Study of dynamically user-changeable multiple infrared marker patterns

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***Abstract*—In this research, we study a multiple infrared marker pattern generation system that is dynamically changeable by the user. A user may be required to handle password generation such as hard token of one-time password. Therefore, we studied a dynamically changeable marker pattern generation system using multiple infrared lights. We developed a box-shaped light source that can emit four different wavelengths from one light source and implemented an IR filter on a slide bar to change the marker pattern. Marker pattern recognition accuracy experiments and communication speed experiments were conducted using this system. From the experimental results, it was confirmed that dynamic multiple infrared marker patterns were generated and the marker patterns could be recognized with high accuracy.**

***Index Terms*—infrared, authentication**

I. Introduction

In recent years, various authentication methods have been proposed as countermeasures to unauthorized access on the Internet. Particularly, the hard token method whereby the user generates a password using a dedicated terminal, has attracted attention. Among them, an optical authentication device using the wavelength characteristics of infrared light has been proposed as one of the authentication methods using light [3]. In this authentication system, a marker pattern was created using infrared light and an optical element, and was used for authentication. The authentication device using this light can generate a password by the hard token method. One of the advantages is that magnetic skimming can be prevented. In a research on creating marker patterns using light in this manner, Nakazato et al. have proposed an invisible marker that can provide information on a real environment using infrared light and a retroreflective material [4]. Aoki et al. have a study called Balloon Tag that uses infrared light to identify individuals [2]. Furthermore, Suzuki et al. have proposed a semitransparent two-dimensional color marker that can overlap different marker patterns [1]. Among these methods, the marker patterns proposed in the research of reference [3], [4] are fixed. However, when they are used for authentication as hard tokens, it is necessary to increase the security strength; therefore, it is necessary to make marker patterns dynamically changeable. Additionally, the marker pattern can be visually recognized by the method proposed in [1]; therefore, it is difficult to use it for security. Therefore, in this research, to directly involve the user in password generation, we aim to realize a system that can dynamically change the created marker pattern created using optical elements that can control light transmission and shielding and infrared light.

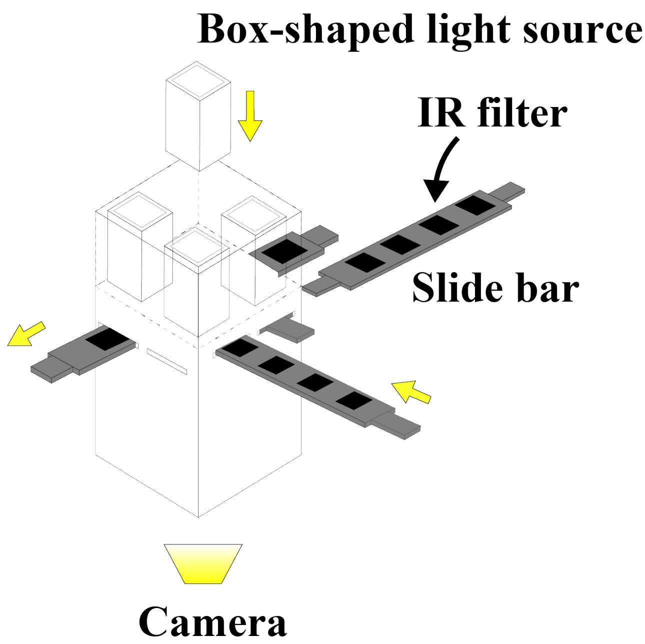


Fig. 1. Marker pattern generate system

II. System Requirements

In an authentication device using marker patterns, security strength can be enhanced by generating several marker patterns. Therefore, it is desirable to be able to create many marker patterns. Furthermore, in the hard token method, it is required that the user be involved in password generation. Security strength can then be enhanced by dynamically changing marker patterns generated by the hard token. Therefore, the user must be able to change marker patterns dynamically. Therefore, the system in this research realizes two points: (1) creation of several marker patterns and (2) enabling users to change marker patterns dynamically. In order to achieve (1), this paper uses an optical element that can selectively

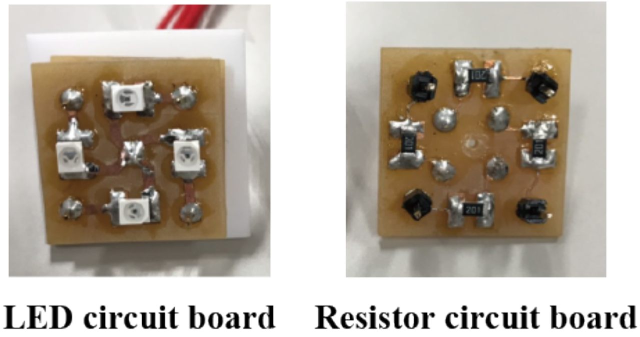
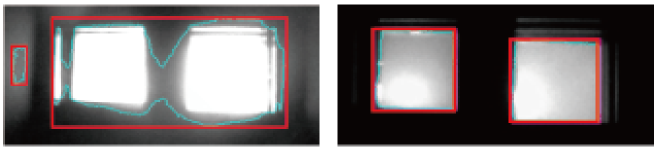


Fig. 2. LED and Resistor circuit board



(a)Authentication failure (b)Authentication success

Fig. 3. Authentication screen

block infrared light of multiple wavelengths and infrared light. Furthermore, (2) is realized by making this optical element combination changeable at any time.

III. Implementation

The system in this study comprises of a box-shaped light source, a slide bar with an IR filter made by Fujifilm, and a web camera (BSWHD06M) made by BUFFALO (Fig.1). The light source is using the acrylic plate that is fine scratches. The two-stage board was housed inside a box-shaped light source. It has one surface-mounted infrared LED capable of emitting infrared light of different wavelength bands (770 nm, 810 nm, 870 nm, and 940 nm), and one resistor for adjusting the light quantity for each LED (Fig.2). This implementation made it possible to emit infrared light of four different wavelength bands from one light source, which satisfied requirement (1). Furthermore, the box-shaped light source simplified the system internals and made it easy to remove the light source during maintenance and inspection. The slide bar is fitted with an IR filter that can control shielding and transmission of the infrared light. By moving this slide bar, the marker patterns could be changed dynamically, which satisfied requirement (2). A marker pattern generator was created using the aforementioned box-shaped light source and a slide bar.

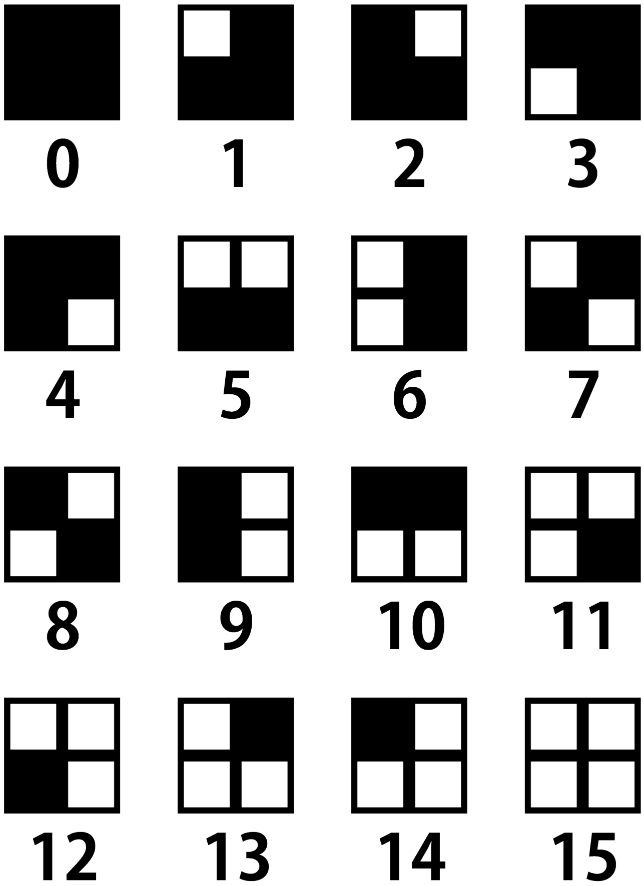


Fig. 4. Marker pattern numbering

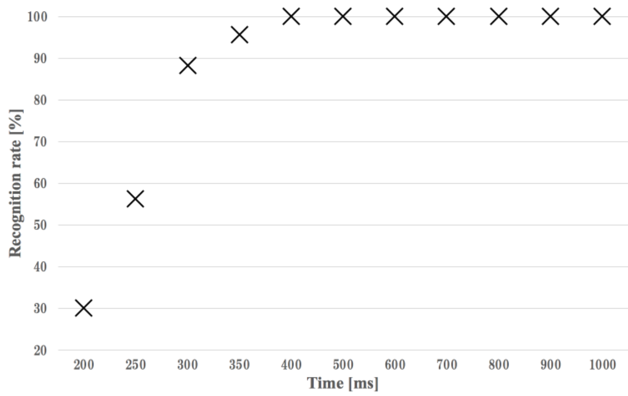


Fig. 5. Communication speed experiments results

IV. Experiment

As a preliminary experiment, we selected an IR filter to selectively shield the light source considering the wavelengths of the four types of infrared LEDs installed in this system. For confirmation of the transmission and shielding, a method was adopted in which the image acquired from the camera was processed using OpenCV, and the contour of the light emission part was extracted when the luminance was higher than a certain threshold. This experiment had two types of sub-experiments: with one IR filter and with two IR filters. It was assessed that 770 nm was IR84, 810 nm was IR 88, and 870 nm was IR 92; and the luminance was below the threshold and shielding was performed. There was no combination for which 940 nm was blocked in either experiment; however, there was a combination in which the two sheets were more dimmed than in the case with one sheet. In this preliminary experiment, misrecognition owing to the combination of light sources was observed (Fig.3(a)). Therefore, the amount of light was adjusted using external resistance of 1.2kΩ. (Fig.3(b)). In this system, a one bit value indicating whether the light from the light source is transmitted or blocked was acquired for the number of light sources. Four light sources are used in the experimental system; therefore, 2^4 marker patterns were created. For verification, we conducted experiments to determine the recognition accuracy of marker patterns and the amount of data that can be communicated in one second. Two sub-experiments in the experiment of marker pattern recognition accuracy were performed: (1) a method of ordered presentation of marker patterns numbered from 0 to 15 (Fig.4) and (2) a method of random presentation of the patterns. The marker pattern change interval was set to 1000 msec, and ten marker patterns were presented in each trial. There were five trials in total. In (1), misrecognition occurred only once in all the trials. It was a misrecognition because the marker pattern was acquired at the timing when the light was weak. In (2), 100% of the marker patterns were recognized in all the trials. TIn the communication speed experiment, the marker pattern change time was shortened by 100 msec; the initial was 1000 msec. When the recognition rate decreased, the experiment was shortened by 50 msec. In this experiment, the marker pattern was presented 10 times for each change time. The experimental results are shown in Fig.5. From these results, it is seen that the maximum communication speed was 10 bps. We believe that this communication speed can be improved by using a camera capable of imaging at a faster frame rate and increasing the number of light sources.

V. Conclusion

In this paper, a password generation system that allows users to dynamically change marker patterns using multiple infrared lights is presented. Dynamic multiple infrared marker pattern was successfully generated as seen from the experimental result. It was confirmed that it was possible to recognize the generated marker pattern. In the future, we will study how to generate a one-time password from a hard token seed that can be changed in this system. In addition, the recognition accuracy is tested when the user moves the slide bar.

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