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Reducing the Number of UVB Lamps for Low-cost Gel Imaging System Implementation

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Abstract

This paper presents a low-cost method of constructing a UV illuminator, which is considered an important component of a gel documentation system. The procedure involves using a smallest-possible UV lamp in the UV illuminator instead of conventional 4 UV lamps. A comparative analysis of images produced by using the commercial gel documentation system and our prototype was performed using MATLAB. Despite the use of only 1 UV lamp, the proposed system demonstrated a similar imaging performance compared to the image quality of a conventional gel documentation system equipped with 4 UV lamps.

Keywords: *Gel documentation system, UV illuminator, gel image analysis, DNA detection*

1. Introduction

DNA detection is paramount for clinical diagnosis and pathogen detection for both humans and animals, environmental test, and forensic inspections, and the use of such technique is becoming more popular [1–3]. In general, DNA detection involves a 4-step process: DNA extraction, DNA amplification, electrophoresis, and gel image analysis. Each step requires expensive equipment [4–6]. Gel documentation system (simply called Gel Doc) is very expensive one, mainly because of its camera and UV lamps. Thus, it is necessary to conduct investigations to identify alternative setups that would reduce the cost for gel documentation by using the same principle of UV illumination. The investigations generally involve performing gel image analysis, considering various types of UV lamps and cameras, as well as the prices of each component. However, only a few studies on this nature have been conducted [7]. We used cheap camera instead of the expensive DSLR camera which is used in the conventional Gel Doc system in our previous work [8] resulting comparable image quality. The conventional Gel Doc system has several UV lamps in the UV illuminator to make the gel image be uniform and retain the sufficient light intensity. However, if we can reduce the number of the UV lamp, we will be able to make more cheap and small sized Gel Doc system. Even if we can involve the use of a smallest-possible UVB lamp, we can deploy low-cost Gel Doc. A less expensive Gel Doc may thus be constructed by using 1 UV lamp instead of 4 UV lamps, which is the typical setup for the UV illuminator.

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In this study, a smallest-possible UV lamp was used at 4 different positions in turn. MATLAB-based comparison of the image quality with that obtained using the existing UV illuminator equipped with 4 UV lamps confirmed a similar performance.

2. System configuration

For the Gel Doc used in this study, a Power Shot G7 camera was employed. Table 1 shows the feature of the high-end camera Canon G7. We proved that this camera is sufficient to use in the Gel Doc system in our previous work [8].

Table1. Specification of Cameras Used

Feature	Description
	- Company : Canon - Model : Power Shot G7 - Pixels : 10 milion pixels - Optic zoom : X6 - CCD sensor size : 1/1.8”

The proposed miniaturized GelDoc is configured to have a camera box, dark box, and UV illuminator from the top as shown in Figure 1. The camera box shown in Figure 2 includes an embedded board (shown in Figure 3), which is used for gel image shooting. The embedded board converts the power from the 12V power supply to the appropriate camera and USB hub power and supplies appropriate power to the servomotor, UV illuminator, and LED of the dark box. Because of this configuration, the camera power that had to be switched manually can now be controlled by the PC.

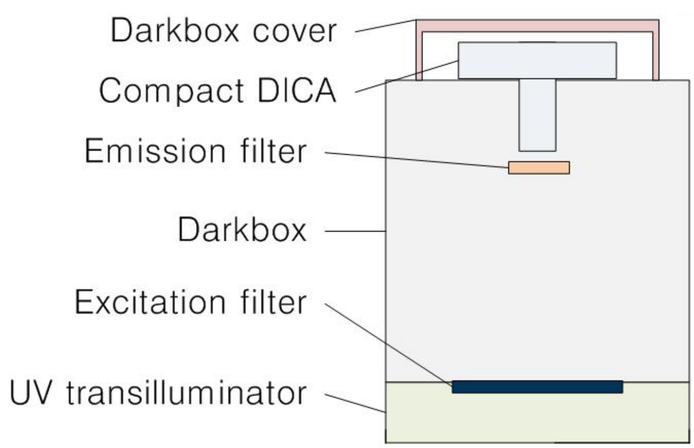

Figure 1. The Smallest Gel Documentation System

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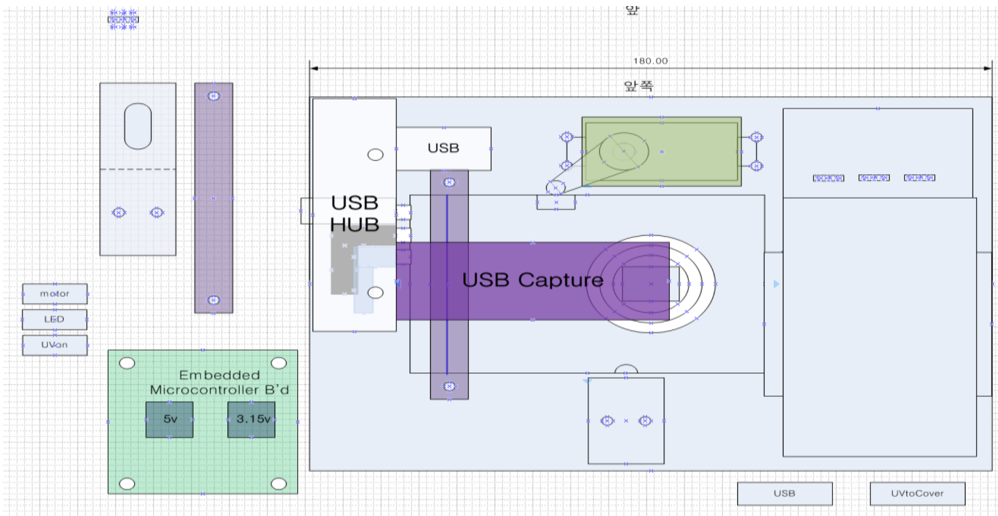

Figure 2. Camera Box Block Diagram

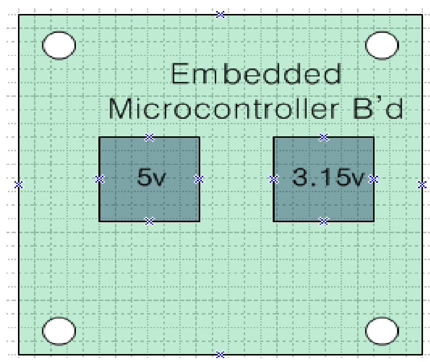

Figure 3. Embedded Board Configuration

By adding the servo motor to control the power of the camera which should be manually on/off, we can on or off the camera from PC through embedded board as shown in Figure 4.

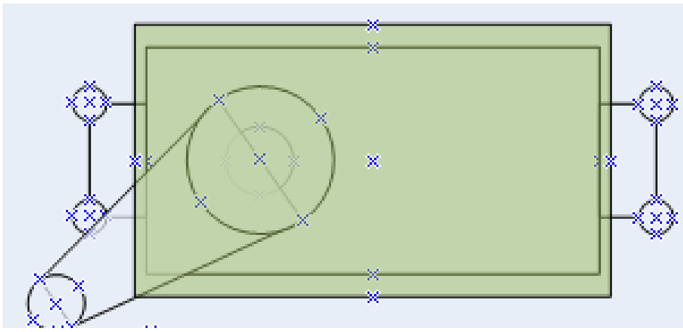

Figure 4. Servo Motor

GelDoc is a device used for capturing the light emitted from a fluorescent material contained in the gel through UV; thus, if the external light is introduced into the dark box, appropriate images cannot be taken. Therefore, we manufactured it without introducing light.

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Further, for the sake of user convenience, an indoor lamp was installed in the dark box, and a function to automatically turn off the UV lamp was added to the device. The UV illuminator used in our experiment was manufactured to be used in the existing GelDoc as well as in the miniature version proposed in this paper. To miniaturize the UV illuminator part, the smallest-possible UV lamp was used. This UV illuminator used four UV lamps and had two ballasts. Further, for the sake of user convenience, four sub UV lamps switch was added to the device. Figure 5 and 6 show the top-view and side-view configuration of the UV illuminator, in which the location of the lamps and ballasts can be seen.

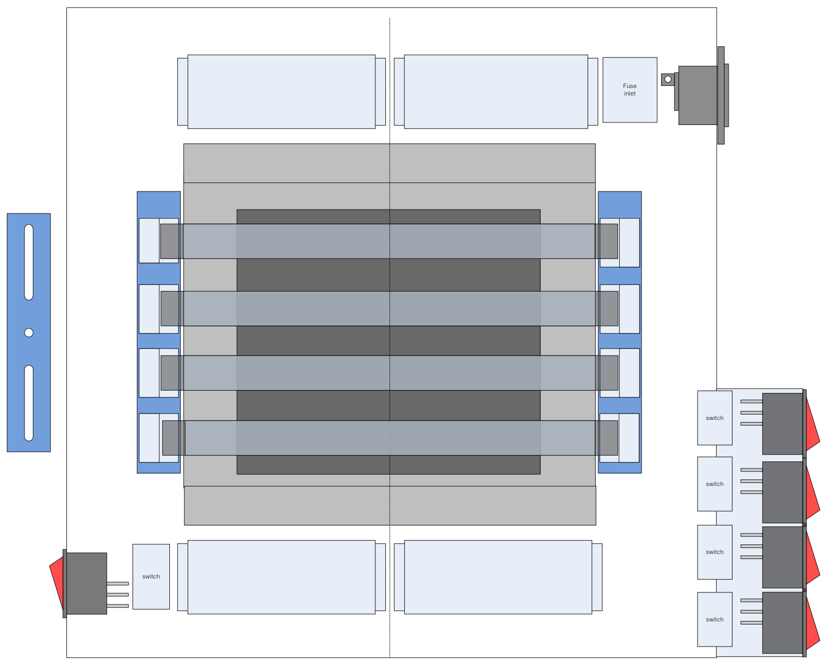

Figure 5. UV Illuminator Top-view Block Diagram.

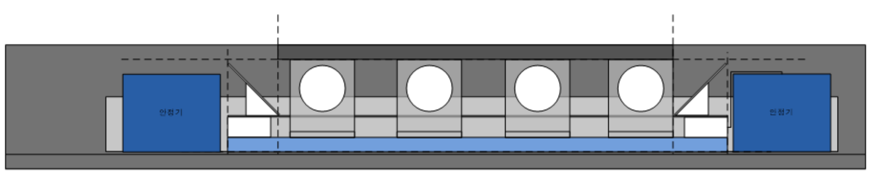

Figure 6. UV Illuminator Side-view Block Diagram.

To make more safe equipment, we implement a safety circuit which can automatically turn off the UV lamps in the UV transilluminator if the dark box is opened. Figure 7 shows this safety circuit.

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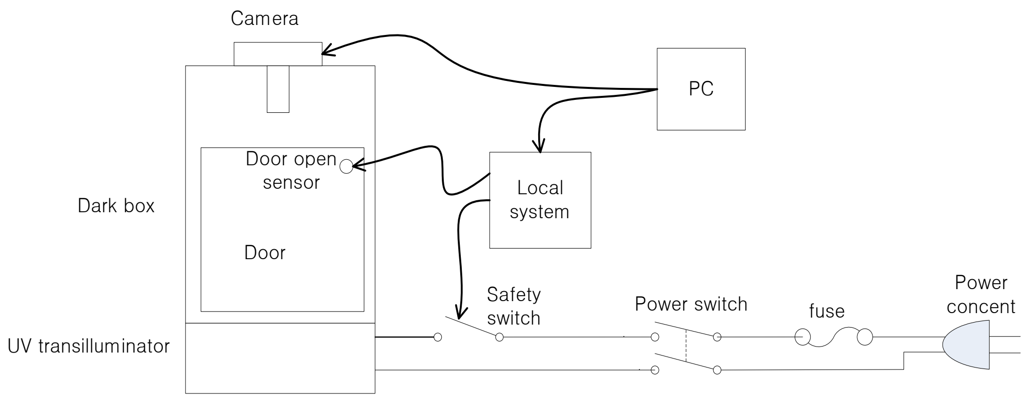

Figure 7. UV Safety Circuit

3. Experiment and Results

According to the method proposed in this paper, Gel images were captured by using only 1 UV lamp at each of the 4 positions and the results are shown in Figure 8.

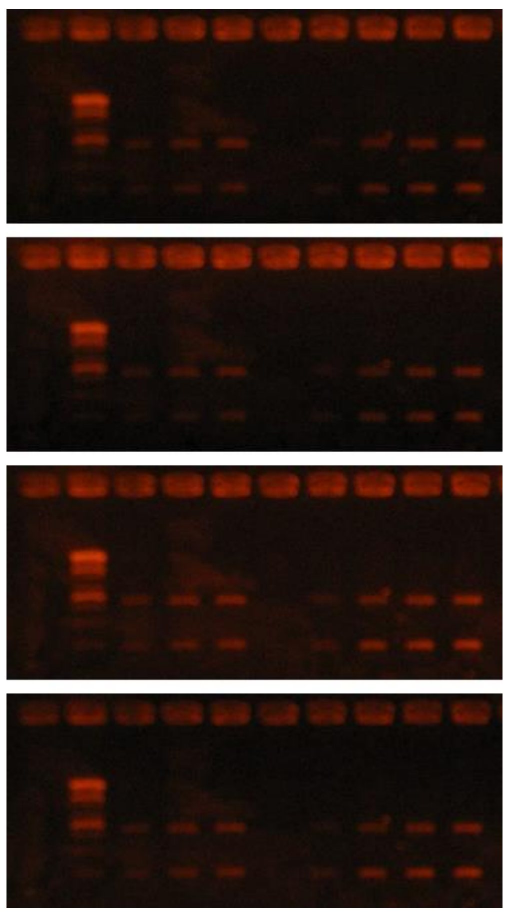

Figure 8. Gel Images Captured by Using Only 1 UV Lamp at Each of the 4 Positions

Figure 9 shows captured by using all 4 UV lamps in the UV illuminator according to the usual usage.

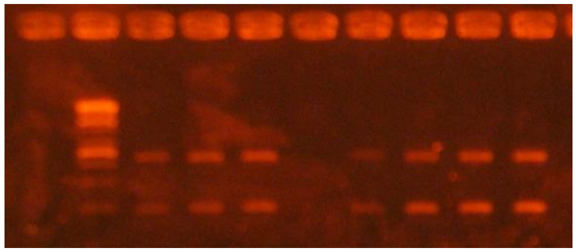

Figure 9. Gel Images Captured by Typical 4 Lamp UV Illuminator

Figure 9 reveals high-intensity bands of DNA in the gel image. For comparing the imaging performance of the proposed method with that of the conventional method, which involves capturing gel images by using 4 UV lamps placed in their respective positions, each image captured in figure 8 sequentially using 1 UV lamp in 4 different positions was gray-scaled and joined using MATLAB and is shown in figure 10. The gray-scale transformation was undertaken to generate more precise image information that was subsequently used for comparative analysis.

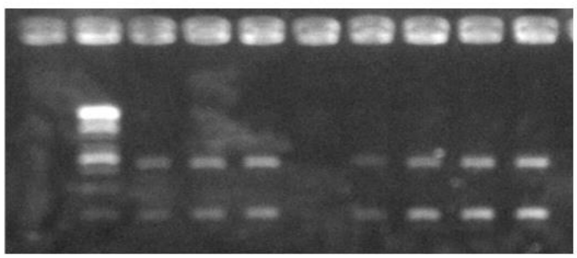

Figure 10. Fused Image of the 4 Shots

After transformation to gray-scale and image fusion, a comparative analysis was performed by subtracting the 1-lamp-4-shot fused image from the 4-lamp-1-shot whole image to identify the differences.

To ensure an accurate comparison, the observed differences were represented using a histogram, which was created by converting the matrix values of the images into row vectors and expressing as bar graphs. Figure 10 is the histogram illustrating the differences between the 1-lamp-4-shot and 4-lamp-1-shot images, in which bars close to 0 indicate that the 2 images were highly similar. The X-axis represents the pixel size, whereas the Y-axis represents the number of pixels. The X-axis was predominated by 0, and the bars sharply decreased as the pixel value increased.

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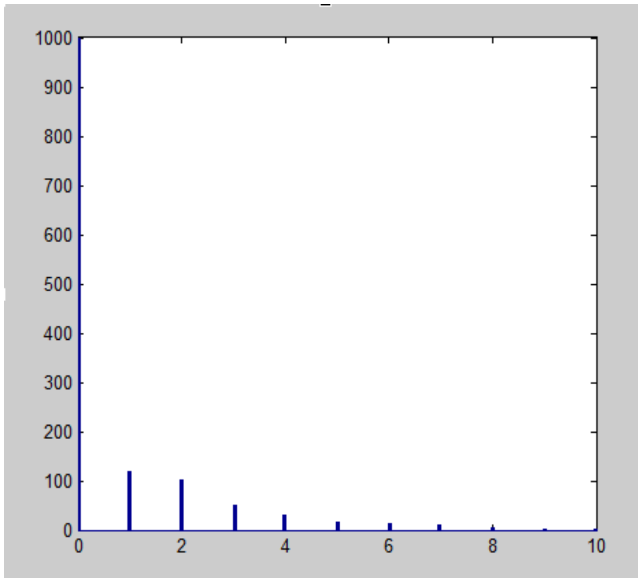

Figure 10. Histogram Illustrating the Differences between the 1–lamp-4-shot and 4-lamp-1-shot Images

4. Conclusion and Future Research

On the basis of the results of our comparative analyses of images captured using the conventional UV illuminator equipped with 4 UV lamps and the fused image of 4 separate images captured using 1 UV lamp at 4 different positions, we confirmed that the 2 images were similar. We plans to conduct further investigations on developing a gel documentation system that is more convenient to use, while delivering similar quality images and to create a motor that could be specifically used in an UV illuminator to increase user convenience and expand equipment supply in a laboratory.

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References

[1] E. Salm, *et al*., "Electrical Detection of dsDNA and Polymerase Chain Reaction Amplification", Biomedical Microdevices, vol. 13, no. 6, **(2011)** December**,** pp. 973-982.
[2] R. Kodziusa, *et al.*, "Inhibitory Effect of Common Microfluidic Materials on PCR Outcome", Sensors and Actuators B, vol. 161, iss. 1, **(2012)** Juanuary, pp. 349-358.
[3] J. Wu, *et al.*, "Fast Detection of Genetic Information by an Optimized PCR in an Interchangeable Chip", Biomedical Microdevices, vol. 14, no. 1, **(2012)** February, pp. 176-186.
[4] I. Bajla, *et al*., "An Alternative Method for Electrophoretic Gel Image Analysis in the GelMaster Software", Computer Methods and Programs in Biomedicine, vol. 77, iss. 3, **(2005)** March, pp. 209-231.
[5] X. Ye, C. Y. Suen, M. Cheriet and E. Wang, "A Recent Development in Image Analysis of Electrophoresis Gels", Vision Interface, Canada, **(1999)** May 19-21**.**
[6] M. C. Alexei, *et al*., "An Iterative Algorithm for Segmenting Lanes in Gel Electrophoresis Images", Brazilian Symposium on Computer Graphics and Image Processing, vol. 235, **(1997)** October**,** pp. 104-146, 14-17.
[7] T. Goldmann, *et al.*, "Cost-Effective Gel Documentation Using a Web-Cam", J. Biochem. Biophy. Methods, vol. 50, Issue 1, **(2001)** December, pp. 91-95.

[8] D. -J. Lee, S. -Y. Kim, J. -D. Kim, Y. -S. Kim, *et al*., "Low-cost Gel Imaging System Implementation in Reduced Size", International Journal of Bio-Science and Bio-Technology, vol. 5, no. 5, **(2013)** October, pp. 151-160.

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