A novel bioinstrument for quantitative skin imaging

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Abstract

The science of skin imaging has been evolving based on advancements in lighting modalities, camera sensors and lens technology; however, the quantitative data available in an image of the skin is not well understood and skin features have seldom been objectively investigated through the means of artificial intelligence. Skin morphology (influenced by micro topography, water content, blood vessel reactivity, and quantity of melanosomes) varies considerably amongst individuals and can make meaningful study design difficult. We have overcome these difficulties and present here the results of a novel technology to provide a comprehensive methodology for skin quantification. We developed a system to perform quantitative assessments of various skin parameters. The key features indicative of aging: spots and lines were evaluated on 5 women- 1 below 30 years of age, 2 between 30-50 years, 1 between 50-60 years, and 1 older than 60 years. Comparisons of image analysis results demonstrated that the severity of photo damage of the woman below 30 years of age was on average 96% less than that of the woman above 60 years of age. While older women have significantly greater number of deep lines and large, dark spots, the younger groups exhibited more fine lines, and spots of less intensity. Since signs of chronological aging are based on these parameters, this study provides insight into skin aging. The results also provide a valuable scientific foundation for measuring intrinsic aging. Using this technology we have successfully demonstrated the methodology of quantitative imaging as a means for objective assessment of skin parameters.

Background

Skin imaging serves an important function for clinical evaluation and investigation of skin aging.

Key Requirements for a Quantitative Skin Imaging system:

- Quantitative imaging requires a consistent capture environment with attention to standardized lighting and fixed positioning of the body area of interest.
- Artificial intelligence for automated and consistent recognition of a skin area and region of interest.
- Automated facial positioning and alignment across multiple capture time points is critical in quantitative skin imaging as it allows for repeatable feature tracking in multiple captures.
- Adjustable filters are utilized in quantitative skin imaging for tuning skin feature recognition based on parameters of interest, such as:
  - fine vs. deep line thresholds
  - spot darkness & size thresholds

Methodology

5 subjects were evaluated for this study. One left-view image and one right-view image of the face was taken in two lighting modalities, sun spectral light and blue light captures, using the BTBP Clarity™ R&D system.

The BTBP Clarity R&D system reports the parameters of each aging feature detected and evaluated in this study: Spots & Wrinkles.

Age Spot Measurements – Aging spot measurements includes spot density percentage and average spot darkness score.

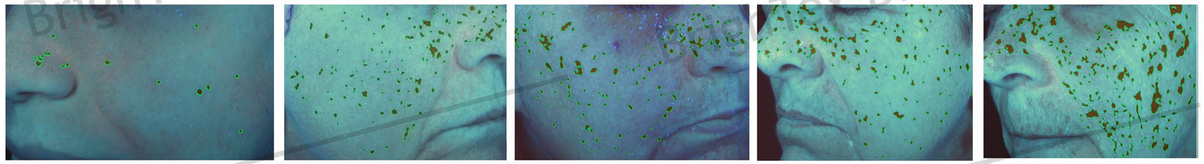
- Spot Density is the percentage of the pixels defined as spots out of the total skin area of interest defined as the measurement area of interest.
- Spot Darkness is the average pigment intensity level of the total pixel region identified as a spot. Spot darkness is measured on a scale of 0-255.

Wrinkle Measurements – Wrinkle measurements include 2 severity categories, fine and deep lines, and also measure the following characteristics of lines as defined below:

- Average wrinkle width
- Average wrinkle length
- Average wrinkle severity

Results

Spot recognition and measurement performed with a consistent region of interest on the subject's cheek in the BTBP Clarity R&D quantitative imaging system.



Subject 1 (Age < 30 years) | Subject 2 (Age 30-50 years) | Subject 3 (Age 30-50 years) | Subject 4 (Age 50-60 years) | Subject 5 (Age > 60 years)

Figure 1. The spot recognition filter applied to the regions of interest utilizes pigment darkness and size criteria for bounding spots included in the measurement.

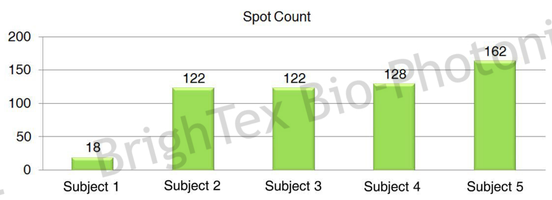


Figure 2. The spot count detailed here is by region of interest for each subject. The spot recognition filter criteria are defined as below:
Pigment Size Filter: 60 – 11,000 pixels in diameter

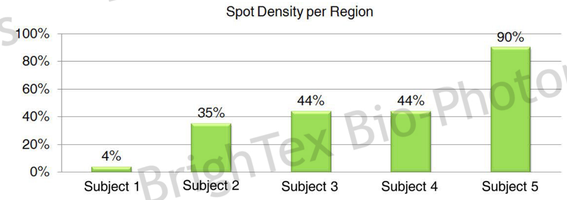


Figure 3. Spot Density score is calculated as the percentage of total pixels identified as spots from the total pixels of the region .

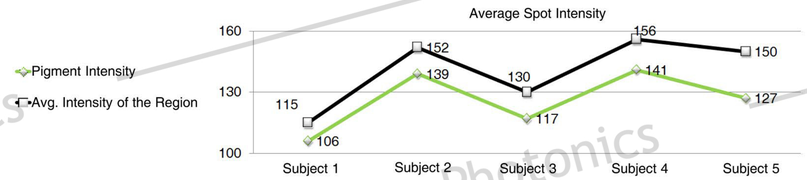


Figure 4. The average intensity of the total pixels identified as spots versus the average intensity value of the region as a whole.
Note: Intensity value range scale is 0-255.

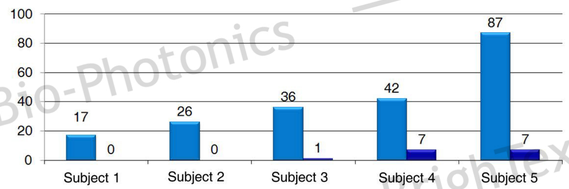
Wrinkle recognition and measurement performed with a consistent region of interest on the subject's eye corner in the BTBP Clarity R&D quantitative imaging system.

Subject 1 (Age < 30 years) | Subject 2 (Age 30-50 years) | Subject 3 (Age 30-50 years) | Subject 4 (Age 50-60 years) | Subject 5 (Age > 60 years)

Figure 5. The wrinkle recognition filter applied to the regions of interest utilizes a filter for line detection specific to the orientation of lines specific to the under eye and eye corner.

Figure 6. The line recognition is defined by the fine and deep line threshold below:
Fine Lines
Deep Lines

Note: The fine and deep line classification criteria are based on the average intensity and the length of the line.



Results

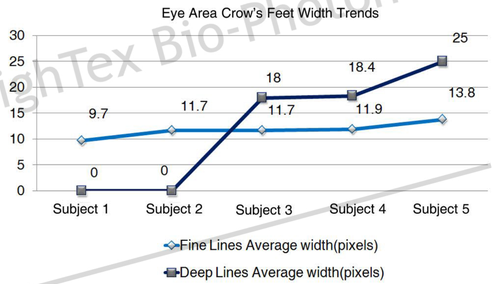


Figure 7. The average width of the lines recognized across each subject for both the fine and deep line severity categories.

Conclusions

Quantifying Chronological Aging:

Aging skin demonstrated a linear relationship with the incidence of greater pigmentation changes and the increased number of age spots. Furthermore, wrinkle counts and severities increased as the age ranges increased.

- The spot density score demonstrates the increased presence of pigmentation, or age spots due to chronologic aging. The subject below 30 years of age measured 86% lower in spot density than that of the subject above 60 years of age.
- There is a significant difference in spot intensity, or brightness, across the various age ranges. The subject below 30 years of age reported an average spot intensity 4% less than the surrounding skin of the region; where in the subject above 60 years of age the average spot brightness fell below 10% of the surrounding skin signifying a greater contrast, or appearance, of spots identified. Subjects 2, 3, and 4, also presented an intensity decrease of 5%, 5%, and 6% respectively.
- Total wrinkle counts across each subject also showed a significant increase from Subject 1 to subject 5. Furthermore, the severity of the lines identified also increased with age. Subject 1 displayed 0 deep lines, where both Subject 4 and 5 had a count of 7 deep lines each.
- The average width of the fine lines in Subject 5 were 4% deeper than those of subject 1, where width of Subjects 2, 3, and 4 were on average 2% less deep than those of Subject 5.
- Furthermore, though both Subject 4 and 5 displayed equal deep line counts of 7 each, the width trends for the lines identified as deep were 6.6% higher for Subject 5.

Quantitative Skin Imaging

There is a significant increase in both spots and lines in count as well as severity based on chronologic aging of the skin. Through the use of filters and thresholds for recognition and quantification of spots and lines the method of quantitative skin imaging provides a consistent method for evaluating trends demonstrating the correlation between age and the presence of skin features indicative of aging.

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