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Implementation on Surveillance Camera Optimum Angle Extraction using Polarizing Filter

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Abstract

The surveillance camera market has developed and plays an important role in the field of video surveillance. However, in recent years, the identification of areas requiring surveillance has been limited by reflective light in the surveillance camera market. Cameras using polarization filters are being developed to reduce reflective light and facilitate identification. Programs are required to automatically adjust polarization filters. In this paper, we proposed an optimal angle extraction method from surveillance cameras using polarization filters through histogram analysis. First of all, transformed to grayscale to analyze the specifications of frames in multiple polarized angle images, reducing computational throughput. Then we generated and analyzed a histogram of the corresponding frame to extract the angle when the highlights are the fewest. Experiments with 0˚ and 90˚ showed high performance in extracting optimal angles. At this point, it is hoped this technology would be used for surveillance cameras in place like beach with a lot of reflective light.

Keywords: *Histogram, Image processing, Polarized light, Surveillance camera*

1. Introduction

In the surveillance camera market, reflective light caused by scattered reflection disturb surveillance through surveillance cameras. In this reason, one of the ways to solve the problem is developing cameras using polarized filters. Polarization filters can play a role in minimizing the reflective light generated in the surveillance environment[1]. As a result, polarization images with minimal light reflection can be obtained through cameras using polarization filters. Among them, surveillance cameras designed to set various polarization angles allow selection of polarization angles suitable for the environment. However, it does not automatically adjust the polarization angle suitable for the environment. Lighting is a crucial part in image is a very important part[2]. Reflected light in a surveillance camera affects lighting. We proposed an optimal angle extraction method from

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surveillance cameras using polarization filters through histogram analysis. We used to ROI (Regions of Interest)[3] and grayscale[4,5] which greatly reduces the computer computations processing cost.

Using polarization videos and images from surveillance cameras using polarization filters to use them as datasets on deep learning where less reflective data should be present, or to take clear images by minimizing reflective light when monitoring places with high reflection, such as coastal areas.

In this paper, it was structured as follows. In Chapter 2, we explained the theory of filters that are the basis of polarization and the histogram of image processing. In Chapter 3, the proposed automatic polarization angle adjustment method was explained. Chapter 4 is the result of the experiment, and Chapter 5 is the conclusion.

2. Background Theory

2.1. Polarization Filter

Polarization filters are filters used to convert natural light into polarization. Natural light shines in all directions. The light that vibrates only in a certain direction is called polarization. Polarization filters allow light in the desired direction to pass through the filter from natural light and block light from the other directions. Figure 1 is an example of a vertical polarizer that passes only vertical light. By utilizing a polarization filter, the effect of removing highlights and eliminating reflected light can be obtained[6,7].

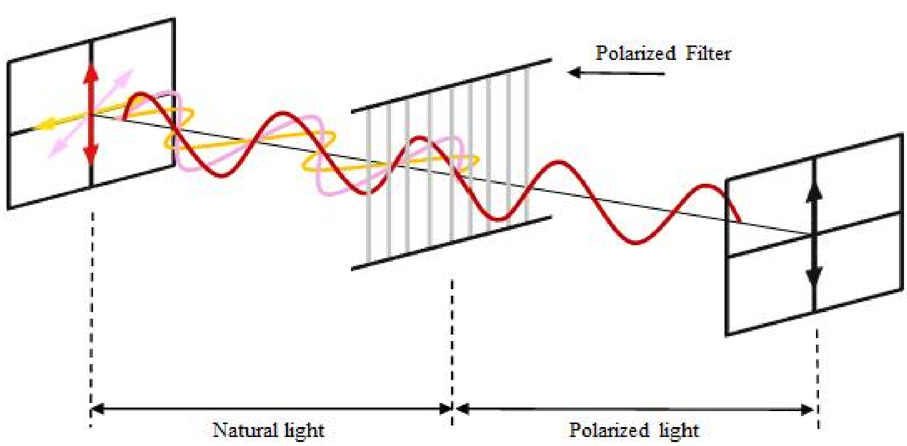


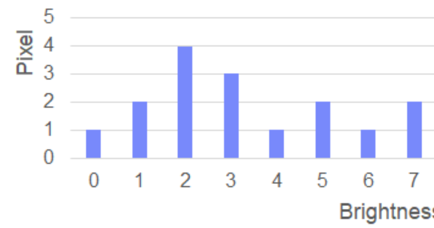
Figure 1. Example of a Vertical Polarization Filter

2.1. Histogram of Image

Histogram is graph that show the distribution over the brightness values of images, and are an important tool for image analysis. By analyzing the histogram of the images being entered, information on the brightness composition of the images, contrast of light and dark can be used as a starting point for video improvement and image quality advancement[8-11]. Figure 2 shows an example of an image representing a pixel's brightness as a histogram.

3	2	6	7
4	5	5	3
2	1	1	2
0	7	2	3

(a)



(b)

Figure 2. Input Image and Histogram
(a) Input Image – Pixel Values, (b) Histogram

3. Proposal Method

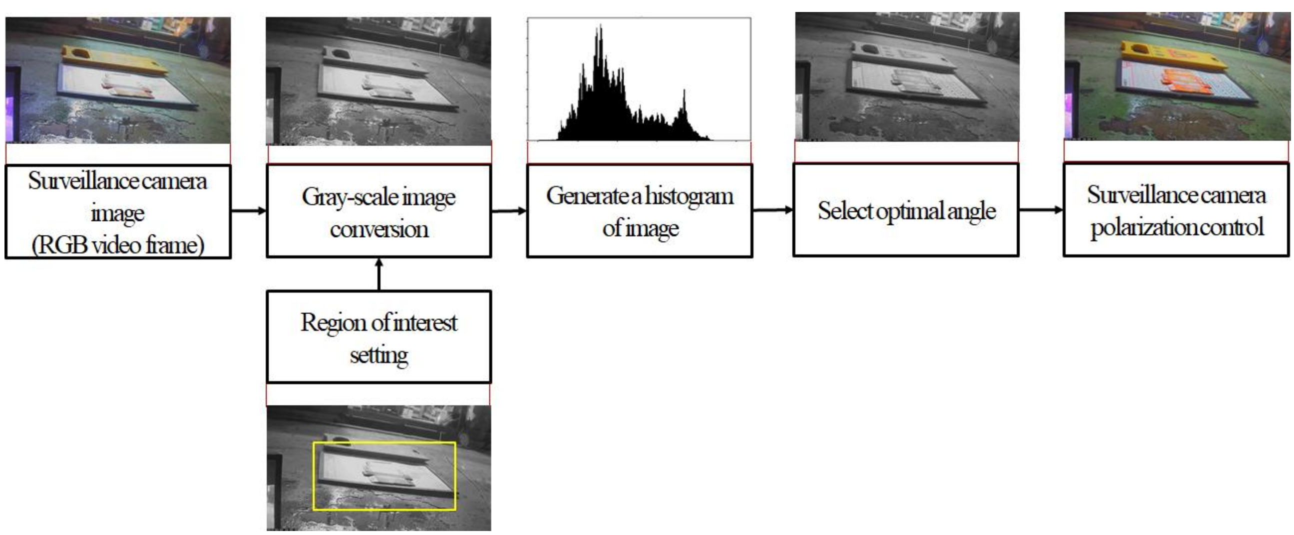


Figure 3. Development Workflow

Figure 3 shows the development workflow. First of all, video frames with multiple polarization angles were acquired with surveillance camera video as shown in Figure 4. Next, in order to analyze the brightness of the video frame of the surveillance camera RGB video, it is converted into a grayscale image as shown in Figure 5 (left). RGB has a 3D color space and 255 cubic operations of computing power, but in the case of grayscale, it takes into account only 0-255 in 1D, which greatly reduces the computer computations processing cost. After that, the histogram of the grayscale image was generated as shown in Figure 5 (right). On this occasion, if a video image having the least reflected light in a part to be monitored is desired, set up the interest area to generate a histogram with only that field.

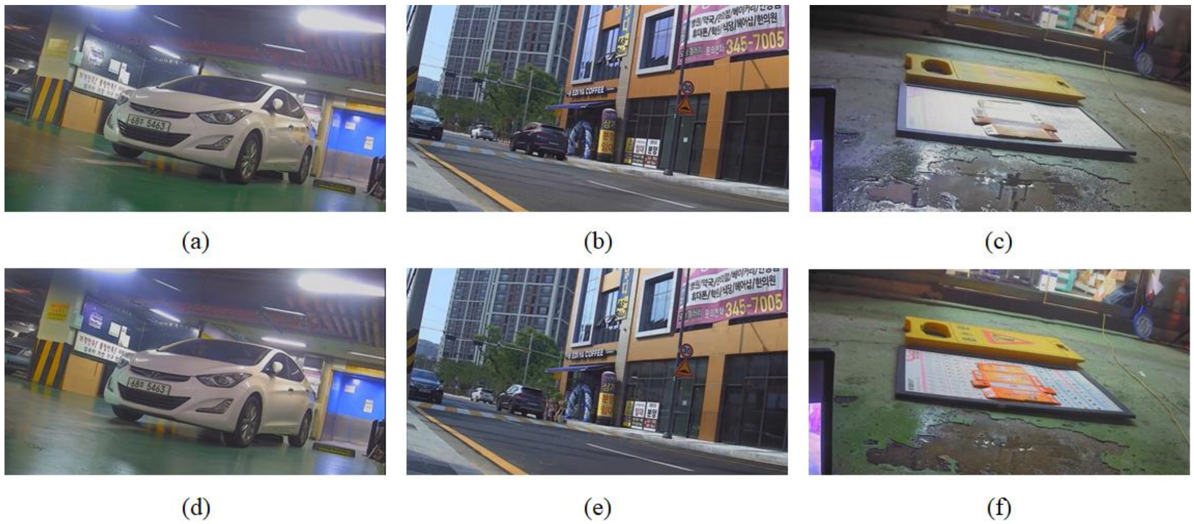


Figure 4. Image Frames with Different Polarization Angles
(a) Park at 0 Degree, (b) Road at 0 Degree, (c) The Objects on the Road at 0 Degree, (d) Park at 90 Degree, (e) Road at 90 Degree, (f) The Objects on the Road at 90 Degree

In three different places, as shown in Figure 4, reflective light was shown differently depending on 0˚and 90˚. With some angles, the surveillance images were sometimes interrupted by reflective light, as shown in c in Figure 3, and the relatively clearer surveillance images were obtained by reducing the reflective light, such as (b), (d) and (f) in Figure 3.

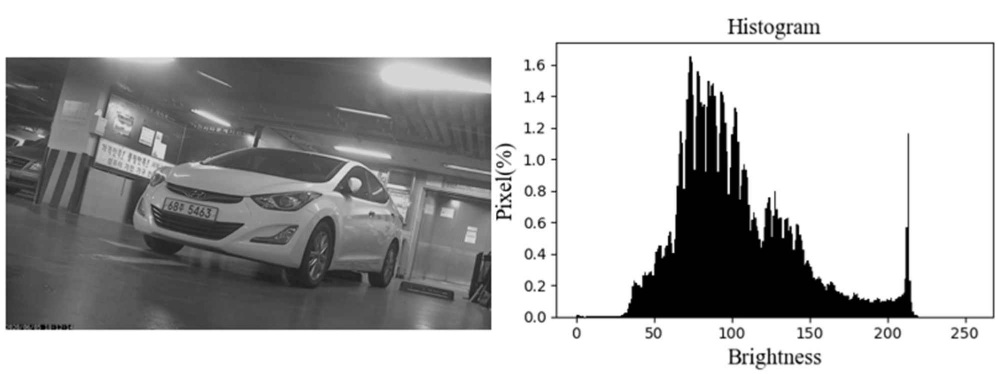


Figure 5. The Grayscale Image (Left) and Histogram Graph (Right)

Figure 5 is a graph of the grayscale transformation image and histogram of the surveillance camera. By extracting histograms, it was able to confirm the distribution of the intensity of the surveillance image frames. The histogram showed a frame with a high brightness, and we analyzed the brightness to find the frame when the light reflection was high.

The histogram's equation $P(g)$ is as follows.

$$P(g) = \frac{n_g}{N} \quad (g = 0\sim255) \tag{1}$$

Where g represents the grayscale pixel value and n_g represents the number of pixels with a pixel value of g. The range of values that g may have is from 0 to 255. N undergoes a normalize process of dividing n_g by the total number of pixels in the image.

When the number of frames f by angle is n, the average histogram value of angle a is equal to equation (2).

$$F_a(g) = \frac{\sum_{f=0}^{n-1} P_a(g)}{n} \tag{2}$$

The threshold M is then obtained with respect to the pixel value g, and Figure 6 shows the order plot for obtaining m.

Algorithm 1 Thresholds algorithm

Require : pixel value g
while $g < 256$ **do**
    if $P(g-1) \geq P(g)$ **then**
        if $P(g-1) < P(g)$ **then**
            Add g to set of peak values M;
    else
        go back to the beginning of current section;
    end
    $g = g + 1$;
end while
critical value m = max(M)

Figure 6. Algorithm for Thresholds

Using equations (3) and (4) with pixel values g, which represent the specifications, $f_1(g)$ finds a value that increases the frequency of the pixel values, and calculates the pixel values before the frequency decreases as a function of $f_2(g)$. Because the reflective light is a high-resolution part, the value is focused on the right side of the histogram. Therefore, the maximum pixel value of the set M of the derived g value is chosen as the threshold value m.

$$f_1(g) = \begin{cases} f_1(g+1), & P(g-1) \geq P(g) \\ f_2(g), & P(g-1) < P(g) \end{cases} \tag{3}$$

$$f_2(g) = \begin{cases} f_1(g+1), & P(g) \leq P(g+1) \\ g, & P(g) > P(g+1) \end{cases} \tag{4}$$

The value w to be calculated for the range of highlight areas was calculated as shown in equation (5) to obtain the average value of the range of pixel values symmetric to the left and right based on the threshold values calculated by the preceding function using equation (5). The algorithm for this is shown in Figure 7.

$$w = max(f_2(g)) - \{255 - max(f_2(g))\} \tag{5}$$

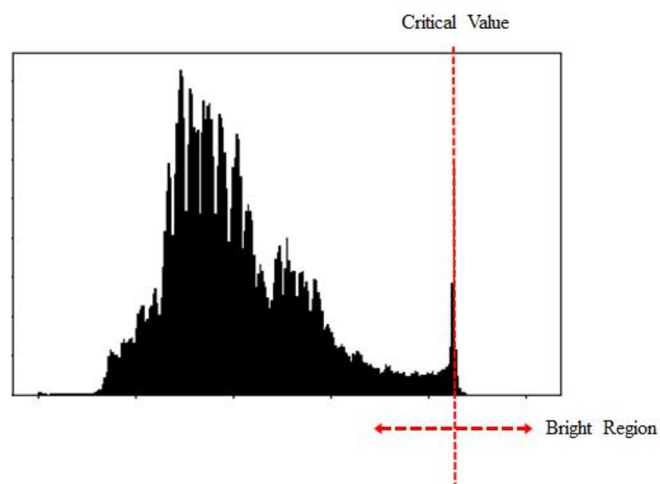


Figure 7. Range of Highlight Areas for Calculation

Accordingly, the highlight mean value $H_a(g)$ was obtained through equation (6).

$$H_a(g) = \frac{1}{256-w} \sum_{w}^{255} F_a(g) \tag{6}$$

According to equation (7), the angle of the minimum value A among the mean values by angle could be obtained at the optimal polarization angle. It was possible to obtain the least reflective image in the environment by conducting surveillance camera shots at the optimal angle found.

$$A = MIN\{H_{0^\circ}(g), H_{30^\circ}(g), \ldots, H_{45^\circ}(g), H_{90^\circ}(g), \ldots\} \tag{7}$$

4. Experiments and Results

Experiments are expected to show results of pixel values focusing on high-definition regions in the histogram for high-reflective images. Therefore, the experiment was conducted using videos with zero polarization angles 90˚.

(a) (b)

Figure 8. Frames and Histograms
(a) 0 degree (b) 90 degrees

The proposed method showed the results as shown in Figure 8(a), 8(b) in the experiments. In the histogram graph, the left side is a dark region with a pixel's brightness close to zero and the right side is close to 255. Figure 8(a) shows that when the polarization angle is 0˚, the histogram shows that the pixel values are centered on the right-hand area with high brightness. Conversely, Figure 8(b) shows that pixel values are distributed in the left region with low brightness in the histogram when the polarization angle is 90˚.

0 Degree	73.0553431
90 Degrees	47.8445269
Optimal Polarization Angle	90 Degrees

(a) (b)

Figure 9. Select the Optimal Polarization Angle between 0 and 90 Degrees
(a) The average value of the higher brightness region of the various polarization angle images
(b) Select the Optimal Polarization Angle

Experiments show that comparing the average values of high-definition regions of 0 and 90 degrees to select an angle with a smaller average as the optimal polarization angle, as shown in Figure 9. As a result of this experiment, the proposed model showed the ability to process 33 frames per second.

5. Conclusion

We proposed an optimal angle extraction from surveillance cameras using polarization filters through histogram analysis. Existing surveillance cameras were problematic in not blocking reflected light, and surveillance cameras using polarization filters had to manually find polarization angles suitable for the environment, even though they could adjust various polarization angles. The proposed method is to analyze the histogram of the images, which analyzed the reflective light of images with different polarization angles in the same environment and extracted the optimal angle that is least affected by the most reflective light.

The proposed method has the effect of obtaining optimal polarization images by receiving the least reflective light among images of different polarization angles to determine clear images and taking polarization images under the filming conditions of those images.

Furthermore, by taking only random reflective light in natural light conditions, clear images can be obtained by eliminating impulses, etc. In particular, it has the effect of securing clear surveillance images in a highly reflective environment such as the beach.

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