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A Novel Method to Determine Patient Skin Type: The Skin Analyzer

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Summary: Measuring skin color for medical research in an objective and nonbiased manner usually requires expensive equipment such as spectrophotometry and requires the subject to be present in person. We present a novel method to measure skin color from photographs using the Skin Analyzer application as a more effective, accessible, and efficient alternative. A desktop application, the Skin Analyzer, was developed to convert skin samples collected from digital images to the L*a*b color space and uses those values to calculate an individual typology angle that correlates to a Fitzpatrick skin type. To assess accuracy in variable lighting, six known colors representing the six Fitzpatrick skin types were printed and photographed in 15 separate locations within the hospital. To account for user variability in sample selection, interrater reliability was calculated with data generated by 13 untrained users testing the app on six subjects. The accuracy of measuring known values, which is the classification accuracy, was calculated to be 80%. Krippendorff alpha test was used to evaluate interrater reliability. The obtained alpha of 0.84 indicates a high interrater reliability. The high accuracy and reliability make the Skin Analyzer a suitable method of objectively determining Fitzpatrick skin type from images. The app may be used to investigate the effects of skin tone in various areas of interest, especially in retrospective studies where skin colorimeters cannot be used. *(Plast Reconstr Surg Glob Open 2023; 11:e5341; doi: 10.1097/GOX.0000000000005341; Published online 11 October 2023.)*

THE APP: THE SKIN ANALYZER

Current medical research and education lacks a robust understanding of skin color as an objective variable, making it difficult to quantify its impact as both a social and physical determinant of health.[1–4] Physical colorimeters or spectrophotometers are the current gold standard to objectively quantify skin color independently from race or ethnicity.[5–7] These tools, however, must be used in person with the patient present. Data collection is limited by expensive equipment, timing, transportation, and prospective planning.[8] Medical records contain an entire database of patient images that can be used in retrospective studies, but current available methods do not allow for the utilization of these images to quantify skin color. At best, these photographs may be subjectively analyzed by professionals with experience in skin color identification. This method is subject to bias and can vary between providers.[6,9,10] We have created a pilot digital app, Skin Analyzer, to harness objective data on skin color from the digital images in medical records, which may ultimately aid research on diverse skin tones.

A desktop app, the Skin Analyzer, was created based on the 1976 CIELAB colorspace[11] and the skin type classification presented by Chardon et al.[12] RGB values in a digital image are first transformed to the CIELAB color space, a device independent color space designed to more closely resemble human color perception. Rather than describing the red, green, and blue content of a color, CIELAB describes color in three axes based on light/dark (the L* axis), red/green (the a* axis), and blue/yellow (the b* axis), which correlate with skin pigmentation, erythema, and pigmentation/tanning, respectively.[6] An individual typology angle can be calculated based on the L*

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and b* values, which may be classified into one of the six Fitzpatrick skin types.[12,13]

The app allows for flexible assistance in data collection and skin type categorization from digital images. (**See Video [online],** which displays a detailed walkthrough of how to use the app.) Briefly, on startup, the user may adjust the aperture to dictate how large an area should be sampled. In the multipoint collection mode, the user may also select how many samples (between 1 and 20) should be collected from each image (Fig. 1). With two-point collection, two color samples will be collected from each image, and an additional parameter, ΔE, is reported as a measure of how different the two locations may be to human perception. After selecting the folder containing the desired images, the app will present each image, and the user will be prompted to select points on the image to populate the samples field on the right (Fig. 1). Care should be taken to avoid areas with glare, shadows, or moles/rashes. The process will repeat until all images have been analyzed. All variables reported by Skin Analyzer and their significance are described in Tables 1 and 2.

To assess the effect of lighting variability on accuracy of Fitzpatrick type calculation, six known colors that correlate to the six Fitzpatrick skin types, as represented in Figure 2 adapted from Ly et al,[6] were printed and photographed in 15 different locations with varying lighting around the hospital. The fifteen photographs were sampled by the app and compared with the original Fitzpatrick score. Although variable lighting led to some classification one category above or below known Fitzpatrick type of each color strip, an overall classification accuracy of 80% was maintained (Fig. 3).

To account for user variability in sample selection, interrater reliability was calculated. The data generated by 13 untrained users testing the app on photographs from six human patients was used to calculate a previously reported coefficient,[14] Krippendorff alpha, which is a reliability coefficient quantifying the agreement between independent raters or judges.[15] We obtained an alpha value of 0.84, indicating a high interrater reliability.

DISCUSSION

Existing research on skin color in the field of plastic surgery has shown that it can be an important factor not only in health equity but also in the prevalence of disease, patient risk for certain conditions, and patient outcomes,[2,16–18] but such investigations are hindered by difficulty collecting objective and consistent data on skin color. It has been reported that plastic surgery journals use significantly more images of white-skinned than dark-skinned individuals.[3] Medical texts and education have also historically lacked diversity in patient examples, which can lead to bias and, ultimately, worse patient outcomes.[1] As medicine and the field of plastic surgery work to increase the diversity of research study patient samples, an accessible way to objectively measure patient skin color is needed. Although race or ethnicity information is commonly used as a measure of diversity in research studies, it does not accurately provide specific information on the skin color of patients. Patient skin color may be particularly important to plastic surgery in fields such as burns and aesthetics, as it is important to understand the skin-related risk factors, treatment, and outcomes as they relate to objective skin color. Currently, a physical colorimeter can be used in prospective studies to assess skin color, although this method is not without flaws.[8] In retrospective studies, the only option to precisely identify skin color is to use experts with experience in skin color identification.[6,9,10] The biggest limitation of the Skin Analyzer is the small effect of variable lighting on accurate estimates; however, this limitation is shared by experts identifying skin type from digital images. We have developed the Skin Analyzer to provide researchers with a more cost-efficient and time-efficient method of collecting objective skin color information in retrospective studies. The Skin Analyzer is open source and available for use at theskinanalyzer.com. The code can be downloaded, and we invite others to improve the app. Despite the current limitations, the Skin Analyzer is a new tool that researchers can use to explore the effects of skin color in plastic surgery treatments and outcomes. We hope this tool will promote research into furthering the understanding of skin color as a variable in medicine and that researchers will find it useful.

Takeaways

Question: Can the Skin Analyzer be used in clinical research to assess Fitzpatrick skin type?

Findings: This technique displayed an 80% classification accuracy for all skin types in various lighting conditions in a hospital setting. A Krippendorff alpha of 0.84 was calculated across 13 different rates, using the app to assess Fitzpatrick skin type.

Meaning: The Skin Analyzer is a new tool that allows for cost and time-efficient Fitzpatrick score calculation from digital images with high interrater reliability and accuracy than can be used in retrospective studies aiming to explore the relationship between skin color and clinical outcomes.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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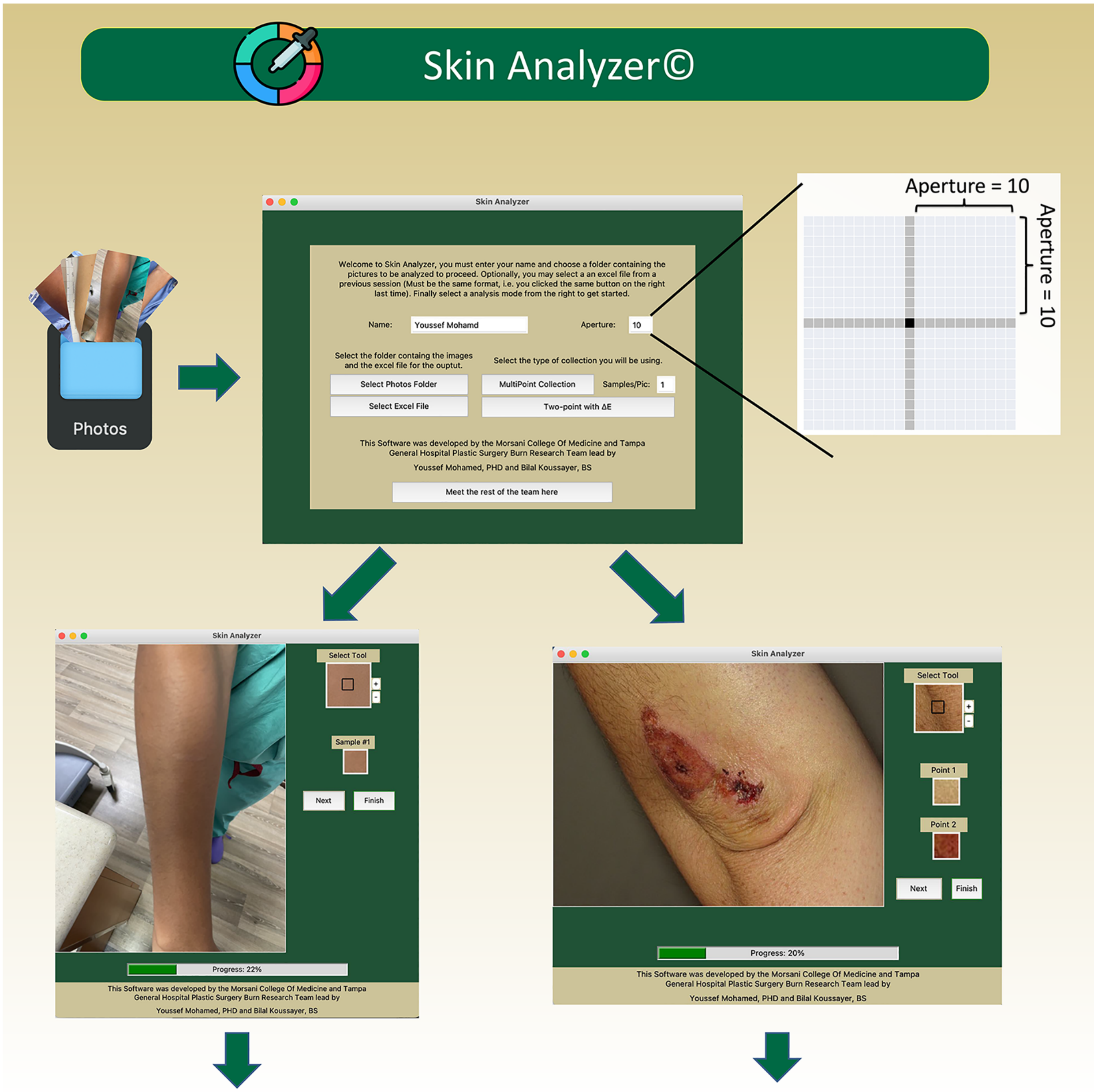

Variable	Output
L*	53.89
a*	13.39
b*	20.48
ITA	10.76
Fitzpatrick Skin Type	4

Variable	Point 1	Point 2
L*	62.63	36.29
a*	8.54	31.58
b*	30.94	29.22
ITA	22.20	-25.13
Fitzpatrick Skin Type	4	5*
ΔE	35.04	

Fig. 1. Pictogram showing the operating principle of the Skin Analyzer.

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Table 1. Variables Collected by The Skin Analyzer

Variable	Description
L*, a*, and b* values	The CIELAB color space is designed to resemble human color perceptual changes more closely than RGB, and it is useful in detecting small color differences. The mean L*, a*, b* values for the selected region are reported
RGB	The RGB color space is used to define color in digital images and is simply the original digital representation of the sample. The mean RGB values for the selected region are reported
x and y coordinates	The x and y coordinates for the center of each region sampled are recorded to allow for the exact pixels used in the Fitzpatrick calculation to be accessed later. This may be used by other software to help identify skin or specific areas on an image without the need for another researcher to reidentify these locations

Table 2. Variables Calculated by The Skin Analyzer©

Variable	Description	Formula	
ITA angle	The individual typology angle condenses the three-dimensional CIELAB values into a single number correlating to skin color "volume," a number that allows for objective classification of skin color for medical research	ITA degrees = $\frac{\arctan(L^{*}-50)}{b^{*}} * \frac{180}{\pi}$	
Fitzpatrick Skin Type	A scale developed to classify skin coloring and response to ultraviolet light. This scale is widely used to determine eligibility and dose for dermatologic treatments and its applications continue to expand	50 degrees < ITA degrees	Skin type I
		41 degrees < ITA ≤ 50 degrees	Skin type II
		28 degrees < ITA ≤ 41 degrees	Skin type III
		10 degrees < ITA ≤ 28 degrees	Skin type IV
		− 30 degrees < ITA ≤ 10 degrees	Skin type V
		ITA ≤ − 30 degrees	Skin type VI
ΔE^{*}	A variable that represents the perceptual color difference between two points, typically on the same subject. ΔE < 1 indicates a color difference discernible by the human eye	$\Delta E^{*} = \sqrt{\left[(\Delta L^{*})^2 + (\Delta a^{*})^2 + (\Delta b^{*})^2\right]}$	

Fig. 2. The Fitzpatrick scale classifies skin types on a scale from 1 to 6, with 1 as the lightest shade and 6 as the darkest shade.

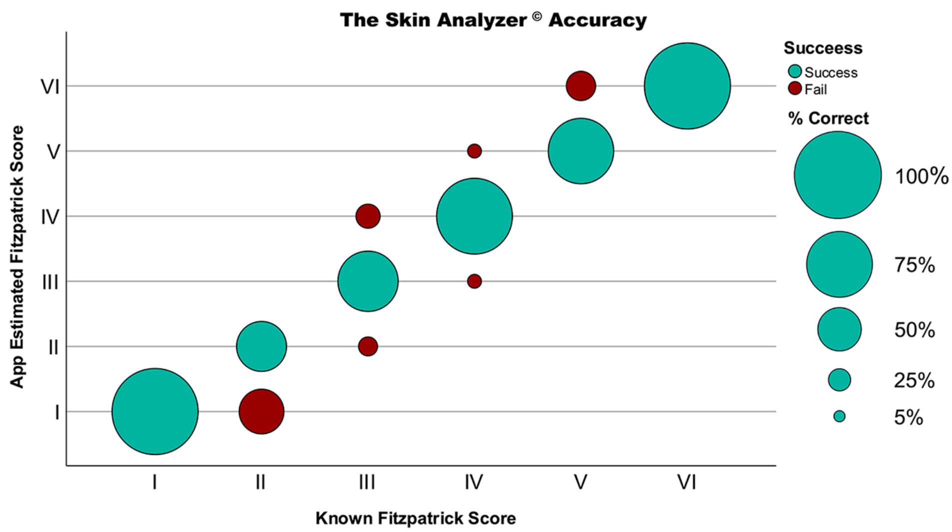

Fig. 3. The Skin Analyzer accuracy.

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