hit the camera's photosites/diodes (tiny receivers that produce electrical signals based on the wavelength of photons that enter when the shutter is open). These electrical signals then create the digital image. Consequently, the root cause of bias in 2D algorithms is they rely too heavily on the tiny details of the skin to measure uniqueness in humans. If the skin is dark, covered with makeup, or is free from signs of aging, facial hair, or other markings, fewer unique details are represented by the photons reflected back to the camera, and thus fewer distinguishing details are provided as inputs to the algorithms.

Challenges for 2D algorithms with users that have dark skin tones, females, and younger people are further compounded if the user has more than one of these characteristics and/or is in low light. Similar effects are observed with light-skinned users in bright environments. In this case, the camera sensor will receive too much reflected light and the sensor will be "blown-out," thus providing less data.

As biometric matching is a statistical calculation that predicts the likelihood of a real-world match, more measurable data increases the statistical confidence in the returned decision. Less measurable data reduces the statistical confidence of the potential match, making 2D biometrics inherently less accurate than 3D biometrics.

Are All Face Biometrics Biased for Age, Gender, and Skin Tone?

No matter how large and/or diverse the training set used is, 2D Face Liveness and 2D Face Matching algorithms will always be less accurate than 3D on darker skin tones, females, and younger people because of the physics of light and how digital camera sensors function. Apple, Intel, and Google understand this, and all use 3D face data on their flagship devices; not outdated 2D algos.

It is important to determine what data the AI is processing before assuming that unbiased performance cannot be achieved using an innovative data capture technique. Some techniques, such as FaceTec's, ensure that low light conditions are not detrimental to the equity of the system.

At the thresholds FaceTec publishes (3D Face Matching FAR white paper), bias for age, gender, skin tone, device cost, country-of-origin, and eyeglass-wearer combinations is not apparent to our trained evaluators and is considered to be unobservable. While developing and improving our matching algorithms, FaceTec assesses any errors from many billions of match pairs, and since the error rate is so low, our trained evaluators are able to manually review 100% of the misidentifications.

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FACETEC EXHIBIT 2075
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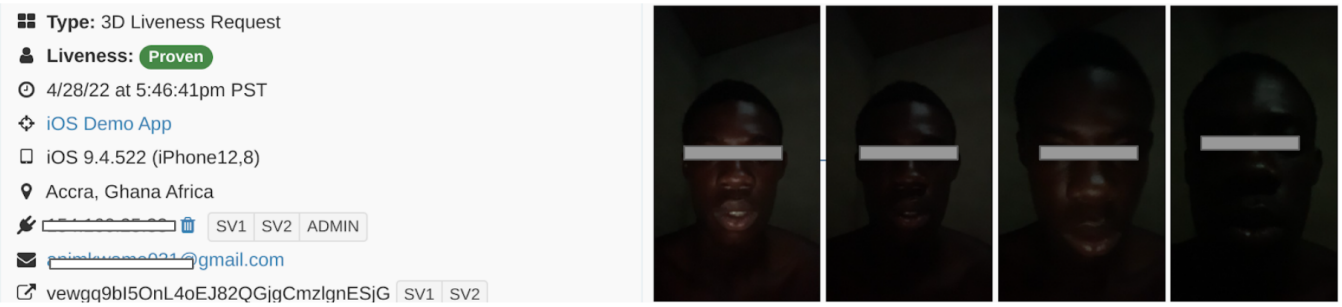
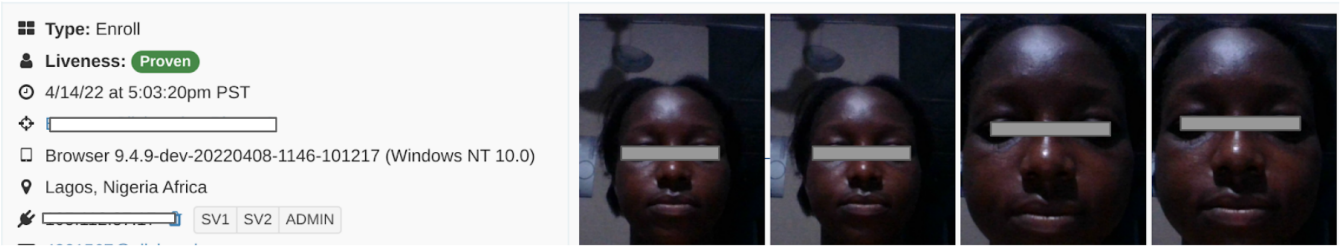
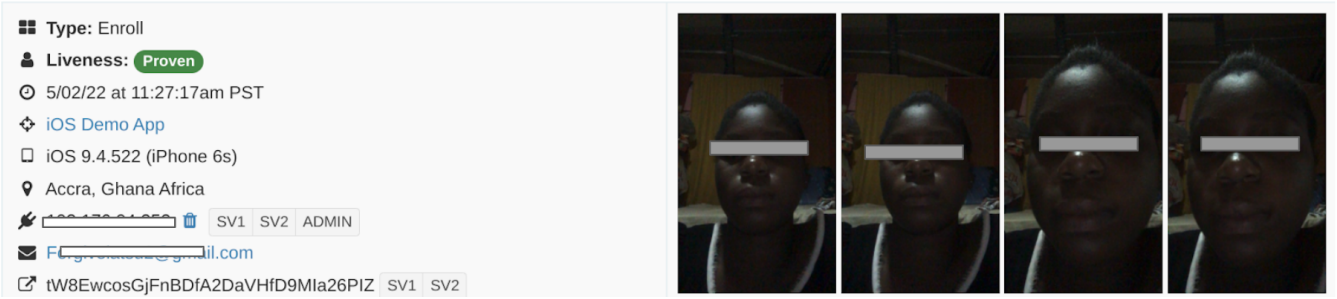
IPR2025-00109

FaceTec's 3D Solution & Why FaceTec Can Claim "No Observable Bias"

As seen in the Pixel Superbowl ad, 2D cameras require visible light to be reflected into the camera's photosites to create an accurate digital image. Darker skin-tones and low-light environments cause problems for 2D face biometrics since fewer unique face details are collected. To enhance performance, FaceTec has users move a bit closer to the camera, and the light emitted from the screen reflects off their skin at changing angles to highlight the contours of their 3D facial features. This data is then interpolated into the 3D shape of the face, resulting in significantly more accurate results than 2D face biometrics. Examples of FaceTec's low light and dark skin-tone performance:







*Not all sessions in environments this dark will pass FaceTec's 3D Liveness, but as shown above, many will succeed even in difficult lighting conditions.

FaceTec states its software has "no observable bias" at the published FAR/FRR levels because when FaceTec reviews its performance in massive tests with 6-10B Match Pairs, there are no observable patterns (i.e., bias) in the errors. The reason for this accuracy is three-fold:

1. Training Set Data - FaceTec's bespoke training set data was collected over seven years from real-world testers using their own devices in real-world environments. FaceTec has a total training set of over half-a-million volunteer testers from more than 180 countries that are highly representative of the global population's diversity. The dataset is curated to contain nearly equal numbers of every combination of human phenotype to ensure the neural network is not taught that it is more important to be accurate on one phenotype than another.

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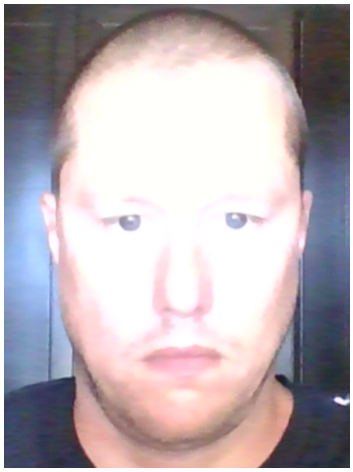
2. 3D FaceScans™ - Because FaceTec's 3D FaceScans and FaceMaps® rely on the 3D relationships of their facial features, they rely much less on the contrast of reflected light from small areas of the subject's skin. Consequently, FaceTec experiences no observable bias when performing Liveness and Matching on any skin tone, gender, age, device cost, country-of-origin, and eyeglass-wearer combination. Errors, when they do occur, are not seen measurably due to factors like skin tone, gender, or age. Rather, they are errors that occur due to the probabilistic nature of ML/AI algorithm predictions and are not incorrect more often with certain human phenotypes.

3. FaceTec software uses dynamic lighting to create the optimal face image capture scenario. By sensing the lighting in the environment, FaceTec's software will brighten or dim the device's screen, so the light emitted from the screen will not be too bright or not bright enough for the user's 3D facial features to be measured during the session. FaceTec has filed for patents in the area of dynamic lighting and considers it to be critical to the performance of its software.

When Environmental Lighting Matters

Usability with Lighter Skin Tones: Camera sensors need light to function, but if too much light is reflected back to the sensor, the camera will be overwhelmed. As a result, people with lighter skin tones and a lot of light in their environment may appear "blown-out" to the camera. This can occur in direct sunlight or other extremely bright environments. However, turning 90-degrees will usually change the directional lighting enough for the sensor to function properly. With a camera sensor that is not oversaturated, FaceTec has no observable difference in performance over the spectrum of skin tones.



Usability with Darker Skin Tones: Darker skin tones can be used in brighter environments and not blow out the camera. However, if enough light is not reflected back to the sensor, the camera will be unable to collect enough data to make an accurate decision. 2D Face Matching is less accurate because of the missing data, which is why observable levels of bias are exhibited in 2D systems. However, with FaceTec's 3D FaceScan UI, less light is required than 2D using the same camera hardware, and the necessary illumination can be provided solely by the screen of the user's device. In large-scale testing, FaceTec's AI has no observable performance difference over the spectrum of human skin tones.

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Why FaceTec's Approach Reduces the Influence of Environmental Lighting

FaceTec's ZoOm-In motion ensures two very important things:

1. During the session, the camera's viewing angle of the user changes along with how the reflected light bounces off the 3D surfaces of the user's face. This change in the camera's perspective teases out the data needed to interpolate the user's 3D face shape and reduces the need for tiny details on the face to be relied upon, as is required with 2D face biometrics.

2. FaceTec gets a closeup of the user's face, and the device's screen illuminates the user's face from only 10-12 inches away. This ensures the camera gets enough photons reflected from the user's skin to create detailed images that are used to recreate the shape of the user's 3D face.

FaceTec 3D technology ensures the highest degree of certainty by providing up to 100 times more data than 2D images/video. And to provide the highest overall levels of security, FaceTec first determines if the person requesting access is alive and present at the time of the request. If the user does not pass the liveness check, access is denied. If the user passes the liveness check, the AI looks for their uniquely identifiable face shape/attributes to validate them as the legitimate account holder. Apple's Face ID uses 3D for the same reasons, though their approach requires expensive hardware found only on their phones, and FaceTec's software runs on all smart devices and PCs with webcams.

For substantial social proof, FaceTec provides over 1,000,000,000 user sessions per year to large organizations in LATAM, all parts of Europe, North America, Asia, and organizations such as ChipperCash (payment processor in Africa), clearly demonstrating our technology works on all human phenotypes.

For more information on Liveness Detection, please visit www.Liveness.com

For more information on 3D Liveness Security, please see the FaceTec Liveness Security Report

For more info on the $600,000 Spoof Bounty Program, visit dev.facetec.com/spoof-bounty-program

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