Customized Casing for Capturing Poorly Illuminated Face Images with Low Level of Reflectance Components

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***Abstract*—Before designing a customized filter to improve the performance of homomorphic filtering technique on face images, the locations of illumination component in Fourier spectrum need to be identified. However, the background information of the face images available in the online database may affect the location of illumination component. Thus, a casing is designed to capture poorly illuminated face images with low contribution of reflectance components and dark background so that the exact location of illumination components can be identified accurately. This paper presents the specification of the casing and the light source circuit used to control the illumination on the face images.**

***Index Terms*—homomorphic filtering technique, illumination, reflectance, casing, face images**

I. Introduction

As one of the image enhancement methods in frequency domain, homomorphic filtering technique is a kind of approach based on the illumination-reflectance image model which is very useful in performing image enhancement by simultaneous brightness range compression and contrast enhancement [1]. There are a few researchers proposing different ways in implementing homomorphic filtering technique to enhance digital images. Apart from using different versions of high pass filters in homomorphic filtering technique [2], Jellus and Kiefer [3] and Delac, Grgis and Kos [4] modified the input image to improve the result of homomorphic filtering technique. Fan and Zhang [5] and Zhang, Ma and Jing [6] introduced the combination homomorphic filtering technique with other image enhancement methods to improve the quality of enhanced images.

Among the methods proposed, the conventional high pass filters used in homomorphic filtering technique are not specifically designed to pre-process face images. Even though an image can be described in illumination-reflectance model, the illumination and reflectance components are not distinctly separated in the frequency domain after the transformation. Thus, the location of illumination components in the Fourier spectrum need to be identified before designing a customized filter to improve the performance of homomorphic filtering technique.

The poorly illuminated face images which are captured under different lightning conditions are available in the online databases (e.g. Yale Face Database B and Extended Yale Face Database B) [7], [8]. However, those face images contain different background information which also contribute to the frequency spectrum and affect the location of illumination as well as reflectance components in the spectrum. Therefore, their contributions must be as low as possible so that the location of illumination component can be identified accurately.

In this paper, a casing is designed to ease the investigation of illumination locations. The purpose of the casing is to capture poorly illuminated face images with low level of reflectance components and dark background. Then, the locations of illumination components are determined based on the face images captured by the casing.

The rest of this paper is outlined as follow. The second section lays out the specification of the casing. Then, the result of the casing will be presented in the third section. Finally, the last section concludes the paper.

II. Methodology

In order to determine the location of illumination components accurately, the face image must be captured under poor illumination condition and with low contribution of reflectance components. Although the illumination of light onto the face image can happen in any direction or angle, in this research, only four illumination directions have been considered. They are from top, bottom, left and right positions. Apart from that, the image captured must consist of face features with dark background. This is because the background information will also contribute to the frequency spectrum and their contributions must be as low as possible so that the illumination components can be identified accurately. Hence, a device to capture face images has been designed according to these requirements.

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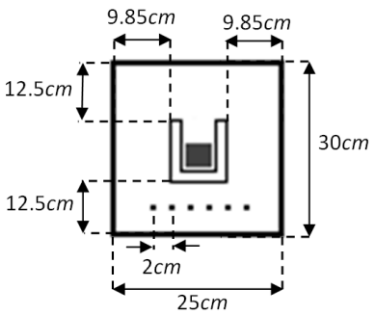
A. Casing Specification

Before designing the casing, a survey has been conducted to collect the maximum dimension of subjects' heads and necks. 20 subjects who have participated in this survey are the male and female students with age between 22 to 25 years old. They are the students from School of Electronic and Electrical Engineering in Universiti Sains Malaysia. The maximum value at each axis is taken into consideration when designing the casing. Then, calculation on the size of casing is made by considering the tolerance at each dimension.

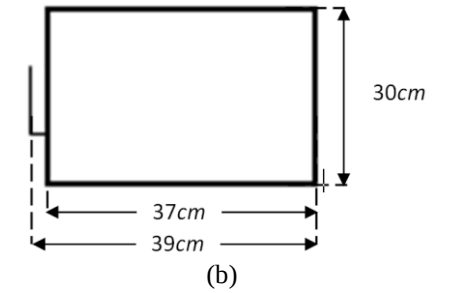
Aside from the dimension, the material selection process is done based on the size, weight and purpose of casing. Aluminium, wood and perspex are the proposed materials for the casing. However, the material chosen need to have size available for the optimum dimension of the casing to ease the fabrication process. Besides, the material has to be light in weight so that the casing can be easily portable to any places. Since the casing is to be used repeatedly, it must have acceptable hardness and durability in order to be long lasting. Thus, perspex has been chosen due to its weight, hardness and durability. It has relative density of 1.19g/cm^3 and tensile strength of 75MPa.

In order to prevent ambient light from affecting the image captured, the internal of the casing is sprayed with black paint whereas the rear part of the casing is covered using black plastics. The use of black plastics also eliminates the necessity to have a complicated mechanism for fitting subjects with different sizes of neck. Moreover, the internal portion of the casing is covered using sugar paper to reduce the reflectance of light.

Fig.1 shows the sketch of the casing and its dimension from different viewpoints. The dimension of the casing is 30cm × 25cm × 37.2cm. It is designed according to the dimension of subjects' heads and neck. There are six holes at the front of the casing, which are being allocated for switches and potentiometer. It provides ease for the user to switch on the light source at each direction and adjust the intensity of the light sources. Besides, the camera holder is designed in pocket-like shape so that the digital camera can be installed or removed from the casing easily. The camera holder is designed using the dimension of the digital camera with some tolerances to ensure that the camera does not displace during image acquisition process. The dimension of the digital camera is 9.1cm × 5.22cm × 1.91cm.



(a)



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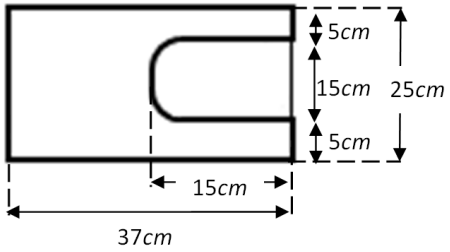

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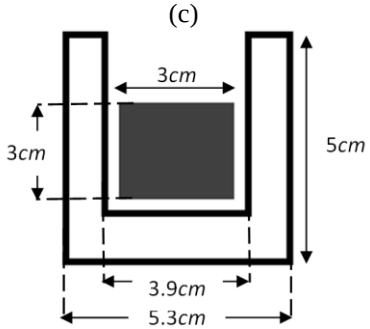

(d)

Figure 1. (a) Frontal view, (b) Side view, (c) Bottom view, (d) Camera holder[1].

B. Casing Specification

According to requirements of the research, illumination from four different directions is required for the study of illumination components in Fourier spectrum. Hence, the casing needs a light source circuit which is able to provide sufficient illumination onto the face image from four different directions. Besides, the circuit needs to have battery source and light source with high durability to allow portability of the casing. Therefore, three rechargeable AA batteries are used as standalone power source to drive the circuit whereas super bright LEDs are chosen to be the light sources due to its durability and energy saving capability. Besides, the light source at each direction can be controlled by using the switch and its brightness can be adjusted by using the potentiometer.

The light source circuit is made up of 14 super-bright white LEDs, five toggle switches, one resistor, one potentiometer and three rechargeable 1.5*V AA* batteries. Fig. 2 shows the schematic of light source circuit in the casing. There is one main switch act as ON/OFF control for the light source circuit whereas four other switches are used to control the light from each direction. Besides,

[1] The area in dark color is a hole reserved for camera lens.

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four LEDs are allocated at top, left and right directions to ensure that sufficient intensity of light projected onto the face of the subject. There are only three LEDs allocated to provide light source from the bottom direction. Each of the LEDs is separated by 4cm to ensure that even illumination is provided to the subject's face. The arrangement of super-bright white LEDs on the strip board is illustrated in Fig. 3. In the circuit, the potentiometer is used to control the intensity of light projected whereas the 100Ω resistor is included to prevent high forward voltage from damaging the LEDs.

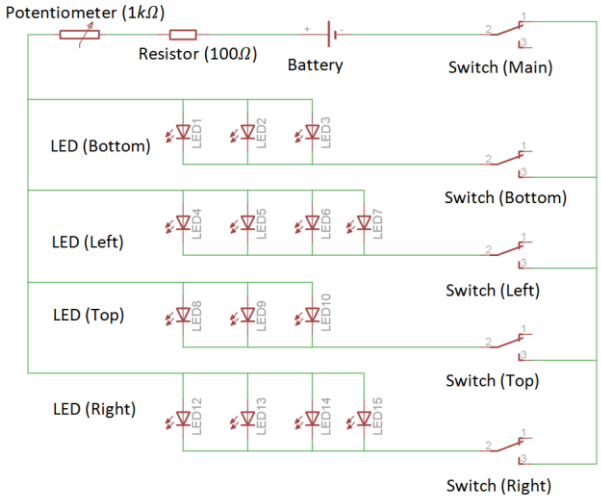


Figure 2. Schematic of light source circuit in the casing

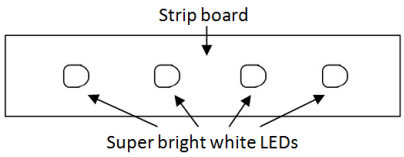


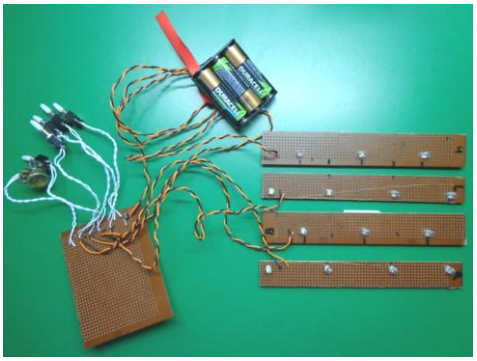
Figure 3. The arrangement of super-bright white LEDs on the strip board

III. Result

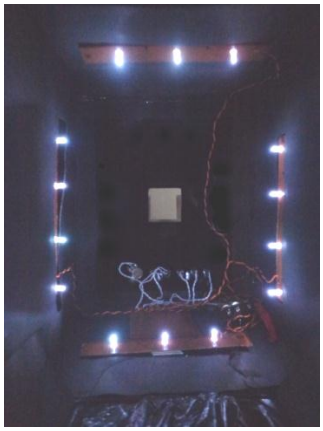
Fig. 4 shows the casing designed to investigate the locations of illumination components. One of the advantages of this casing design is the height and size of the subject is not a concern during image acquisition process. Therefore, subjects with different heights and body sizes are able to take part in this project without having a lot of adjustment during the image acquisition process.

Figure 4. The casing designed to capture face images under the exposure of poor illumination

The light source circuit which designed to provide illumination from four different directions is illustrated in Fig. 5(a). For the light source, LEDs are chosen due to their energy saving capability and durability. The LEDs consume low amount power and can last long provided that it is operating within the rating specified. In normal operation, this light source circuit can last for about 10 hours. Since the light beam spread angle for LED is small, several LEDs are used to provide sufficient illumination onto the face image. In order to provide even illumination, the LEDs are equally spaced from each other. The set-up of the light source circuit in the casing is shown in Fig. 5(b). The poorly illuminated face images captured by the customized casing are presented in Fig. 6.



(a)



(b)

Figure 5. The light source circuit designed to provide four directions of illumination, (b) The set-up of light source circuit in the casing

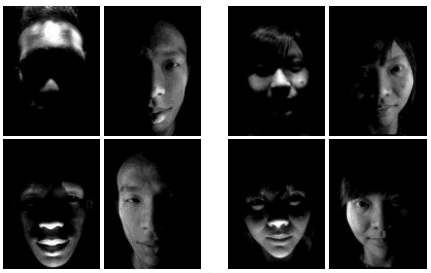


Figure 6. The poorly illuminated face images which are captured using the customized casing

IV. Conclusion

In order to overcome the limitation of the conventional filters, the location of illumination components in the

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frequency domain need to be determined. Therefore, a casing is designed to ease the study on the location of illumination components. Although illumination onto a face image can happen in any direction or angle, only four illumination directions are considered in this project. The illumination is provided using a light source circuit. The advantage of this casing design is the height and size of the subject is not a concern during image acquisition process. Besides, the light source circuit is designed to have high energy saving capability and easily portable to anywhere.

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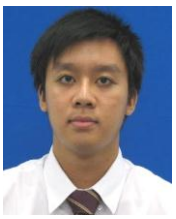

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