

Experiments on the Reducing the number of UVB Lamps for Gel Image System

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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 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, gel image analysis, DNA detection.

1 Introduction

In general, DNA detection involves a 4-step process: DNA extraction, DNA amplification, electrophoresis, and gel image analysis. Each step requires expensive equipment [1–3]. Gel documentation system (simply called Gel Doc) is a very expensive equipment, 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 [4]. Involving 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.

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 Structure

For the Gel Doc used in this study, a Power Shot G7 camera was employed. The components of the Gel Doc include a camera box, dark room, and a UV illuminator, arranged in a top-to-bottom order. The camera box contains an embedded board that is used for taking gel images. The embedded board modulates the output of the 12V power supply, which is delivered to the camera and USB hub, and serves as the power source for the servo motor, UV illuminator, and the dark box LED. Given that Gel Doc is a device that captures the UV-induced illumination of fluorescent material within the gel, the dark box was constructed to restrict light and to ensure proper photodocumentation of fluorescent DNA bands. To achieve the miniaturization of the UV illuminator part, a smallest-possible UV lamp was used. A typical UV illuminator consists of 4 UV lamps and has 2 ballasts. Figures 1 and 2 are schematic diagrams of the top-view and side-view blocks, respectively, which illustrate where the lamps and ballasts are positioned.

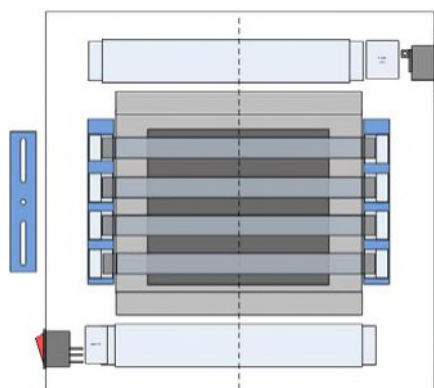


Fig. 1. Camera box block diagram.

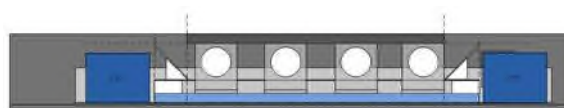


Fig. 2. UV illuminator side-view block diagram

3 Experiment method and results

Gel images were captured first by using all 4 UV lamps in the UV illuminator (Figure 3) according to the usual usage, and then the experiment was conducted by capturing the same DNA gel images by using only 1 UV lamp at each of the 4 positions in turn according to the method proposed in this paper.

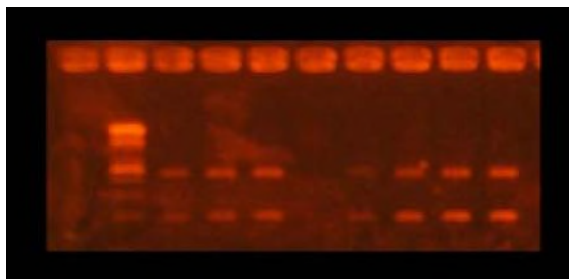


Fig. 3. Gel Images captured by typical 4 lamp UV illuminator

Figure 3 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 sequentially using 1 UV lamp in 4 different positions was gray-scaled and joined using MATLAB and is shown in figure 4. The gray-scale transformation was undertaken to generate more precise image information that was subsequently used for comparative analysis.



Fig. 4. 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 5 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.

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.

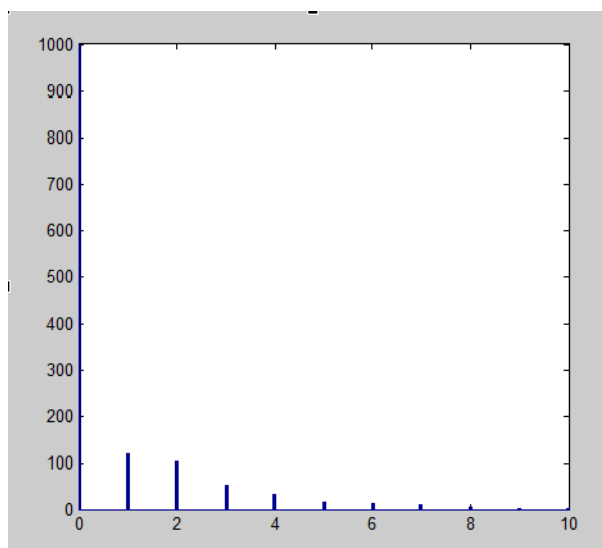


Fig. 5. Histogram illustrating the differences between the 1-lamp-4-shot and 4-lamp-1-shot images

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References

1. I. Bajla et al., "An Alternative Method for Electrophoretic Gel Image Analysis in the GelMaster Software", *Computer Methods and Programs in Biomedicine*, Vol. 77, Issue 3, pp. 209-231, March 2005.
2. X. Ye, C.Y. Suen, M. Cheriet, and E. Wang, "A Recent Development in Image Analysis of Electrophoresis Gels", *Vision Interface, Canada*, May 19-21, 1999.
3. Alexei M. C. Machado et al.: An Iterative Algorithm for Segmenting Lanes in Gel Electrophoresis Images. *Brazilian Symposium on Computer Graphics and Image Processing*, Vol. 235, pp. 104-146, (1997)
4. T. Goldmann, et al.: Cost-Effective Gel Documentation Using a Web-Cam. *J. Biochem. Biophys. Methods*. 50, Issue 1, 91-95, (2001)