Analyze Digital Images by Improving the Methods of Advanced Intelligence by the Image Processing Program Developing Process

Bilal Majeed Abdulridha Al-Latteef
The General Directorate of Qadisiyah Education.
E-mail: bil.pro84@gmail.com

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Abstract

The remarkable development of digital photography has been possible thanks to joint advances in computer science and photography processing and retouching software. The scientific use of photography is now possible as long as its intrinsic limits are comprehended, particularly in the very specific time-limited structure of clinical trials. We list the two main limitations inherent to this method: geometrical calibration and colorimetric calibration. These limitations are illustrated by numerous images used in our practice in Besancon during the last decade.

Keywords

Colorimeter, Azimuth, Approximate Repositioning, Saturated Colors, Standardization.

Introduction

Digital photography and image analysis have made tremendous progress over the last 20 years. The development of computing and power of calculation allowed the key technological advances (migration of film cameras, improvement of CCDs, image processors) (Gove, 2020) (Nixon & Aguado) (Al-Rikabi, 2013). It is now possible to realize images in resolutions > 25 million pixels and apply their reserved analysis algorithms initially to computing stations (neuronal detections, nonlinear filtering (Alotaibi & Mahmood, 2017) (A. Abbaspour, Aboutalebi, Yen, & Sargolzaei, 2017). The combination of these two techniques is all more interesting in dermato-cosmetic than its cost hardware is weak (Photoshop CS4 = 1000 euros, Canon Eos 50d = 800 euros. its use apparently simple. In Besançon, we use photography digital as part of clinical protocols since the beginning of years 2000, initially for illustrative purposes (like most laboratories), then gradually with a desire to quantification (detection, segmentation, automatic counting) (Bayle, Platre, & Jaillais, 2017) (Guo et al., 2018) (Ferrari, Lombardi, & Signoroni, 2017). Our practice then allowed us to identify two major recurring and unavoidable problems: repositioning (or calibration geometric) and the management of color (or colorimetric calibration). These known obstacles of most users may seem obvious from first, but they are extremely difficult to master, both from practical than technical. They are not unique to digital photography, but concern virtually all imaging methods (3D profilometry, microscopy).This presentation aims to detail these two issues, show how they meet in practice, and detail the solutions that we brought. We will also show how their taken into account makes it possible to envisage analysis methods at once simpler but also more rigorous.

Literature Review

Professor Glenn Knoll at the University of Michigan was fond of the pictures, so he set up a lab in his basement, and also loved technology and was captivated by the emergence of a personal computer. He had two sons, Thomas and John, who inherited the characteristics of their father.

Thomas was passionate about photography, image display, and color balance, and while Thomas was learning about image processing in his father's lab, John was messing with his father's personal computer that was replaced by a Mac in 1984 and that was an important achievement for John, Thomas was interested in image processing and began using the computer in digital processing In 1987, Thomas acquired the Apple Macintosh Plus to assist him with a Ph.D. "Digital Image Processing". Here he started the kernel of the famous Photoshop program, as the new device did not meet Thomas' need for color hue, so he wrote the Subroutine function to solve the problem of color hue in digital images.

John and Thomas began to intensify their work and unify their efforts in collecting those scattered codes to create an integrated program for digital image processing. His Excellency Thomas and John, with their accomplishments, pushed them to ask for more, such as the ability to store images in different formats, and the ability to open image files in another program and print them, and other new ideas, After several months of attempts, Image Pro was produced in 1988, but after that, some obstacles that delayed the appearance of Photoshop, like John's preoccupation, started waiting for the new baby and their need for material support.

Only one company showed serious interest in the program, Barney Scan, and here is the beginning of Photoshop, where the first version of Adobe Photoshop1.0 was released in February 1990 after agreement with the Adobe Group, and since then the development of the program has begun until Photoshop8.0 was released, and here is a story A simple lab in the "Knoll" family basement has turned into the most popular digital image processing program.

Research and Information Collecting

1) Geometric Calibration

In the context of clinical protocols, the digital photography is used before everything to follow the evolution of an object (skin color, wrinkle size, area face...) over time. Ideally, so it's about photographing the same zone, under the same geometric conditions and with the same optical settings. This ideal is difficult to obtain, especially at the 3D angle of view (azimuth) defined between the camera and the volunteer (Fig. 2). This angle is absolutely critical, because by modifying it, we will alter most of the observations made on the photograph (by changing the lighting, obscuring areas of interest). By changing this azimuth, we change the perspective and therefore the perception of our object, its appearance, its surface, independently of any other cause. Solutions exist to control image capture and avoid these positioning drifts in space. So stereo taxis tables (stereo taxis is basically a technique of locating the internal structures of the brain by means of a device placed on the outside of the skull.

Figure 1 Examples of azimuths (the reference image at the top is indicated by a black border)

This is examples of azimuths (the reference image at the top is indicated by a black border). On the left the azimuth remains the same, we simply close to the face. On the right, the azimuth is modified; the change of perspective makes permanently lose information on areas of the face (especially on the hemi left face)., and guiding surgical instruments) allow to control the face of the volunteer (in the manner of ophthalmological) (Fig. 2), making him to adopt a more or less comfortable pose, but reproducible. The camera is attached to this table, mounted on a displacement rail, which allows to precisely define the angles of study (face, profile, 3/4...). Some features also exist for photographing the body (especially cellulite) and are based on the same principle (a column or a tripod on which comes to mount the device photographic).

These positioning tables constitute a first level of requirement, necessary because guaranteeing a rapid positioning of the volunteer (which is a definite advantage in a protocol clinical trial) and to eliminate most common placement errors. There is however no standardization in the design of these tables (often expensive, artisanal and bulky) and their use remains limited overall in the face. Other methods exist (and are currently under study in Besançon) for refine the positioning of the volunteer, including using computer guides superimposed on the image during the acquisition. These guides work like tattoos digital, they are customized for each volunteer and allow to compare very exactly photographs taken at different times (if the subject move, the guides are no longer aligned).Our practice shows that despite all these precautions, residual positioning variations remain (Fig. 3). Thus, we often observe very slight homotheties (the volunteer moves away or comes closer imperceptibly objective). These changes in distance are practically impossible to detect when taking pictures, but are obvious when we superimpose the images time in time. The solution is then to readjust our images. The registration is a set of operations geometries consisting of superimposing 2 or more images, aligning an image to transform on a reference image (Fig. 4). Most of the registration algorithms derive work done at the end of the 80s, during the advent functional medical imaging (Maintz & Viergever, 1998) (Brown, 1992). Electronics "multimodal" require in fact to be superimposed during a same exam different imaging method in order to combine their benefits (X-ray or MRI scanner and tomography for example).The registration consists of 3 steps:

1) Manual selection pairs of points;
2) Mapping of these points and creating a geometric transformation (more or less complex) from spatial coordinates;
3) Application of this transformation to the entire image. The number of pairs of points determines the complexity of the transformation that can be applied.

Figure 2 Different repositioning systems (from top to bottom and left) right: Canfield table, Faraghan system, Eotech table)

These devices allow quick positioning of the volunteer and eliminate placement errors most common. Mounting the camera on a table or tripod limitsrisks of moving. Most of the time the cameras are controlled (settings and trigger) directly from a computer.

Figure 3 An example of approximate repositioning

The images on the left appear correct, but by superimposing them on the right view, we can go that the subject has moved significantly between the 2 shots. The registration is going to compensate for these residual errors. A pair of points makes it possible to compensate for a translation (variation horizontal or vertical), 2 pairs a homothety, and 3 pairs a rotation. These points are successively placed on the different images, at the level of anatomical motifs as small as possible but constant and invariable structurally (moles, corners of eyes, pores dilated...). This choice is difficult since these reasons must to be present in all images (a pore or a defect skin may be present only on certain images and disappear), be in solidarity with the object under study and be pointed very precisely. We remain mathematically in the case of a affine transformation, rigid (without local deformation), which keeps the right angles, which turns out to be the most enough time. By defining a larger number of points (several tens or even hundreds of pairs), it becomes possible to locally distort sets of pixels and change the entire structure of the object being photographed (warping). This type of treatment allows in particular to model the aging of a face (or its rejuvenation).

The registration is a rather laborious manual step, but it still helps to significantly improve the superposition of the images (Fig. 5). We get elsewhere almost perfect results on objects such as the crow's feet.

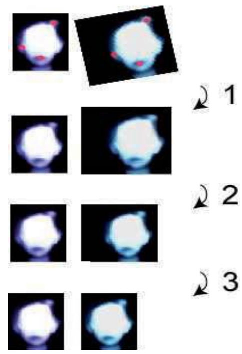

Figure 4 The registration is a set of operations geometries consisting of superimposing 2 or more images, aligning an image to be transformed on a reference image

The selection pairs of points (the red dots placed on anatomical landmarks of the skull, ear and mouth) compensates for a rotation (1), a homothety (2), or a translation (3).There is no theoretical limit to the number images (and therefore time) potentially recallable. In practical, everything becomes very difficult beyond 4 images, and the risk increases to have an image in the batch that disturbs, even invalid the calculation of the global transformation. We note that paradoxically, the lapse of time between images is not necessarily correlated with a drift of repositioning. Plus, the object of study is photographed in a framing tight, the easier the repositioning is, because the pose of the volunteer is then less visible and the choice of reasons for easier registration (the potential reasons for repositioning are more numerous…). In this case, we will have to pay attention changes of expression that can alter the relief of the image (frowning brows for the forehead, folding of eyes for the crow's feet, smiling for the lips), and this, especially since these changes, because of the framing, do not will not be detectable in the image.The face photographed from the front remains a difficult object to apprehend, even with a repositioning table readjusted.

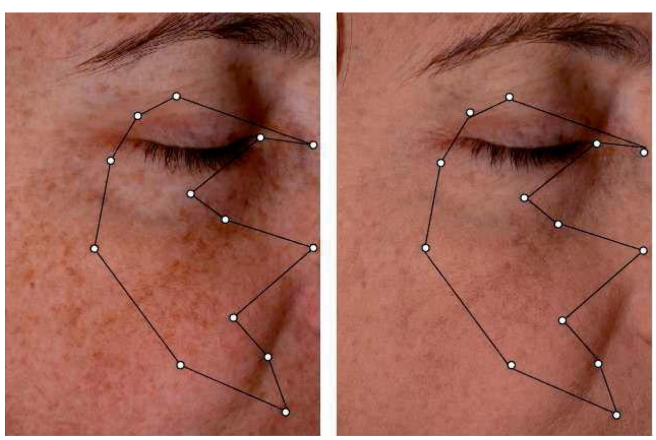

Figure 5 These 2 images (from a clinical study) were areas of interest (symbolized by the polygon) are therefore comparable

This ensures that all changes noticed in the images (and therefore the calculated parameters) come only from intrinsic causes in the study (here in the occurrence the application of a foundation), and a computer registration. It's an object that is no only mobile and fluctuating, but it's also a stimulus to which we are instinctively extremely sensitive.The slightest variation is accentuated, amplified and affects the whole by modifying the expression and therefore the perception (especially the eyes and the mouth).On the other hand, our experience shows that some subjects are more difficult to photograph than others because of their posture and their attitude. For these "difficult" topics because that nervous, it is useful to provide a greater number of taking pictures (for problems related to the lips by example, we may have to take several tens of photographs). In the end, the registration is only a first stage in the preparation of a temporal kinetics of comparison. From a mathematical point of view, this control is necessary but it is not enough. Many issues indeed need to characterize the evolution the color of the skin over time. We must not only be able to compare areas photographed in the same geometric conditions, but we must also ensure that no color drift disturbs the evolution of these images. This control, this management of color makes another calibration step necessary: colorimetric calibration.

Implementation

1) Color Calibration

Without calibration, a digital camera "sees" colors, but we do not know exactly which colors (compared to our eye), nor how much (his gamut) (Delmas, 2005) (Eismann, 2004) (Elias & Lafait, 2006).To make sure of what our system actually sees, we will use a test pattern, that is, a set of patches or colored areas to measure space colorimeter of the device and its deformations (Fig. 6).Each patch has been measured and we know so exactly the color Lab that he matches. Then just compare what our camera sees with this he should have seen (Fig. 7).We use the Lab space (CIELAB 1976) because this space was built in reference with what an eye sees average human (Fraser, Murphy, & Bunting, 2003) (Niemetzky, 1992) (Niemetsky, 2005). A defined color in this space corresponds to a single absolute color for this standard eye. From a practical point of view, we are photographing the sights by setting the settings photographic (aperture, speed, sensitivity) of the device and controlling ambient lighting. We convert then the image of the sight in space Lab (computer conversion of space (RGB to the Lab space). Values averages of each patch will then go compared to those provided by the constructor of the test pattern (or measured with a colorimeter). At first, this comparison allows to know the behavior colorimetric of our device (with the settings we have set for it). More the gaps between the patches are important, the more the colors move away from what they should be (Fig. 7)

(Russ, 2007) (Wikipedia, LAB color space) (Wikipedia, Color difference). A gap average (sum of the differences / number of patches) allows to characterize simply the colorimetric drift of our camera. This colorimetric signature is naturally only valid for a set of photographic parameters well defined. If we change the opening, we will change the exposure and so alter the Lab values measured on the patches. Practice shows that the drift is from the order of 10 (average) on the housing's midrange DSLR (Canon Eos 20, Nikon D70) with correct exposure. Compact housings are globally also powerful (Minolta, Olympus).The most important gaps are observed at the level of the most saturated colors (the reds and blues), more difficult to restore because located at the borders of the gamut (the color space that can represent an acquisition device). The balance of whites (calculated on neutral tones) often indicates the presence of a bluish dominant, which gives an appearance rather cold in the image (Figs 7 and 8).It is then possible, from this characterization, to calculate a mathematical transformation (linear, polynomial...) between the Lab triplets measured on the patches and theoretical ones. This second step is the calibration itself. Practically, a second image is generated from the first photograph

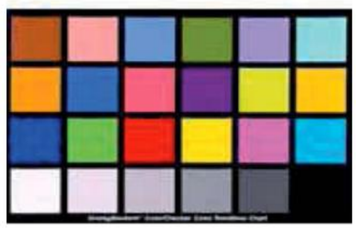

Figure 6 Gretag Macbeth color chart. It has 24 referenced colors (18 colors of increasing saturation and 6 levels of gray), optimized for hues current (sky, skin tones, greenery, saturated colors)

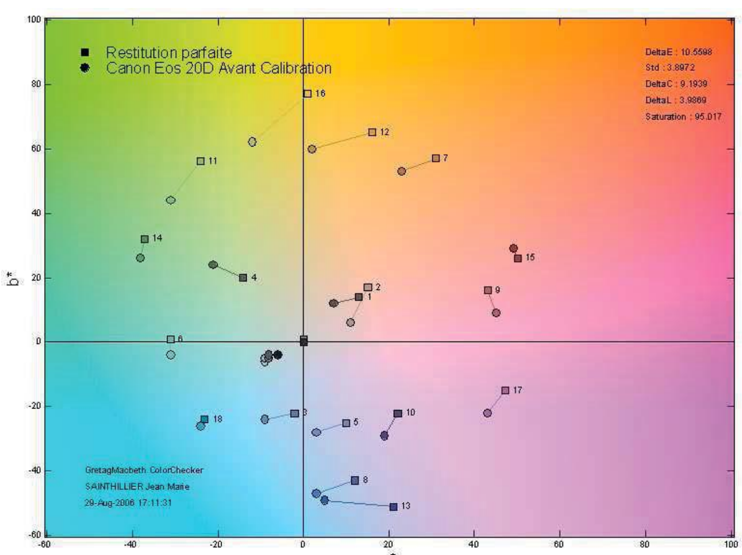

Figure 7 Example of colorimetric characterization of a Canon Eos 20D

The sights Greta Macbeth was photographed and the colored areas were measured in the image. We can thus compare the colors as they are on the photograph and as they should have been if the acquisition had been perfect. More segments are larger, the larger the color gap is important. We observe that the differences are more important for very saturated colors (zones 13 to 18). Gray levels indicated by circles are substantially shifted in blue tones. Integrating the test pattern (Fig. 8). Every pixel of this image is recalculated thanks to the mathematical transformation set on the patches. We can then reduce the drift around 2 (average E). The white balance is corrected, the image becomes redder, more natural, alone some gaps remain at the level of the colors most saturated. These treatments require the integration of the test pattern into the photograph, placing it next to the object under study, in the same plan. This placement is not always obvious for the face, the sight taking a certain place in the scene and can generate shadows (Fig. 8). It is however possible to fix the sight directly on the positioning table, so as to have it systematically in the field. The colorful patch record and the calculating the polynomial transformation can be done for each volunteer, but practice shows that recent devices present a very high stability when used in a well-defined environment (even place, same lighting, same setting). He is wiser in this case to calibrate the device at the beginning of the study and for each time. If no drift is noticed, we then apply a single calibration profile to all the images of the study. By definition, this management of color is particularly interesting for multicenter studies, combining devices and different places. We then calculate a transformation for each center ("dependent center") and consider then all the images as a whole, coming from a single and same digital camera.

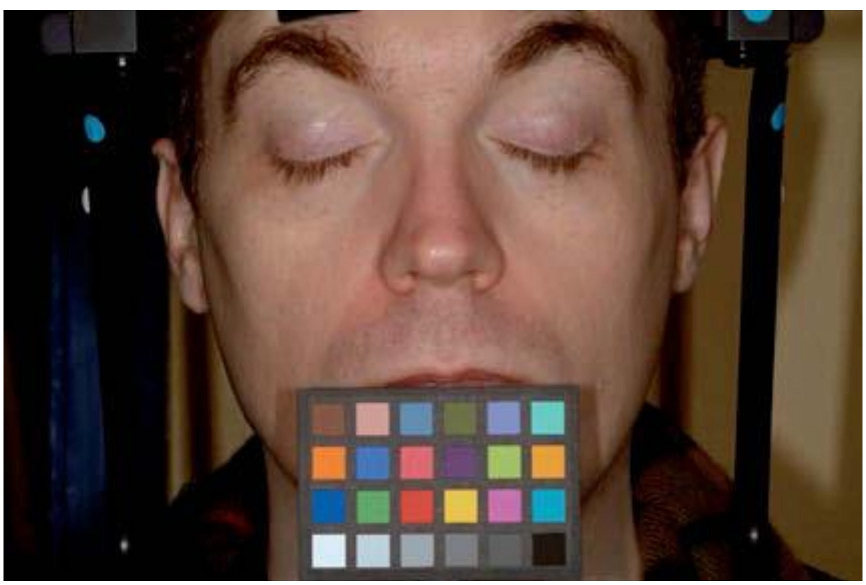

Figure 8 Colorimetric calibration example (front left and right after)

The color chart placed in the image allows to characterize the drift of the device photo for given settings (sensitivity, aperture, shutter...) and in a specific environment. After calibration, there are warmer tones (less bluish) and realistic.

Figure 9 Double calibration (geometric and colorimetric) images (from a clinical study) before and after application a foundation (top left and right respectively)

The Result and Discussion

The rectangular area of interest (indicated by a white rectangle) selected on the nose (details below) is perfectly comparable on both photographs. It is then possible to calculate a heterogeneity parameter adapted to this problematic (Sainthillier, et al., 6-9 October 2008). Here this parameter decreases considerably and from 53.4 to 13.6, and a simple photo editing (through corrections performed in Photoshop) is thin and can lead to all kinds of excesses (like it can be seen regularly on television or in the press). A certain intellectual and deontological rigor is necessary here, especially since the digital photography (and photography in general) is often suspected of being the source of all kind's manipulations. All calibrations must therefore be documented in the interests of transparency and traceability.

That said, it should be noted that calibration is a problem when the starting colorimetric signature is too important (> 15, when the image is too overexposed or too underexposed for example). The transformation mathematical then generates saturation artifacts in the image in the form of parasitic colors. After these 2 calibration steps, we have of aligned images, whose colorimetric drift is known and as small as possible. It is then possible to batch these images, that is to say, to generalize the treatments of an image by applying them to all others (Fig. 9). The repeatability and robustness of our measures are guaranteed by the respect of the conditions of image taking, both from a geometric point of view color. We have applied these methods in many clinical protocols, especially for the follow-up of cicatrization lips, evaluation of rosacea, application bluish asset, a foundation (Fig. 8).

Conclusion

Digital photography offers many perspectives in clinical evaluation but its low cost and its apparent simplicity should not hide the difficulties theories that flow from it. Its use in a goal of characterization and quantification involves a level of requirement much higher than that required for a purely illustrative use. Like any new imaging method, digital photography assumes rather heavy IT developments, a large technical precision and a good dose of experience before to be properly controlled.

The methods presented here modify deeply the images and the way they will be perceived. The border between a scientifically-based calibration and a simple photo editing (through corrections performed in Photoshop) is thin and can lead to all kinds of excesses (like it can be seen regularly on television or in the press). A certain intellectual and deontological rigor is necessary here, especially since the digital photography (and photography in general) is often suspected of being the source of all kinds' manipulations. All calibrations must therefore be documented in the interests of transparency and traceability.

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