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A STUDY ON THE APPLICATION OF IMAGE PROCESSING FOR THE SKIN DIAGNOSIS IN AUGMENTED REALITY (AR) WITH HEAD MOUNTED DISPLAY (HMD)

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Abstract

Recently, the beauty industry has been evolving the multiple types of product developments or distribution and service models by the integration with IT. Especially, augmented reality (AR) with head mounted display (HMD) system is able to reflect various information of the real world by real-time image processing algorithm. Therefore, it is required to study the multiple utilizations such as medical diagnosis by image processing algorithm in the environment of AR HMD. This study aims at to suggest the ideas related to applications of image processing for skin diagnosis in the environment of AR HMD. To do so, the existing image processing algorithm was applied for the characteristics of AR HMD system and the diagnosis of skin spot. Median filtering to remove the noise, Otsu's binarization to extract the skin characteristics and *K*-means for clustering in the skin diagnosis were applied. Then the image on the skin spot was made with threshold and the required information during the diagnosis was reflected and realized with AR HMD. Since the results of this study showed the application potential to the real-time skin diagnosis with

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AR HMD, this is anticipated to increase the utility of the diagnosis further.

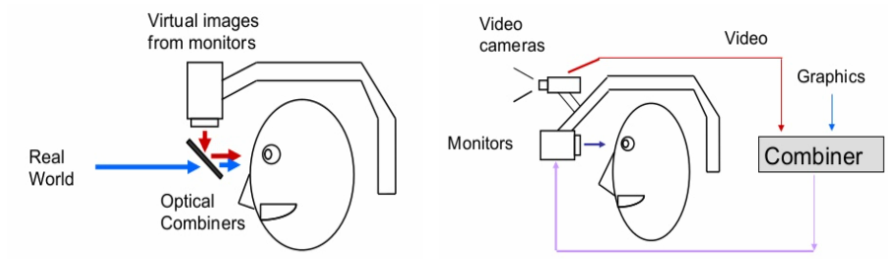
I. Introduction

Recently, the beauty industry showed the trend of high growth in the Asian market including China, and this is anticipated to be continued for a while. In addition, ‘smart’ has been positioned as the important trend in the beauty industry, and the convergence with electronics and IT has been tried in a variety of areas [7, 10]. Electronics and IT can make the emergences of new category products such as cosmetic devices, or play a role to make the usage experiences of the existing products more abundantly by the applications of smart-phones and experiences of virtual reality. As HMD realizes virtual reality and augmented reality, recently in the market, multiple forms of industrial applications got suggested to integrate these [2, 12]. Augmented reality can provide with live information systemically by realizing the virtual information as well as the real world, simultaneously, and the interest level and concentration can be facilitated by sensible devotion. Especially, real world based integration, liveliness, and interactive characteristics which augmented reality has are applied to diagnosis and surgical procedures in the healthcare industry. Also, technological advancement of AR HMD can lead to new alternative which can popularize personal analysis for the skin status together with the improvement of image technology, and the following business models can be suggested using this. In case of skin diagnosis by image, the utility of the diagnosis can be made by reflecting the analysis results of skin pores, spots, and wrinkle on AR HMD [6]. Hence, the study is required on the measures to apply image processing application of the skin analysis on AR HMD.

This article consists of the following: AR HMD system is described on AR HMD system in Section II, and the traditional skin analysis and image processing algorithm are analyzed in Section III. Section IV is devoted to the utilization plans of the study for the applications of image processing on AR HMD. The paper ends with the conclusion in Section V.

II. AR HMD (Augmented Reality Head Mounted Display) System

Mixed reality can be classified into real environment, augmented reality, augmented virtuality, and virtual environment [5]. AR is the technology to show one image with the virtual image on the background of real life image. HMD type AR systems can be classified to be optical see-through HMD system and video see-through HMD system. Optical see-through system is the type to be shown with the optical integration of augmented information using transparent display and real life information as seen in Figure 1(a). At the moment, the products such as Google Glass or Moverio by Epson are used with this type of system. Video see-through system is the type to be shown with combination of required information on the image captured by the camera as in Figure 1(b).



(a) (b)

Figure 1. AR HMD system (a) optical see-through HMD (b) video see-through HMD [3, 6].

Moverio BT-200 model which is Optical see-through HMD type by Epson was used in this study. BT-200 has the individual display structure of both eyes so that the volume image can be realized by binocular disparity. It is equipped with the interface based on android platform, switchable sensor (gyroscope, GPS, accelerometer) and front-facing camera. Front-facing camera can be used in the image processing like recognition. The image is projected through LED backlight and HTPS panel, and it is displayed on half mirror based free-form optical surface.

III. Image Processing Algorithm for Skin Analysis

Skin analysis can be mainly divided into contact type and non-contact type. Especially in non-contact type, the main examples of skin analysis factors are skin pore, reversal and wrinkle. The method of skin analysis by general image is conducted by the extractions of characteristics such as skin pore, pigment deposition and wrinkle. Traditional image processing methods for this include filtering to remove noise, binarization based on certain threshold value of image histogram to differentiate the segments, and *K*-mean clustering to detect the final segment [9, 11].

(a) Filtering to remove noise

Noise in the image means unnecessary information. Therefore, removing noise is the pre-processing for the image analysis including mean filter, media filter, etc. as the representative traditional algorithm. Mean filter is the method to set the values of specific coordinates as the mean values of the surrounding pixels. In case of the existence of noise, it may disappear, however, the image will be obscured since it can dim all the pixels without considering noise or edge. Median filter defines the pixel with specific coordinate value by arraying it with ascending order within the window area and selecting the median value. It has the advantages of edge value conservation and clear image [8, 11].

(b) Binarization

Binarization means conversion of the set $f(x, y)$ having multiple values into a new set $g(x, y)$, where $f \in \{0, 1\}$ with only two values. By setting the threshold *T*, the brightness value of pixel in the image is changed into 0 or 1. The multiple methods to set up the threshold have been suggested including the one to use the mean value of the total image brightness value, and the one to decide the threshold up to certain rate in the histogram of brightness. Otsu's method suggested in 1979 [4] was introduced in this article. Otsu's method is to define the threshold (*T*) with the valley point in the histogram considering that the type of histogram is bimodal. That means, relatively concentrated parts are classified as the same class which provides certain groups to consist of two classes.

Total variances can be presented as within-class variance and between-class variance. In other words, to get good threshold (*T*) is to get the minimum variance within-class and maximum variance between-classes. Within-class variance is given by formula (1):

$$\sigma_\omega^2(t) = \omega_1(t)\,\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t). \tag{1}$$

$\sigma_\omega^2(t)$ is within-class variance, ω is weighted value, $\sigma_1^2(t)$ is the variance of class 1 and $\sigma_2^2(t)$ is the variance of class 2. Between-class variance is given by formula (2):

$$\sigma_b^2(t) = \sigma^2 - \sigma_\omega^2(t) = \omega_1(t)\,\omega_2(t)[\mu_1(t) - \mu_2(t)]^2. \tag{2}$$

Between-class variance is an inverse of within-class variance, so it is to get the maximum of between-class variance to find its threshold.

(c) Clustering

Clustering is the process to cluster similar groups from physical or abstract object [1]. Especially, it is to define the groups on the mixed data in the image processing. *K*-means is the representative algorithm. This is the classification method to compare Euclidean distances from the centers of the groups:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2, \tag{3}$$

k is the number of clusters, n is the number of cases, $x_i^{(j)}$ is case I and c_j is centroid for cluster j. The value of $\| x_i^{(j)} - c_j \|^2$ is the distance function and its objective is to minimize J value. Defining cluster is to calculate Euclidean distance to c_j of each cluster from the data and to allocate the data to the cluster which is the shortest distance from the related data. Then the calibration of the cluster center is to define c_j as the center of gravity value of the data in each cluster. If the cluster is not changed, then stop repeating. Each spot is divided into the groups of k, and the groups are separated by connecting each spot into the shortest one from the center of gravity.

IV. Application of Image Processing in AR HMD

The AR technology provides with important information during the diagnosis or surgery by conformation with the real skin. The image processing algorithm of skin spot was applied and realized under the AR HMD (BT-200) environment to suggest the utilization plan of skin analysis in this article.

(a) Skin diagnosis using AR HMD

Since interior camera of BT-200 has low resolution VGA, 640 by 480, this article suggests the method of skin image capturing by the linkage of mobile microscope. Figure 2 shows the environment of skin analysis with AR HMD. It captures the skin image by mobile microscope and the captured image is transmitted to BT-200 platform so as to project the diagnosis results to the user after image analysis. The user can do treatment, therapy and surgery as real-time basis based on the projected information.

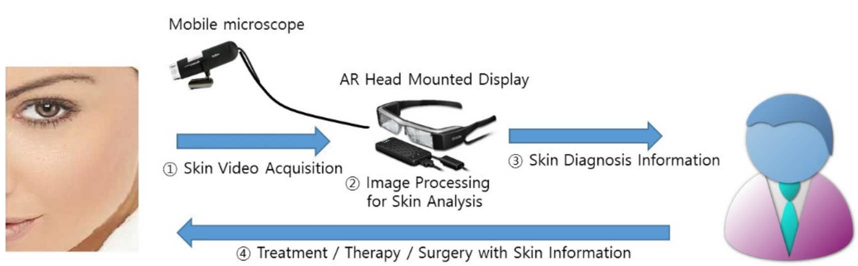


Figure 2. Concept of skin analysis in AR HMD.

(b) Experiments of skin spot analysis in AR HMD

Figure 3 shows the flow chart of skin diagnosis using AR HMD. Skin image is captured by HMD camera or connected microscope camera in the image attained part. The captured color image is transformed into lab space, and it is saved as grayscale using only '*L*' element among these. Noise is removed by median filtering and the skin characteristics are extracted by binarization algorithm. Based on the extracted information, the skin analysis data are acquired including number, size, type, and so on by clustering algorithm. The useful information on the patient diagnosis is displayed on HMD by projecting the acquired information.

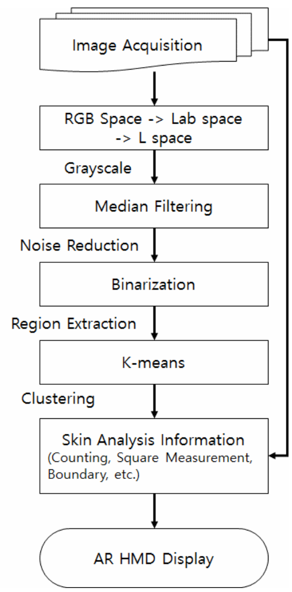
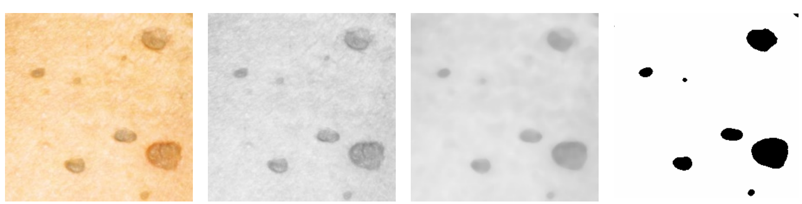
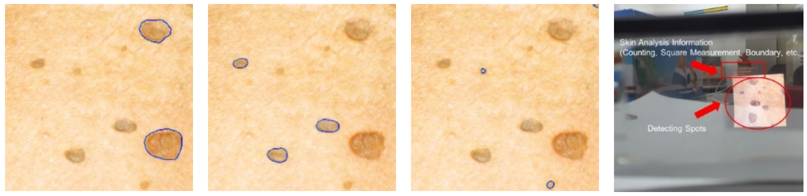


Figure 3. Flowchart of skin analysis.



(a) (b) (c) (d)

Figure 4. Experiment images (a) RGB image (b) grayscale image (c) noise reduction with median filtering (d) binarization image with Otsu's algorithm.



(a) (b) (c) (d)

Figure 5. Detecting spots with *K*-means (a) large size spots (b) medium size spots (c) small size spots (d) projected in the space with AR HMD.

Figure 4 shows the feature of displaying. Figure 4(a) is the original image captured with color one, and Figure 4(b) is the grayscale image captured only with *L* element after transformation into lab image. Figure 4(c) is the noise reduction image with median filtering, and Figure 4(d) is binarization image with Otsu's algorithm. Figure 5 is the boundary detecting image of skin spot areas using binarization image in Figure 4(d). It shows the classified images by spot size using *K*-means clustering algorithm. Figure 5(d) shows the image of skin analysis information and detecting spots projected in the space with AR HMD.

V. Conclusion

AR HMD system is applied in a variety of fields such as medicines, national defense, computer games, and so on for the information delivery by projecting the information simultaneously based on real life information. Especially, AR HMD can enhance the utility of diagnosis by real-time projection of patient information. This is the study on the image processing and application plans for the skin diagnosis with AR HMD. Since image based skin diagnosis is performed mainly by extraction of distinguished area, noise removing and binarization by threshold, clustering algorithms were studied. The captured image was transformed into grayscale and binarized with Otsu method to tell the characteristics after noise removal. After binarization, the characterized spots were acknowledged as the skin spots and they were projected with AR HMD after clustering and information analysis. AR HMD was to capture the image by camera linkage using EPSON BT-200 and to extract skin spots, which implicate the potential to project various information including skin number, area, color, etc. The results of this study are expected to be utilized not only in the medicines but also a variety of fields like national defense, computer games, and so on by projecting the image processed information with AR HMD.

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