International Journal of Bio-Science and Bio-Technology
Vol.5, No.5 (2013), pp. 151-160
http://dx.doi.org/10.14257/ijbsbt.2013.5.5.16

Low-cost Gel Imaging System Implementation in Reduced Size

Deuk-Joo Lee[1,2], Sang-Yoon Kim[1,2], Jong-Dae Kim[2,3], Yu-Seop Kim[2,3], Hye-Jeong Song[2,3] and Chan-Young Park[2,3],*

[1] *Department of Computer Engineering, Hallym University, Korea*
[2] *Bio-IT Research Center, Hallym University, Korea*
[3] *Dept. of Ubiquitous Computing, Hallym University, Korea*
{ dlemrwn, yskim01, kimjd, kimjimin87,hjsong, cypark }@hallym.ac.kr

Abstract

In this paper, we proposed a method for configuring each component of a gel documentation system for the miniaturization and penetration of the system. To miniaturize the UV illuminator part, the minimum type of UVB lamp was adopted along with ballasts that can drive four lamps. As the imaging system, a conventional compact digital camera, which has a similar performance to that of a DSLR, was adopted. By developing and supplementing the PC remote control function of which lack in the low-end digital camera, the price and size of the gel doc equipment can be significantly reduced while still maintaining the performance and function of the gel doc. The proposed system showed comparable performance and image quality to those of the existing Gel documentation system even though if it was small and inexpensive.

Keywords: *Gel documentation system, 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]. Analysis of the DNA properties can be separated into 4 steps: DNA extraction, DNA amplification, electrophoresis, and the analysis of the gel image. Each step requires the high-cost and specific equipment according to the process [4-6]. The DNA is isolated from the sample and amplified, then inserted into a well in the agarose gel containing after mixing with a substance that reacts with to be electrophoresed. Gel documentation system (GelDoc) then captures the image of the electrophoresed agarose gel by illuminating it with UV with a camera [7]. The properties of the DNA such as the molecular weight and concentration can be gained by analyzing the image captured from the GelDoc [5].

A gel documentation system (GelDoc) has been widely used as a DNA detection device, but it is expensive. In GelDoc particularly, a camera for gel image shooting, UVB lamp in the UV illuminator part, and an emission filter account for a significant portion of the total system cost. Therefore, it is expected that the device will be widely used if the existing expensive cameras used in GelDoc are replaced with inexpensive ones and the smallest-possible UVB lamp is adopted [7].

In this study, a low-cost digital compact camera is adopted, and the miniaturization of GelDoc is carried out followed by a performance evaluation. The result reveals that the

* Corresponding Author: cypark@hallym.ac.kr

ISSN: 2233-7849 IJBSBT

miniaturized device has a comparable performance to that of the existing GelDoc. Since the low-end compact digital camera does not provide computer-control, a remote control system for the low-end camera was invented and utilized in the experiment. 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.

2. System Structure

The miniaturized GelDoc proposed in this paper is divided into software and hardware. The Canon PowerShot A495 camera adopted for the experiment does not have a remote control function; thus, a PC remote control function is implemented. Further, the Canon hack development kit (CHDK) is stored in our memory card. Moreover, because the PowerShot A495 model does not have a preview function, an Easy CAP image capture device is used. Table 1 shows the features of the image capture device.

Table 1. Features of the Image Capture Device

Easy CAP	Features
	- USB 2.0 Fast transmission speed - RCA connector and S-VHS connector support - Capture capability of HD wide screen NTSC : 720 x 480 PAL : 720 x 576

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 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.

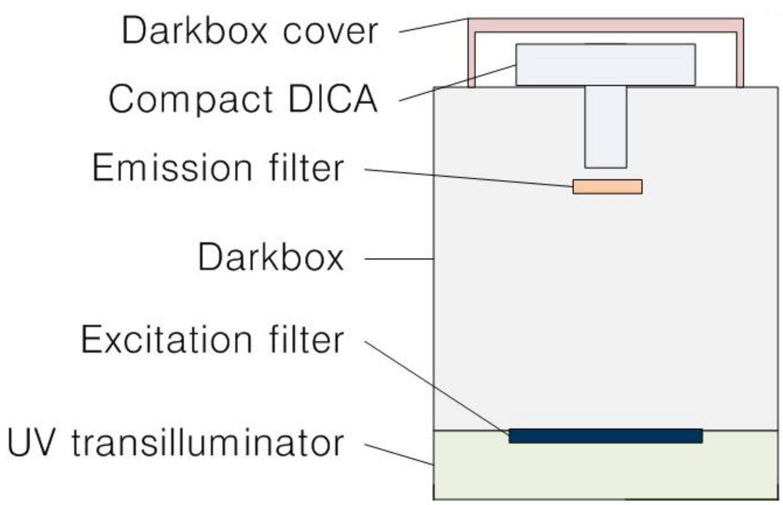


Figure 1. The Smallest Gel Documentation System

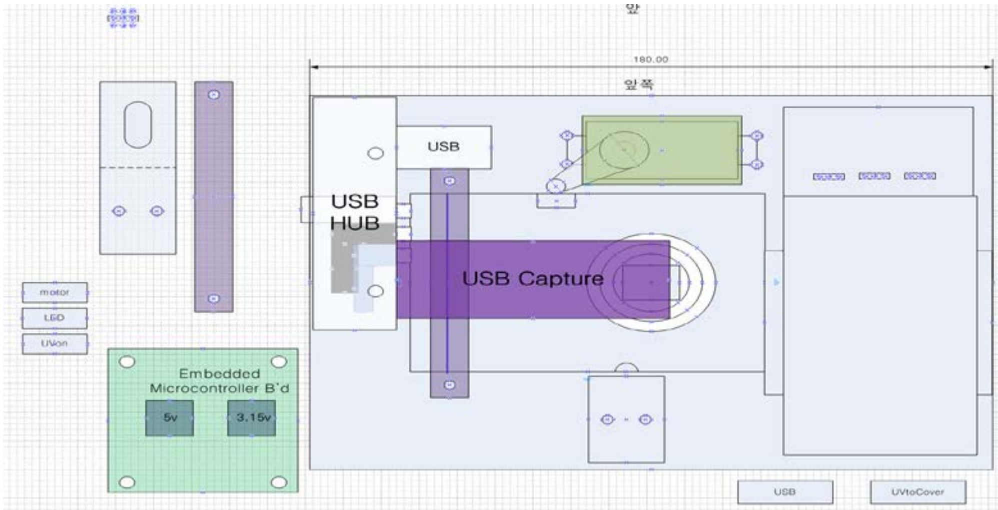


Figure 2. Camera Box Block Diagram

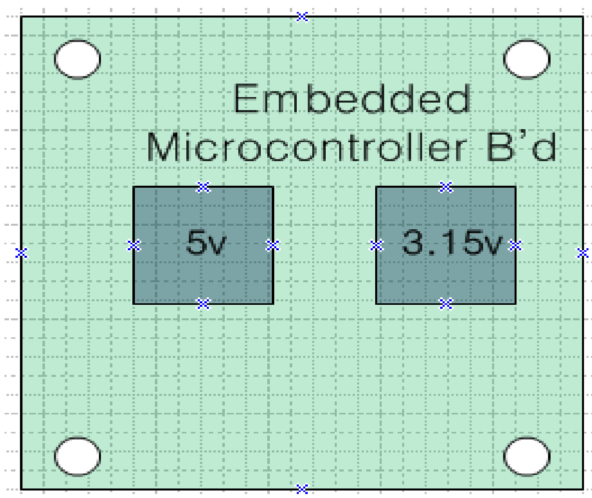


Figure 3. Embedded Board Configuration

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.

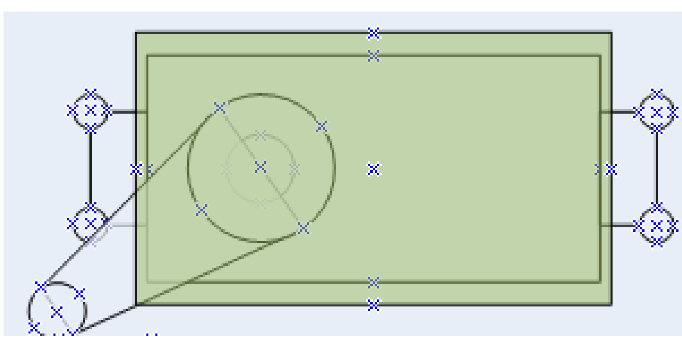


Figure 4. Servo Motor

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. 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. 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.

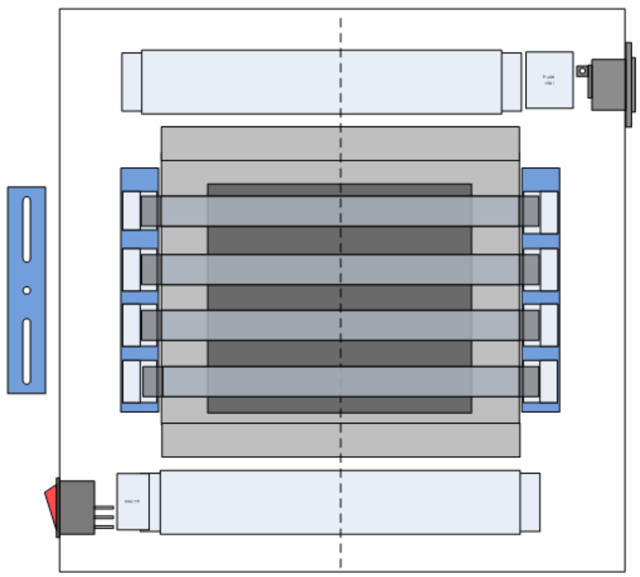


Figure 5. UV Illuminator Top-view Block Diagram

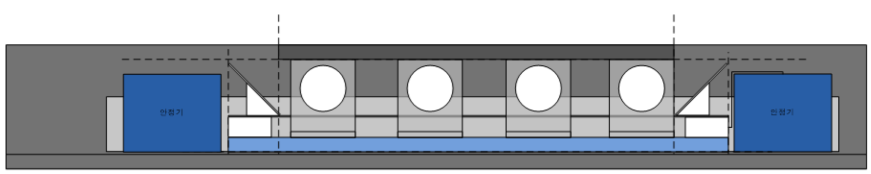


Figure 6. UV Illuminator Side-view Block Diagram

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.

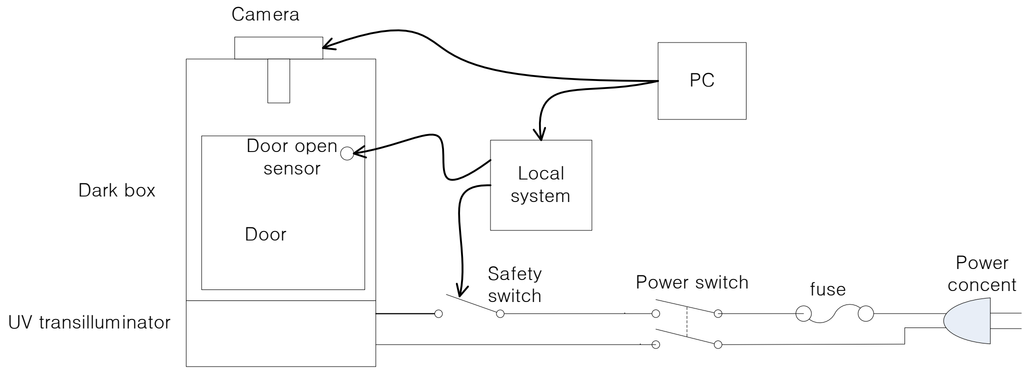


Figure 7. UV Safety Circuit

3. Experiment Method and Results

To compare and observe the images obtained via the DNA shooting experiment, two experiments using the existing GelDoc device and the proposed one were performed. The camera used for the low-cost GelDoc was Canon A495, which is a low-end compact digital camera. Table 2 shows the features of the high-end camera Canon G7 and low-end camera Canon A495.

Table 2. Specifications of Cameras Used

Camera	Features
	- Company : Canon - Model : Power Shot G7 - Pixels : 10 million pixels - Optic zoom : X6 - CCD sensor size : 1/1.8”
	- Company : Canon - Model : Power Shot A495 - Pixels : 10 milion pixels - Optic zoom : X3.3 - CCD sensor size: 2/3”

Figure 8 shows the screen of the program in which the PC remote control function was implemented. The low-end compact camera’s computer control function was incorporated, and the program was controlled by the GUI. The GUI had camera control functions such as zoom, autofocus, and autofocus lock, and exposure control functions such as Av, Tv, and ISO. From the top left side, the part A is Camera mode control which can capture the image while adjusting the camera zoom ratio and focus. The part B is capture mode control which determines the function of AUTO, Av, Tv and specifies the values for Tv, ISO. The part C is camera control which controls AF-Look(fix focus), use of RAW or not, camera OFF and reboot. The part D is the preview window which shows the same image as camera’s LCD image. The part E is image capture window which displays the captured image. And the part F shows camera state which checks whether the order sent by the camera is properly executed or not

Figure 8. User Interface of the Remote Control Program for A495

Figure 9 shows an actual gel image. The image on the left-hand side was that shot from the existing GelDoc using a G7 camera. The image on the right-hand side was obtained by using the low-cost camera A495 and the proposed miniaturized GelDoc device.

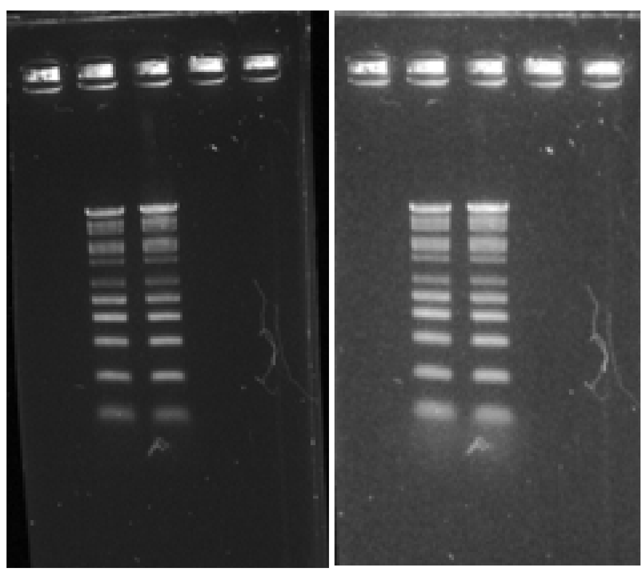


Figure 9. Image Captures with G7 and with A495

Figure 10(a) is the reversed image of the Figure 9 to analyze accurately the images captured with cameras, and figure 10(b) is the image of enhanced contrast.

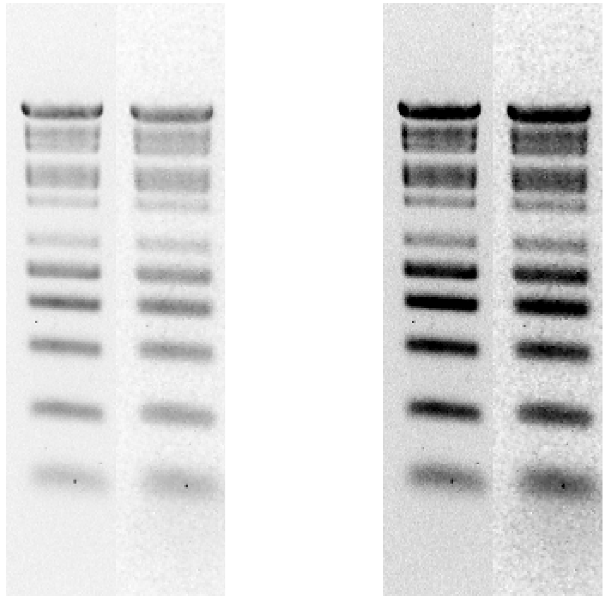


Figure 10. (a) Reversed Image (b) Picture of Concentration Dark

4. Conclusion and Future Research

The results of the comparison between the existing GelDoc and the proposed low-cost miniature version revealed that the two systems had a comparable performance. As future research, we intend to develop a more inexpensive GelDoc device having a comparable performance by focusing on factors other than the camera price, such as reducing the number of expensive UV lamps used in the device.

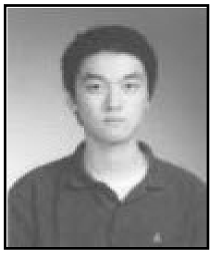
Acknowledgments

The research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2012R1A1A2040381).

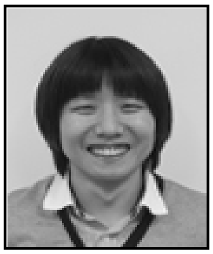
References

[1] E. Salm, "Electrical Detection of dsDNA and Polymerase Chain Reaction Amplification", Biomedical Microdevices, vol. 13, no. 6, **(2011)** December, pp. 973-982.
[2] R. Kodziusa, "Inhibitory Effect of Common Microfluidic Materials on PCR Outcome", Sensors and Actuators B, vol. 161, no. 1, **(2012)** January, pp. 349-358.
[3] J. Wu, "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, "An Alternative Method for Electrophoretic Gel Image Analysis in the GelMaster Software", Computer Methods and Programs in Biomedicine, vol. 77, no. 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, pp. 19-21.
[6] A. M. C. Machado, "An Iterative Algorithm for Segmenting Lanes in Gel Electrophoresis Images", Brazilian Symposium on Computer Graphics and Image Processing, vol. 235, **(1997)** October 14-17, pp. 104-146.
[7] T. Goldmann, "Cost-Effective Gel Documentation Using a Web-Cam", J. Biochem. Biophy. Methods, vol. 50, no. 1, **(2001)**, pp. 91-95.

Authors



Deuk-Joo Lee received the B.S. degree in Computer Engineering from Hallym University in 2012. He currently studies for a master's degree in Computer Engineering at Hallym University.



Sang-Yoon Kim received a master's degree in Computer Engineering from Hallym University. He is getting a PhD in Computer Engineering at Hallym University

Jong-Dae Kim received the M.S. and the Ph.D. degrees in Electrical Engineering from Korea Advanced Institute of Science and Technology, Seoul, Korea, in 1984 and 1990, respectively. He worked for Samsung Electronics from 1988 to 2000 as an electrical engineer. He is a Professor in Department of Ubiquitous Computing, Hallym University. His recent interests focus on biomedical system and bioinformatics.

Yu-Seop Kim received the Ph.D. degree in Computer Engineering from Seoul National University. He is currently a Professor in the Department of Ubiquitous Computing at Hallym University, South Korea. His research interests are in the areas of bioinformatics, computational intelligence and natural language processing.

Hye-Jeong Song received the Ph.D. degree in Computer Engineering from Hallym University. She is a Professor in Department of Ubiquitous Computing, Hallym University. Her recent interests focus on biomedical system and bioinformatics

Chan-Young Park received the B.S. and the M.S. from Seoul National University and the Ph.D. degree from Korea Advanced Institute of Science and Technology in 1995. From 1991 to 1999, he worked at Samsung Electronics. He is currently a Professor in the Department of Ubiquitous Computing of Hallym University, Korea. His research interests are in Bio-IT convergence, Intelligent Transportation System and sensor networks.