Evaluation of Age-related Effects on Human Skin Surface Roughness using Optical Coherence Tomography

Sanzhar Askaruly[1], Yujin Ahn[1], Hyeongeun Kim[1], Andrey Vavilin[1], Pilun Kim[2] Haekwang Lee[3] and Woonggyu Jung[1]

[1]*Department of Biomedical Engineering, Ulsan National Institute of Science and Technology, Ulsan, Korea*
[2]*Oz-Tec Co., Ltd., Korea*
[3]*Amorepacific Corporation R&D Center, 1920 Yonggu-daero, Giheung-gu, Yongin-si, Gyeonggi-do 17074, Korea*

MOTIVATION

There are studies (1) reporting changes in skin surface topography with age. Although researchers (2,3) investigated epidermis layer properties, e.g. epidermal depth, there were few attempts to quantify skin roughness and its correlation with age of subject using OCT.

Figure 1. Young and old skin

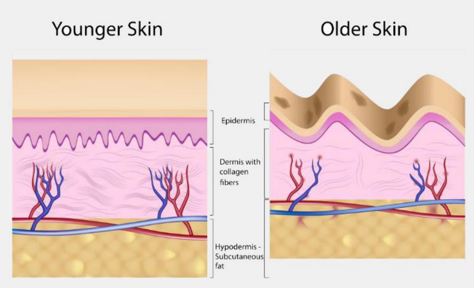


Figure 2. Younger and older skin surface

Figure 3. PRIMOS Small Field Systems

As objective measurement tool for skin microrelief, PRIMOS device, working on principle of fringe projection cameras, was proposed (4), with special software package included for numerical analysis of skin roughness. However, it has drawbacks, such as insufficient three-dimensional information. In this paper, we examine the feasibility of OCT for skin surface topography measurement and its correlation with aging of the subject. To detect skin surface from an image, we suggest a novel algorithm with calculations of roughness.

METHOD 1: OCT IMAGING

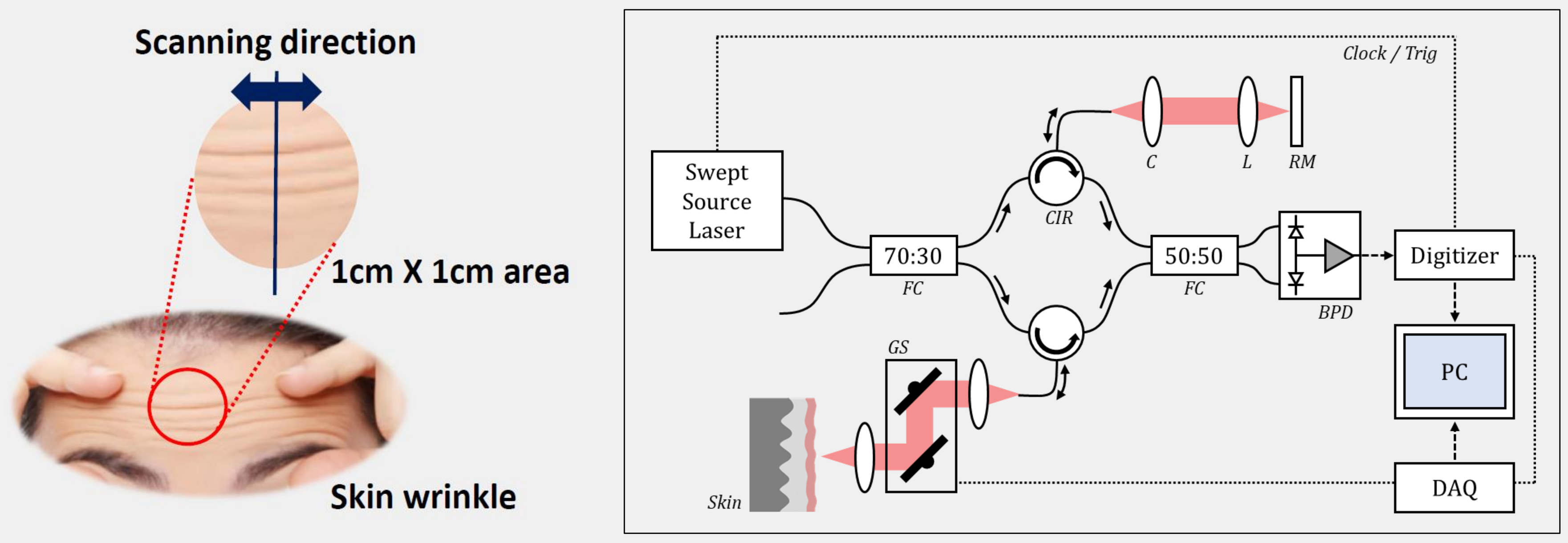
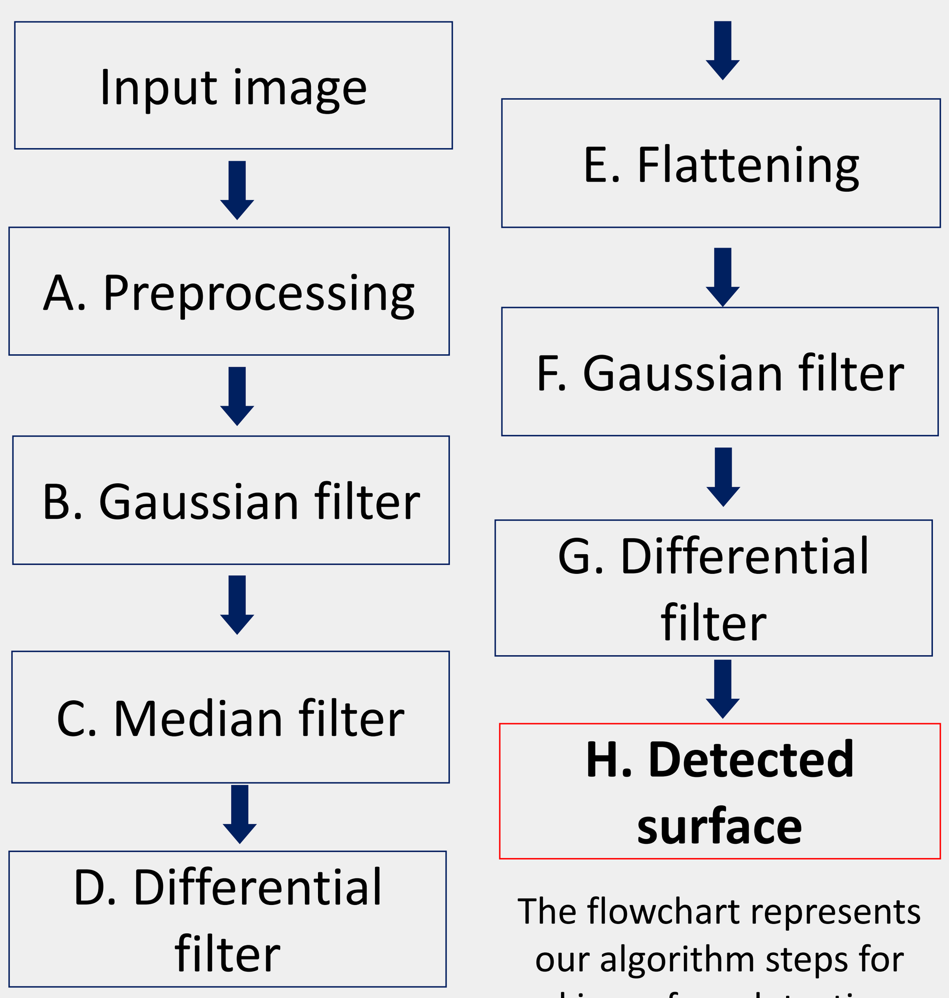


Figure 4. Image acquisition of human skin and swept-source optical coherence tomography (SS-OCT)

Experiment was conducted using various parts of human skin. Swept-source optical coherence tomography (SS-OCT) that enables 3D OCT imaging was used in this study. OCT systems can transversely section skin surface topography.

- Center wavelength : 1310nm
- Bandwidth : 50nm
- Acquisition rate : 50,000Alines/s
- Axial resolution : ≥8μm
- Lateral resolution : ~17μm

METHOD 2: SKIN SURFACE DETECTION ALGORITHM



The flowchart represents our algorithm steps for skin surface detection

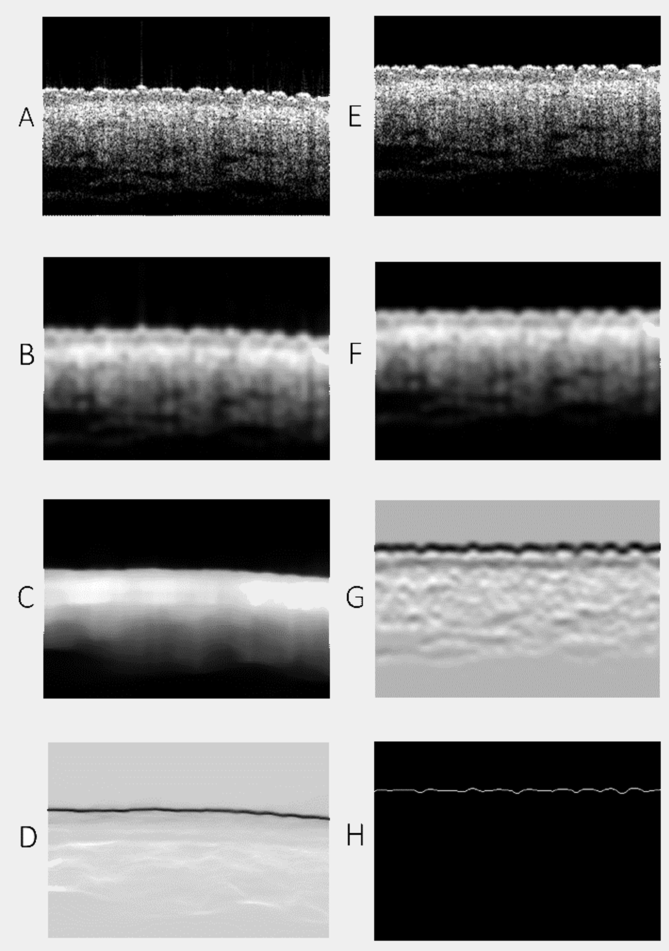


Figure 5. Result of algorithm flowchart

METHOD 3: ROUGHNESS DEFINITION

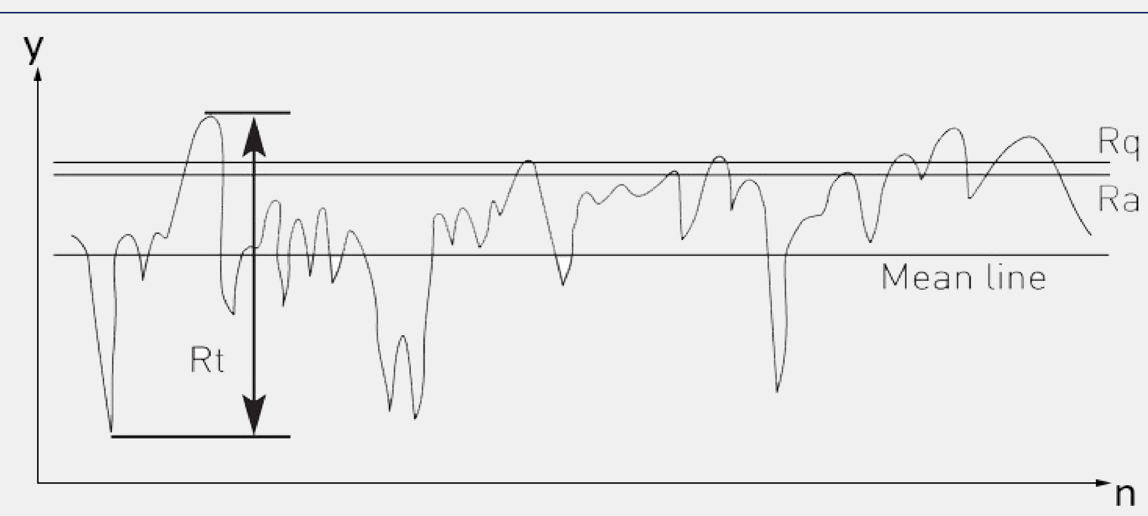


Figure 6. Roughness parameters illustration

1. Average Roughness
Arithmetic mean of the roughness values:

$$R_a = \frac{1}{n}\sum_{i=1}^{n}|y_i|$$

2. RMS Roughness
Root mean squared of the roughness values:

$$R_q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2}$$

3. Maximal Profile
Sum of the highest peak and the lowest valley level

$$R_t = R_p + R_v \quad \begin{cases} R_p = \max\limits_i y_i \\ R_v = \min\limits_i y_i \end{cases}$$

RESULT 1: FLATTENING AND SURFACE DETECTION

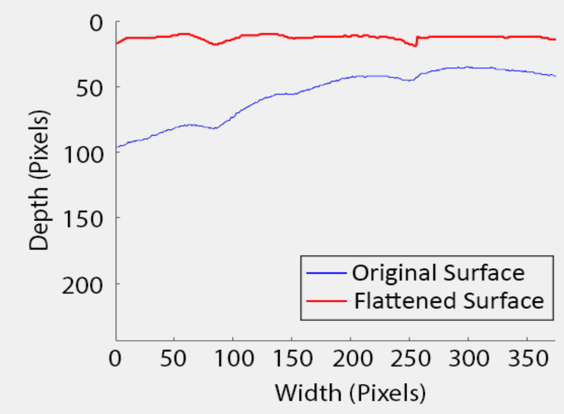


Figure 7. Original surface (blue line) and surface after flattening (red line)

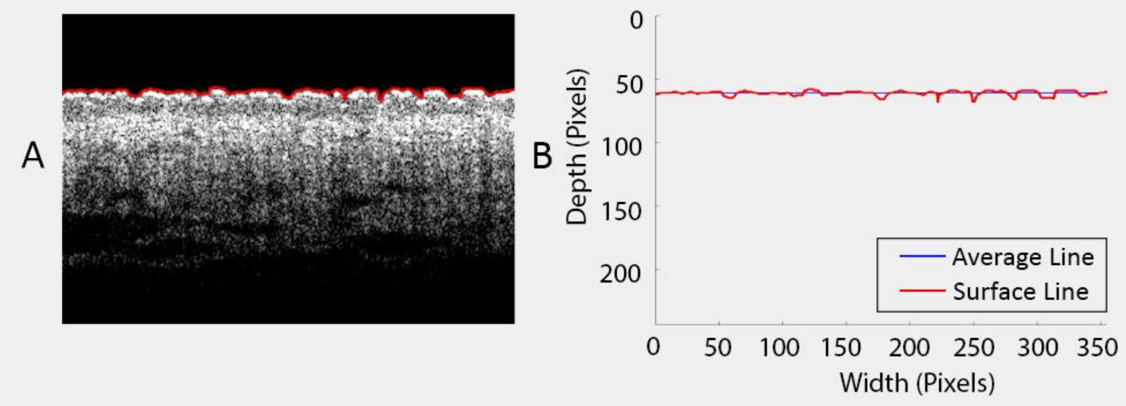


Figure 8. A) Detected surface (red line) on top of OCT skin image
B) Detected surface (red line) and calculated average from surface (blue line)

We preserve structure of original surface after flattening by removing longer wavelength components (Figure 7). The results of described algorithm are presented in Figure 8.

RESULT 2: ROUGHNESS CORRELATION WITH AGE

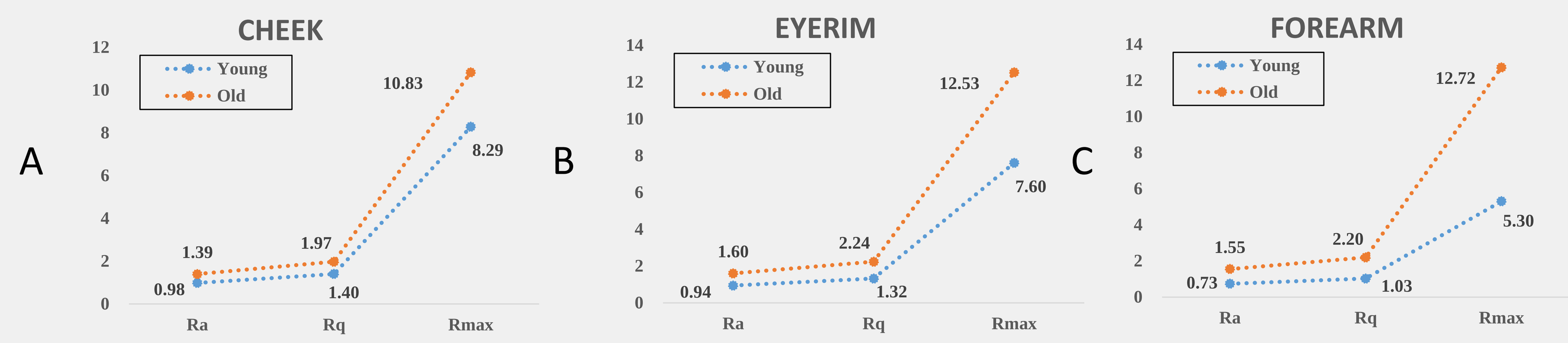


Figure 9. Average, RMS and Maximal profile roughness values shown in
A) Cheek B) Eyerim C) Forearm

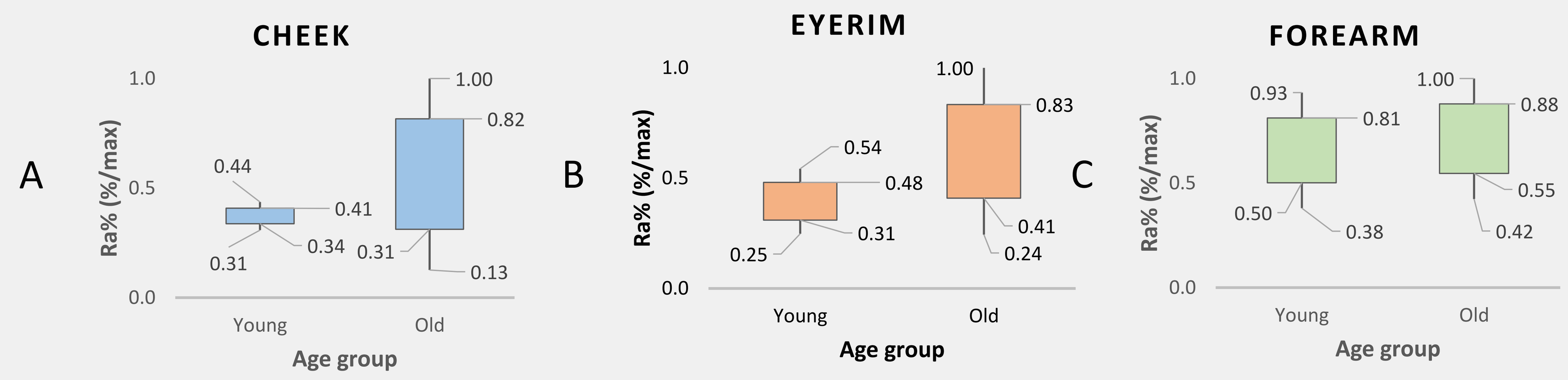


Figure 10. Distribution of average roughness values in young and old age group subjects for three skin regions shown for
A) Cheek B) Eyerim C) Forearm

We involved five subjects representing young (mean: 27) and five subjects for old (mean: 55) age groups, including cheek, eyerim and forearm skin regions into our study. Outcome of conducted experiments suggests that there is a positive correlation between subject age and roughness parameters. Also, we observed a wider range of deviation for roughness parameters in older people when compared to younger representatives.

RESULT 3: ROUGHNESS CORRELATION WITH DIFFERENT SKIN REGIONS

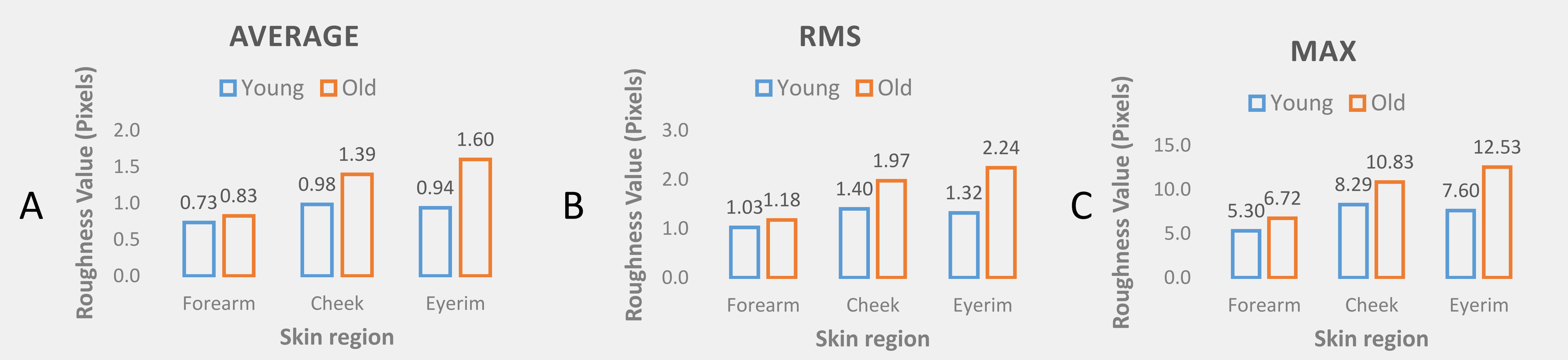


Figure 11. Roughness parameters (A. Average B. RMS C. Maximal profile)
in forearm, cheek and eyerim for young and old age groups

Finally, among three collected skin regions, eyerim demonstrates the highest roughness values in older subjects. On contrast, forearm part shows the lowest average, RMS and maximal profile roughness parameters.

CONCLUSION

In this work, we investigated correlation of skin surface roughness with age and three different skin regions obtained from OCT images. We also suggested a novel algorithm to detect skin surface, which performs accurately on whole image dataset, consisting of 15000 images in total.

Our preliminary study shows that proposed technique is a promising tool for accurate quantitative analysis of volumetric skin. It could become a valuable method in addition to existing PRIMOS solutions serving to both cosmeceutical and dermatological field.

REFERENCES:

1. Li (2006). Age-related changes in skin topography and microcirculation, *Archieves of Dematological Research*, 297(9), 412-416
2. Tsugita (2013). Positional differences and aging changes in Japanese woman epidermal thickness and corneous thickness determined by OCT, *Skin Research and Technology*, 19(3), 242-250.
3. Gambichler (2006). In vivo data of epidermal thickness evaluated by optical coherence tomography: effects of age, gender, skin type and anatomic site, *Journal of Dermatological Science*, 44(3), 145-152.
4. Bloemen (2011). An objective device for measuring surface roughness of skin and scars, *Journal of the American Academy of Dermatology*, 64(4), 706-715.
5. Figure 1: Young and old skin. Retrieved October 23, 2017 from Google Images: https://images.google.com
6. Figure 2: Younger and older skin surface. Retrieved October 22, 2017 from Deka Medical Laser: http://www.dekalaser.com
7. Figure 3: PRIMOS Small Field Systems. Retrieved October 22, 2017 from Canfield Scientific: http://www.canfieldsci.com

ACKNOWLEDGEMENT

This work was supported by a grant of the Korean Health Technology R&D Project, Ministry of Health & Welfare, Republic of Korea (Grant No. HN13C0078) and by the 2017 Research Fund (1.170009) of UNIST(Ulsan National Institute of Science & Technology)