RBX® Technology Overview

Ramazan Demirli, Ph.D.; Paul Otto, Ph.D.; Ravi Viswanathan, M.S.; Sachin Patwardhan, Ph.D.; Jim Larkey, M.B.A.

Abstract

Dermatologists and aesthetic skin care professionals are typically called upon to treat patients with various skin conditions, often in the facial area. In most cases, these conditions present themselves as localized discolorations and reflect skin tone variations or disturbances. Included among the unique challenges to the skin care professional are: the documentation as to the extent and nature of these conditions, the ability to communicate the need for specific treatments to the patient, and the ability to monitor the effectiveness of treatments over time. Where the visible presentation is subtle or is not visible to the unaided eye, these challenges are further exacerbated.

The use of suitable cameras, dermascopes, and various types of probes have proven to be useful. However, these instruments might not adequately present the condition clearly enough for the patient. The emergence of specialized imaging devices, such as the VISIA Complexion Analysis System, addresses these issues. A new technology with the trade name RBX, developed by Canfield Imaging Systems, enables these devices to see beneath the skin surface, visualizing specific conditions as related to both vascular disorders and hyper-pigmentation. RBX provides the professional with significant new capabilities to detect, analyze, and communicate a wider range of skin conditions and their associated treatments.

Skin Color Analysis

Skin colorization is characterized by a limited number of colorants, or "chromophores", within the layers of skin. The primary colorants are melanin and hemoglobin[1]. High concentrations of melanin and hemoglobin are often markers for various skin diseases and are primary factors which disturb overall skin tone. Melanin occurs at varying depths within the epidermis and is primarily responsible for the overall skin color. In normal, healthy skin, the melanin particles are small and uniformly distributed, resulting in a smooth, even skin tone. Increased melanin deposition can be caused by either extended exposure to sunlight (UV radiation) or skin diseases such as acne. Deposition in specific skin areas (e.g., hyper-pigmentation) naturally has a negative impact upon an otherwise smooth skin area.

Correspondence to:
Jim Larkey, Canfield Scientific, Inc., phone +1.973.434.1201
4 Wood Hollow Road, Parsippany, New Jersey 07054 USA
e-mail: jim.larkey@canfieldsci.com

Hemoglobin occurs within the vascular structure at the papillary dermis, a sub-layer of skin, in oxygenated and deoxygenated forms and is responsible for red colorations of skin tone. Some skin conditions, such as acne, rosacea, and telangiectasia can cause organic changes in the patient's vascular structure and elevate the level of hemoglobin present in the dermis. The increased amount of hemoglobin and the formation of new vascular structures will cause a red coloration and will therefore have a negative impact on the evenness of the skin tone.

A number of instrumental methods have been used to evaluate skin pigmentation as early as the 1920s[1, 2], when it was recognized that "the more melanin present, the lower the percentage of light reflected from the surface of the skin and the lower the brilliance"[1]. However, skin pigmentation cannot be estimated by measuring only the total attenuation of broadband light because, apart from melanin, hemoglobin in skin also absorbs visible light in a wavelength dependent manner. Therefore, methods are required to measure light absorbance in more than one spectral band[3].

Skin images obtained from digital cameras using various imaging modalities such as UV and polarized imaging are not capable of directly displaying melanin and hemoglobin distributions. This information can be derived from multi-spectral imaging techniques which include: (a) Spectral imaging, i.e., the acquisition of a multitude of images filtered at narrow wavelength bands, which can be analyzed similarly to spectroscopic methods. Extremely accurate quantification of tissue chromophores can be achieved with this method. However, these type of imaging systems are largely in the research phase and/or their cost and complexity prohibits their commercial use in skin imaging applications. (b) Digital color image acquisition which is commonly comprised of three broadband filtered images (red, green, and blue) approximating the light sensitivity of the cones in the human eye[3, 4]. Using such color images, some research labs offer solutions that are based on skin optical modeling and/or spectral measurements as a reference. Data fitting and estimation techniques are then utilized to obtain estimates of hemoglobin and melanin distribution[4, 5]. The accuracy of these techniques is influenced by the optical properties assumed in the tissue model formulation or the difference between the subject's skin and the measured spectral reference. Further, the estimation algorithm may generate multiple solutions that fit the measurements with the reference.

Canfield Imaging Systems has developed a very practical solution based upon a novel color-space model capable of analyzing melanin/hemoglobin decomposition across different subjects and skin types. A universal transform, the RBX transform, is computed based upon a large population of skin images with different skin types to produce a unique comparative solution.

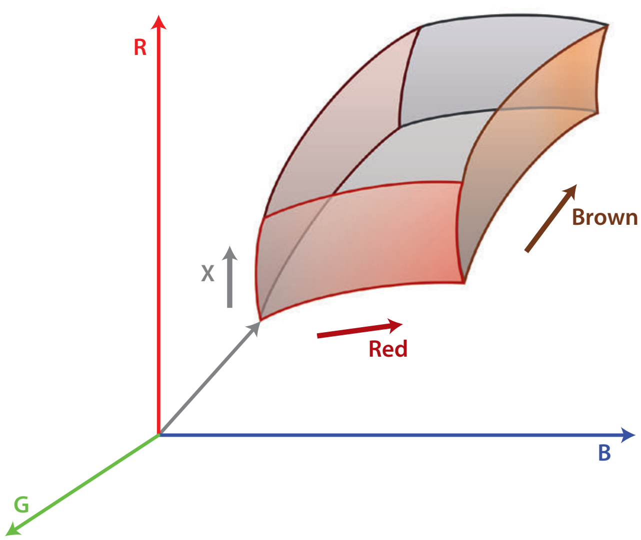

Figure 1 *Graphic illustration of the RBX Color Space*

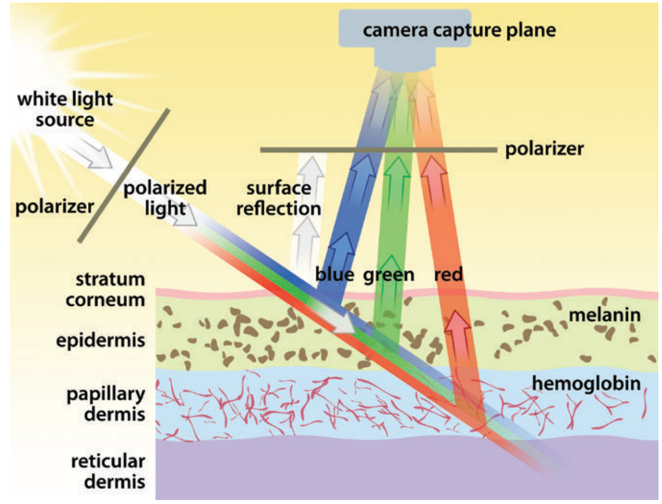

Figure 2 *Structure of normal skin and schematic illustration of light remittance.*

RBX Color Space

RBX® is a novel technology that can represent skin images in terms of melanin and hemoglobin components. Insofar that primary color signatures Red and Brown denote hemoglobin and melanin components respectively, this color space is called Red/Brown/X identified by the proprietary designation RBX. The skin image captured by the digital camera is comprised of Red (R), Green (G) and Blue (B) channels and is presented in a camera's native RGB space. RBX transforms this RGB image into the RBX color-space where the *Red* and *Brown* channels represent hemoglobin and melanin distributions, respectively (see Figure 1).

The RBX color-space design is based upon random samplings of facial skin images selected from a large population of patients with different skin types. This color model is based on the light transport model of skin as illustrated in Figure 2. According to this model, the dominant chromophores affecting the remitted light (i.e., skin color) are predominately melanin and hemoglobin.

For accurate imaging of melanin and hemoglobin, it is essential that the re-emitted light from the skin is free of specular reflections (see Figure 2). The skin image is captured under polarized illumination with a pair of orthogonally-polarized filters placed over the flash and on the camera lens respectively. Cross-polarization

Figure 3 *Standard and cross-polarized images of a skin patch taken from the face. Subsurface details are more visible in the cross-polarized image.*

eliminates specular reflections from the skin surface, improving visibility of re-emitted light from the epidermis and dermis where melanin and hemoglobin reside (see Figure 3).

RBX Technology Applications

The proprietary RBX algorithm is incorporated in various Canfield imaging systems such as the VISIA® Complexion Analysis System and VISIA-CR for Clinical Research. These technologies are both capable of capturing cross-polarized images. Shortly after the image capture process, RBX processing is applied to the resultant cross-polarized image(s), and *Red/Brown* images are displayed on the computer monitor. A typical cross-polarized image of a patient and the RBX-generated *Red/Brown* images are shown in Figure 4.

Red/Brown images can be further processed to identify and highlight features, e.g., hyper-pigmented spots and vascular structures. The *Brown* image is further

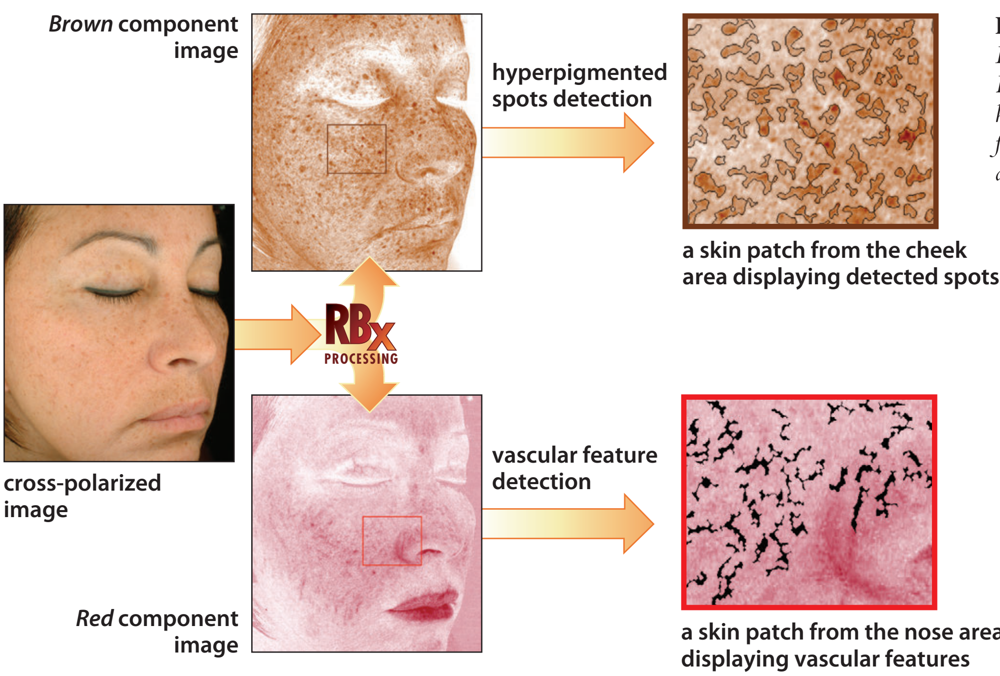

Figure 4 *Schematic flow of RBX analysis and typical Red & Brown component images: detected hyperpigmented spots and vascular features are displayed in certain areas.*

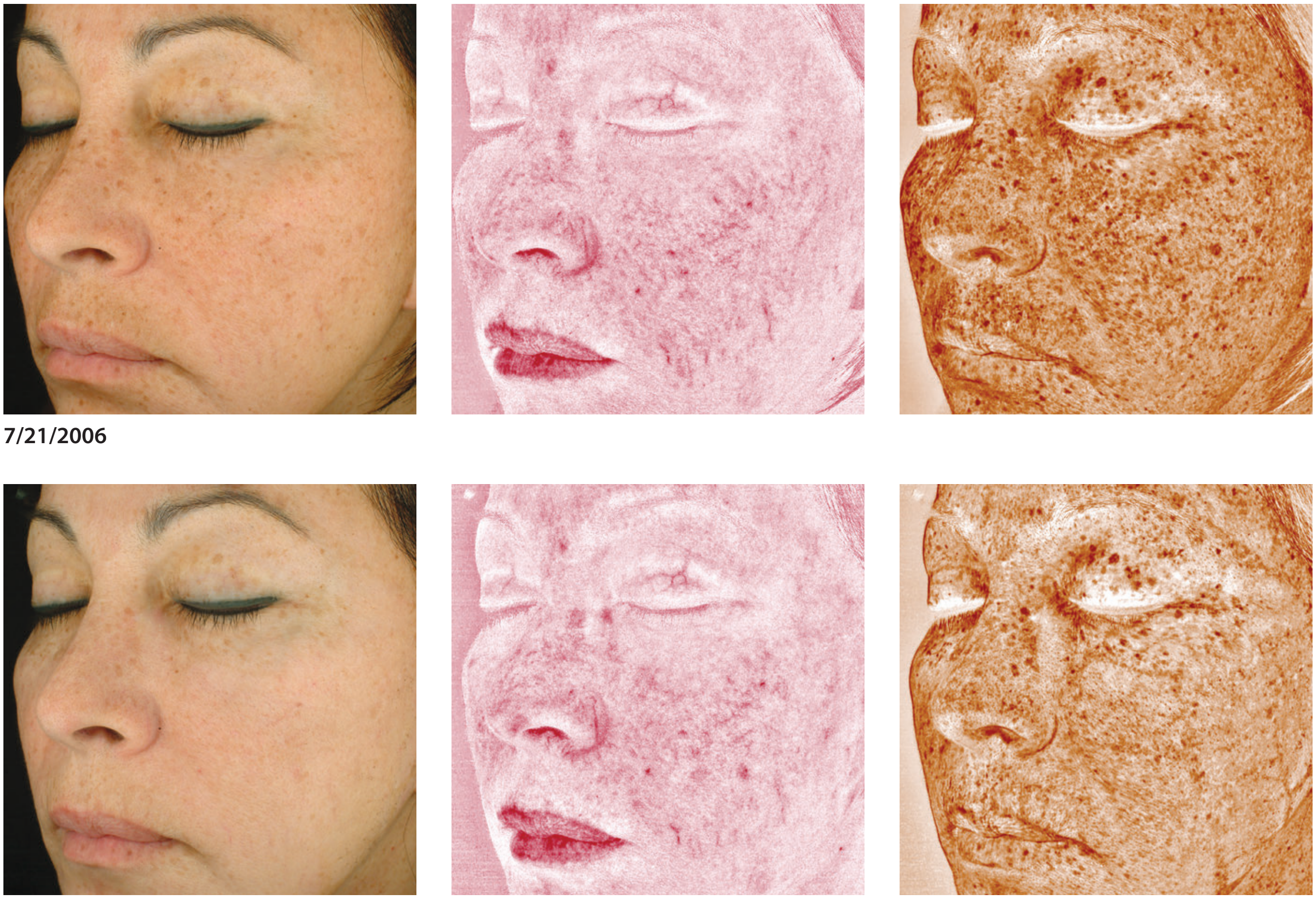

Figure 5 *IPL treatment documented using cross-polarized, RBX Red, and RBX Brown images. Vascular changes are better visualized with RBX Red, and pigmentary changes are better visualized with RBX Brown.*

analyzed to detect and mark hyper-pigmented spots. A severity score associated with the degree of pigmentation is then generated. Similarly, the *Red* image is processed to detect vascular features. A severity score associated with these vascular structures is likewise generated. The severity scores provide quantitative measures for hyper-pigmentation and vascularization and can be used to rate patients within their analysis group. The severity scores can also be used for monitoring the progress after treatment for hyper-pigmentation and vascularization. RBX technology enables the visualization of melanin and hemoglobin distributions in skin, the detection of hyper-pigmented and vascularized regions, and comparative analysis among patients. This level of skin analysis has not been possible with conventional skin imaging techniques.

Clinical Implications

The clinical value of RBX technology lies in its ability to enable visualization of skin conditions related to abnormal melanin concentrations or vascular disorders. Visualized abnormalities would include conditions such as sun damage, rosacea, melasma, telangiectasia and others.

During the initial consultation process, a series of baseline photographs is made under several lighting modalities. Minimally, these would include both standard and cross-polarized white light. In some cases the patient would be photographed using ultraviolet illumination and/or parallel polarized light. The cross-polarized images are then transformed into the RBX color space, creating separate red and brown area maps representing vascularity and pigmentation respectively.

Figure 6 *The VISIA Complexion Analysis System with RBX technology.*

These baseline photographs document the patient's current condition and can be effective in planning a course of treatment which may include laser therapy, photorejuvenation, microdermabrasion, chemical peels, and/or cosmeceuticals. Follow-up imaging sessions would be used to demonstrate the results of these treatments. These follow up images are substantially more demonstrable than those captured with conventional photographic technique (see Figure 5).

Commercial Applications of RBX Technology

Currently RBX technology is available in two configurations from Canfield Imaging Systems. These systems are intended for facial analysis and are useful in the fields of dermatology, cosmetic medicine, and aesthetic skin care. Core technology can be readily implemented in other systems designed for clinical skin imaging.

Hardware and software implementation of RBX varies slightly, depending on the host device. VISIA and VISIA-CR are both fully automated closed systems. Every aspect of image capture and analysis, including ambient lighting, is controlled by the system, and is transparent to the operator. The patient positions his or her face in the window of the booth, and the operator follows on-screen prompts. Shortly thereafter, RBX processed images are displayed on the system's monitor (see Figure 6).

Other imaging systems currently in development will incorporate RBX technology where appropriate to their intended applications.

Conclusions

The development of Canfield Imaging Systems RBX technology will greatly enhance the ability of the skin care professional to detect and display vascular structures and high concentrations of melanin. This will offer a greater degree of clinical information on a wider range of skin conditions. Patients receiving this information will be better equipped to elect treatment options for their conditions.

References

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