ANALYSIS OF HUMAN SKIN TEXTURE USING IMAGE PROCESSING TECHNIQUE

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Abstract

Analyseof skin texture is very useful for creation and invention of cosmetic products. There are some methods needed to analyze the skin. In this study, skin texture was analyzed by an image analysis technique with computer assisted. The objective of this study was to analyze the texture of the human skin by image processing method. In order to do so, the research was done by first preparing thereplica of the human skin, and hence the skin image was obtained by taking the projection of the replica by image grabber. Image processing analysis was done to measure the skin roughness parameter. The results shows that the software can display the image and calculate the skin pameters.

Keywords: *skin texture, skin image, skin replica, image processing,and image analysis*

1. INTRODUCTION

Estimation of skin roughness is an increasing interest especially in the field of cosmetic research. There are some established methods for assessing skin roughness. For fundamental research on ultrastructure of the stratum corneum surface scanning electron microscopy is a suitable method. A direct method is the surface evaluation of living skin, which is based on an optical system in a CCD camera measuring four parameters of roughness, scaling, smoothing and wrinkling. A similar but non-direct method is optical profilometry using skin replicas. Laser profilometry produces a variety of data that can be analyzed using complex mathematical functions. A new method is transparency profilometry (skin visiometer) using a very thin skin print that allows parallel light to pass through and is analyzed immediately after production. The different methods can be used for characterization of the skin microrelief in dermatoses or for dynamic measurements of time-dependent changes in skin surface topography after application of cosmetic or medical products.

There are several parameters of the skin that can be determined objectively, and in this study the skin roughness is the purpose to be determined. Skin replica image acquisition was conducted using a commersial skin visiometer which is connected to the computer for further analysis. However, during acquiring the image, some inveromental condition such as moisture contents of the stratum corneum must be considered.

2.METODOLOGY

The methodology used in the study covers the skin replica preparation, skin replica image acquisition, image processing and skin replica parameter calculation.

2.1. Preparation of Skin Replika

Toreplicate the human skin, a liquid substance made of silicon mixture was used. The skin area for the relief measurement has been selected. It had to be found an area without hair as they will damage the replica when pulling-off the skin or lead to errors in measurement. The inside of the forearm close to the elbow, for instance, is a representative skin area. The special double stickers (measuring adapters) was stick on a specified skin part, for example on the forehead (exactly on the wrinkles, on purpose to measure the roughness), and should be located to the skin spot whose edge is open towards one side so

that excessive silicon can flow out of this opening and not too much pressure is on the skin. Attention should be paid that the opening shows always in the same direction guarantee the same position and orientation of the replica. The cover foil of the upper-side was removed before sticking the corneofix onto the skin in order to proceed continuously.Vacuum stirrer was pumped to stir the silicon liquid.

Silicon liquid was dropped into flask and stirred by a pumped vacuum stirrer in order to mix the silicon liquid without the presence of air bubbles. One drop of each blue-colored silicon components of ratio 1:1 was dropped into the small stirring cup, the lid with the stirring compound fastened on and the vacuum pump was already activated with the foot-pedal. During the pump procedure (approx. 15 to 20 seconds) the material had to be mixed very carefully in order to avoid even minor air bubbles in spite of the negative pressure. After finishing the stirring process, the pump must be switched-off and the lid should be removed very slowly.

A plastic stirring rod was used to take the silicon mixture to drop it on the specified skin part (which the double sticker was attached), a larger drop of the mixed silicone material was dropped on the inside-space of the plastic ring sticking on the skin.

The prepared small glass-cover-plate (corneofix) was taken at the edges, and was placed onto the edge of the ring which is opposite to the outflow-aperture and was dumped into the direction outflow-aperture till it lies plain on the sticker-ring. The silicon material was spread over the whole inside of the sticker. Corneofix was applied to press the silicon liquid mixture on the skin surface and wait approximately for 3 to 4 minutes until the mixture of silicon was dried to produce the silicon replica that was attached on the corneofix.

The replica then was detached from skin surface and was attached to a replica frame to be put in the skin visiometer and measured (the roughness). The silicon mixture dropped on the skin surface must be in a precise amount so that the replica produced would not be too thick or too thin.

The special-frame with the replica was inserted into the magazine of the projector (the profile side of the replica must show in direction CCD-camera, the side covered with the small cover-plate in direction of the projector's lamp as the focal plane did not lie in the cutting-plane of the slide-frame).

The result was measured by skin visiometer and shown on computer, and be checked whether we got a good or bad result, so that we could reproduce thebetter replica for the better result. The result was able to be read and analyzed The skin replica tension should be the same at each replica test. This can be achieved by the defined position of the arms: the elbow should be positioned in 90° of angle, the forearm and the open stretched hand on a leveled place.

In this research, replicas were printed in 5 selected parts of skin on body which are on the face (cheeks and foreheads), hands, hips and abdominal parts. The selected skin area could be exactly marked in order to find it again in case of long life tests.Skin replicas are used for non-direct measurements of skin topography. The visiometer technique is a recently developed method, which uses a thin silicone gel print of the skin surface, which allows parallel light to pass through and is registered as a change of transparency by a CCD video camera. The silicone gel has a low viscosity and is composed of two components in the ratio of 1:1 and stirred by a vacuum pump without forming bubbles. A small double-sided self-adhesive film with a thickness of 0.5 mm is fixed on the skin as a frame, and after adding a droplet of the silicone gel in the center, a glass platelet is placed on the gel and self-adhesive film. The silicone gel hardens within 3-4 min.

2.2. Image Acquisition

In this research, SkinVisiometer SV 400 as shown in Fig.1 was modied and used for image aquisitiom. This machine consists of a special projector where a light source and a CCD camera with optic were installed. The silicon skin replica is placed into a 38mm slide frame and inserted into the magazine of the projector and ready for evaluation. A usb based frame grabber was installed and a computer program based on Matlab was developed for image acquisition, processing and analysis.

2.3. Image Processing Technique

After drying, the printed siliconereplica was placed onto a concentric special carrier frame that is placed in a specially constructed slide projector between the light source and the CCD camera. The thickness of the relief is calculated according to the Beer-Lambert law as absorption of the transmitted light. The absorption is measured by the CCD chip and processed into gray levels. These differences are transferred to a monitor, which shows the

structure of the skin surface topography. The advantage of this method is the short processing time and the direct visual control of the skin replica on the computer display.

The structure of the skin surface is displayed on the video monitor according to its height and depth by 256 gray layers. The video-image is digitized with a definition of 360 x 274 pixels. That means 1 pixel equals approx. 21 µm in X- and Y- direction. The theoretical definition per pixel with a skin replica thickness of 0.5 mm, a constant illumination and 256 gray layers will be approx. 2 micron, i.e. full utilization of complete gray layer scale will achieve an optimal definition. The image is processed using median filtering.

2.4. Image Analysis

The analysis covers:

- RT (skin roughness) is the average of the distance between the highest and lowest curve.
- RM (maximum roughness) is the longest wave.
- RZ (average roughness) is the average of the skin roughness.
- RA (arithmetic average roughness) is the average deviation of actual profile from the average profile.
- RP (smoothness depth) is the depth of smoothness which is average distance between actual profile and inference profile.

The average roughness is the arithmetic average of the different segment roughness Zi, calculated from 5 succeeding measurement segments of the same length:

$$R_Z = \frac{1}{5}\sum_{i=1}^{5} Z_i \quad (1)$$

where, Rmax = Z_5

Smoothness Depth Rp

$$R_p = \frac{1}{l}\int_0^1 h\,dx \quad (2)$$

The smoothness depth Rp is the mean distance between reference profile and actual profile, h is measured starting from the reference profile – here, from the upper enveloping curve.
Average quadratic deviation of the repartition of h values Rq:

$$R_q = \frac{1}{n}\sum_j R_{qi} \quad (3)$$

Where

$$R_{qi} = \sqrt{\frac{1}{N}\sum_j z^2(x_j)} \quad (4)$$

Skin Roughness Rt

The skin roughness Rt is the distance between the basic profile and the reference profile, referred to a reference length *l*. Rt does not include the waves.

Arithmetics Average Roughness Ra

The maximum roughness Rmax or Rm is the biggest roughness out of the different segment roughness, measured on the total length *l*.

3. RESULTS

InThe roughness of the skin surface is subject to internal as well as external influences. It mainly depends on the water content of the stratum corneum, age, climatic influences (temperature, intensity of solar radiation, etc.), health condition of the skin and on the efficiency of cosmetic products. Therefore measurement of the skin roughness becomes more important to classify the skin conditions and to test and evaluate products in the cosmetic industry.

The methods for the determination of the skin roughness known up to now are only used by a limited group of laboratories, hospitals and manufacturers of cosmetic products because of the extreme time consumption and high costs, most used in the cosmetic products laboratories.

The measurement method of the Skin Visiometer SV 400 offers an alternative to the existing measurement method of the skin surface profile and shows the perspectives to determine the microrelief. That is based on the light transmission through a specially prepared silicon replica.

The measuring principle of the Skin Visiometer SV 400 is based on transmission of a very thin and especially dyed silicon replica. The light is absorbed according to the thickness of the silicone material. The replica reproduces the heights and depths of the skin as a negative.

The visualization of the light absorption on a PC monitor, e.g. by a black-and-white CCD-camera, makes it possible to represent the heights and depths of each pixel of the replica by a corresponding classification on a grey scale.

The distance in 1 / 100 mm between each pixel and the basis line of the skin replica can be calculated by the individually developed picture digitizing technique and the software of the Skin Visiometer SV 400.
Different mathematical models and parameters have been discussed in the literature to determine the skin surface roughness. Such parameters include RT, RM, RA, RZ and RP.

The software calculates the parameter for each line and direction. Even individual wrinkles become visible with a macro function. Depth and width could be determined exactly and distances to other wrinkles could be calculated. The cursor-function could reach any requested point (pixel) and therefore determines its x-, y- and z-coordinates.

Furthermore, it was able to select a square or a circle in any desirable size. 1 – 180 lines could be produced within the plane and within the square even in horizontal as well as vertical direction. The most important parameters for those lines were calculated within seconds and the average value was displayed.

The measuring principle makes it possible to calculate the x, y, z-coordinates of each pixel. The angle of the representation can be chosen freely in horizontal and vertical direction. The representation can be printed out in black and white. Therefore it is necessary to use certain printers.

3.1. Results from the reading of the replica projection

Firstly, the volunteer's skin was replicated in five different parts which are on the cheek, forehead, hand (wrist), hips and abdominal.In this research, there were five selected points taken from the replica projected to get the amounts of parameter and measure the average.

Cheek

Fig.1: Image of cheek skin tetxture

The volunteers had their difference of age, they are 20 years old, 30 years old, and 40 years old. Their cheek parts that were replicated were located 90° of angle between the eye and nose.

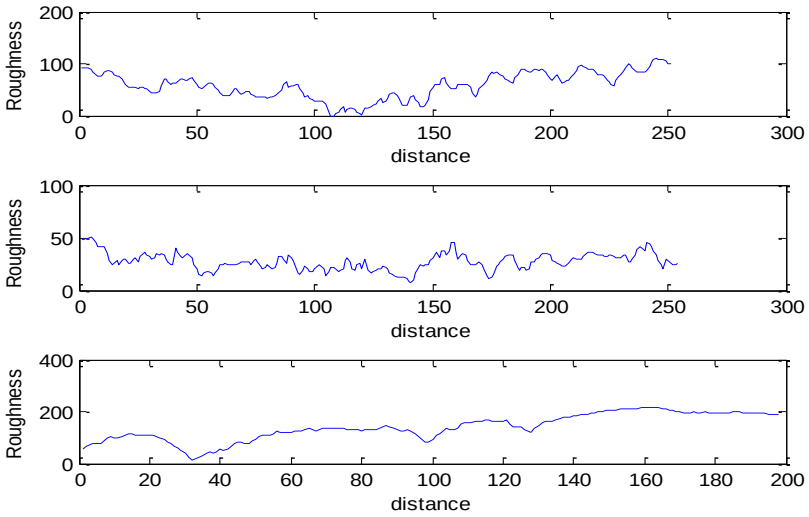

Fig.2: Roughness of the cheek skin tetxture

The replicas of cheek skin were inserted to the magazine of projector, and the parameters were calculated.The figure above is one of the projection results of cheek skin replica that was done. After the skin replica was projected, points of the parameters calculation area could be selected (in this research, 5 points were selected on every image of projected replica), and the result:

Table 1 Data of Figure 1 Cheek skin parameters of a 20 years old woman

Parameters in µm	Age 20				
	1st point	2nd point	3rd point	4th point	5th point
LL	1.446	1.607	1.607	1.607	1.607
RT	0.083	0.058	0.066	0.067	0.058
RM	0.044	0.039	0.038	0.043	0.039
RZ	0.029	0.029	0.026	0.029	0.029
RP	0.039	0.033	0.030	0.029	0.027
RA	0.015	0.011	0.015	0.014	0.011
RQ	0.019	0.013	0.018	0.017	0.014

The average of these results could be calculated to measure the average roughness of all measurement of the cheek skin, and the results could be compared to the cheek skin of a 30 and a 40 years old woman.

Forehead

The volunteers had their difference of age, they are 20 years old, 30 years old, and 40 years old. Their forehead parts that were replicated were located right on the center of the forehead.

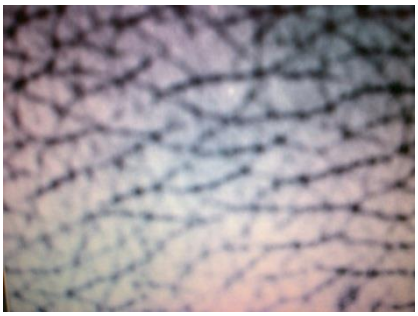

Fig.2: Image of forehead skin tetxture

The replicas of forehead skin were inserted to the magazine of projector, and the parameters were calculated.

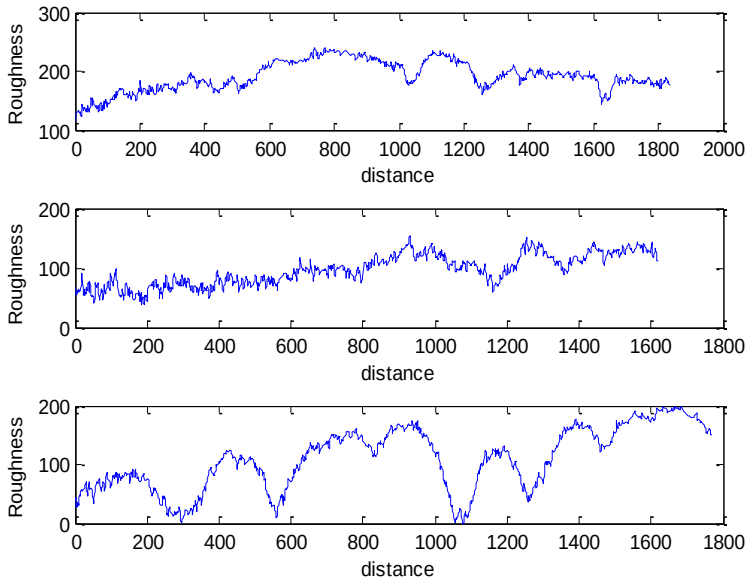

Fig.3: Roughness of the forehead skin tetxture

4. CONCLUSION

The following concluding remarks can be drawn from the current works:

1. Skin replica of hand, check and wrist for various ladies have been developed.
2. Images of such skin replica have been acquired using a modified skin visiometer which is connected to computer.
3. The skin parameters of various images of skin replica have been obtained.
4. Image processing technique has been used to obtain the skin roughness parameters.
5. The recently modifiedskin visiometer, based on light transmission through blue colored silicone replicas, had been sucessfuly used to study skin microrelief.
6. In comparison to other systems, it is superior by accuracy, easy and fast handling. It offers many possibilities and advantages and has become an essential help for cosmetology and dermatology
7. The software that had been developed makes it possible to stretch areas and to determine them in a state. The huge amount of information and the precise data make the assessment of the skin roughness more accurate, easier, and quicker

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