Advanced Science and Technology Letters
Vol.93 (Security, Reliability and Safety 2015), pp.28-33
http://dx.doi.org/10.14257/astl.2015.93.07

A User Authentication System Using Color-coded Images

Byunghun Oh[1] and Kwngseok Hong[1],

[1] College of Information and Communication Engineering, Sungkyunkwan University, Suwon-si, 440-746, South Korea
sincelife@skku.edu, and kshong@skku.ac.kr

Abstract. We propose a novel user authentication system using RGB color-coded images. This system is divided into two parts: a sender system, and a receiver system. When the user inputs a digital password, such as text or numbers, the sender system converts this password to color-coded images, using a previously prepared coding algorithm. The receiver system detects these color-coded images by using a camera, extracts the color values, and decodes them into the original digital password. We present an experimental result of data transfer accuracy, to show that this system can work in real situations.

Keywords: Color communication, Color-coded image, User Authentication

1 Introduction

Security has become an important issue in modern society, and various types of security systems are being developed. Some of them use direct password input systems, like keypads; some use wireless remote input systems, and some systems use the iris [1] or fingerprint [2]. However, each system has its own weaknesses that can be critical in security. Direct input systems can be broken, when the password is leaked to other people. Wireless systems have prevented this problem by using a remote device, but this is not strong enough, considering that radio frequency signals can be easily interrupted. Using iris or fingerprints can be safer, but these methods are expensive, and have a relatively low recognition rate. To solve these problems, we suggest a system that receives a password through a personal mobile device, and transfers the password using a safer wireless communication method, after encoding it by a special encryption method. Using this system, there is no problem, even when a password leaks, if the user possesses a mobile device. There is no worry about radio frequency interruption, and cost is not a problem, if users use their own smartphones or cellular phones.

We propose a novel user authentication method that uses an RGB color code display on a subdivided mobile device screen area. There are some existing works like patents [3] and [4] that propose a similar method, but our system firstly uses ‘reference colors′, which can make the color code images robust to illumination, and secondly uses periodically-changing color codes, to make it able to send larger password data.

ISSN: 2287-1233 ASTL

2 Proposed Algorithm

2.1 System Architecture

The proposed system needs a sender device with a color screen attached, and a receiver device with a camera. Devices that can receive digital data directly from the user and that have a color screen are appropriate for the sender device. Personal computers and smart mobile devices may be usable. The receiver device needs a camera that can continuously take images of the sender device screen, and should be able to show received data to the user. Fig. 1 shows an overall figure of the proposed system.

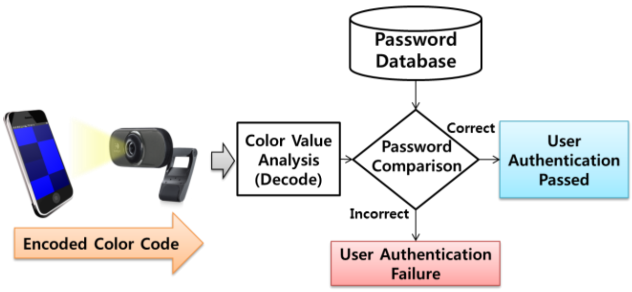

Fig. 1. Overall architecture of the proposed system

The sender device needs to convert digital data to RGB color codes, and display color codes on the orthogonally divided screen. When the user inputs digital data, such as text or numbers, the sender device converts these data to color codes, using a previously prepared encoding algorithm. The sender device can transfer the converted color codes to the receiver device, by periodically displaying them on the screen for a short time.

The receiver device needs to detect the sender device's screen, from images taken by the camera. The sender device screen can be readily detected using image-based object-detecting algorithms. When detected, the RGB color values should be extracted from all of the subdivided rectangular areas of the screen. The extraction speed can be determined considering the displaying speed of the sender device and the image processing time. The receiver device has to periodically extract RGB values, keeping to the extraction speed that been decided on. The extracted color values can then be converted to digital data. When this data is reported to the user, data transfer of the proposed system is performed.

2.2 Data Encoding Algorithm

To detect the sender device, we used the Camshift algorithm [5], which is a color-based object-detecting algorithm extended from the Mean shift algorithm [6]. Because the blue color showed the best detection rate in our experiments, we explain the algorithm using the color blue in this paper, but red and green can also be used in the same way.

Suppose we set the red value to 0, the green value to 0, and the blue value to a number between 60 and 255, making the object-detecting algorithm continuously detect the color. Then, using the blue color, we can organize the encoding algorithm as follows. First, we divide the range of 60 to 255 into four smaller sections. Using the fact that all the digital data is made up of bits (0 and 1), we assign 00, 01, 10, 11 bit values to each section. This means that if the sender device wants to send one of those four values, it needs simply to display the representative color of the section. We determine the median colors as representative colors of each section. Then, the receiver device can distinguish which bit value among the four is being sent by the sender, using a decoding algorithm.

However, the received color values can change every time, even if the displayed colors are the same. This happens because images taken by digital camera are very sensitive to the surrounding illumination conditions. To address this, and to make this system robust to illumination, we suggest a method using reference colors. We can fix two rectangular areas to display 60 and 255 values only, and make the receiver device extract colors from these two areas in every frame. If the receiver device already knows that these two colors are originally 60 and 255, it can calculate the difference. We can then use this difference to check how much the value of the received color is affected. Also, because we used two edge values in the detectable range, we can determine the range of colors that the receiver device extracted. Fig. 2 shows the structure of the designed digital data encoding algorithm.

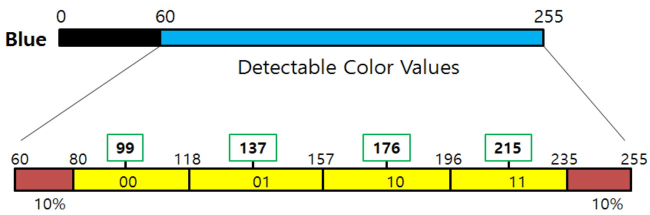

Fig. 2. The Digital Data Encoding Algorithm

The upper bar in Fig. 2 indicates the range of the blue color value, and the brightly colored part is the range of the detectable color value. This part is expanded in the lower bar, which consists of four small sections (yellow part) having the assigned bit values. Reference colors have to be distinguished from other colors, so there are additional sections for the reference colors. The red-colored parts, which take up 10% at each side of the lower bar, indicate the sections of reference colors. The remaining 80% of the area is divided into four smaller sections, which have bit values assigned. Thus, if we pick the median values of each section, 99, 137, 176, and 215 will be the representative blue values, and when transferring digital data, they will be displayed on the sender device screen.

2.3 Color Code Decoding Algorithm

The color code decoding algorithm: The receiver device needs a decoding algorithm that can convert the extracted color values to digital data. This can be designed by analyzing the RGB values of the received colors. Fig. 3 shows graphs of the received RGB color variation, when the displayed blue color changes from 0 to 255. The distance between camera and mobile device is about 20cm.

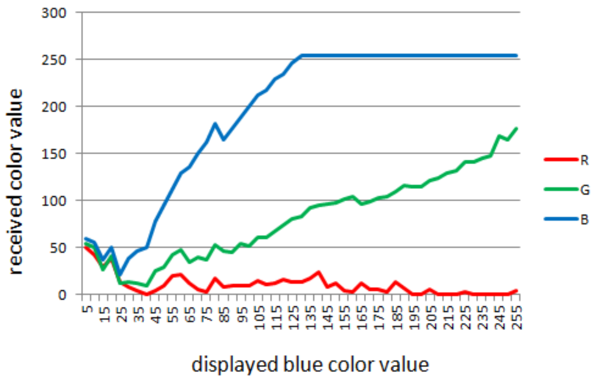

Fig.3. The received RGB color variation accrding to change of the displayed blue color

When the displayed blue color value increases, the red value is fixed under 25, and the blue value increases rapidly to 255, finally being held at 255. The green value shows a tendency to increase linearly, versus the other colors. Thus, we judge the green color to be more useful than the blue color when designing the decoding algorithm; but this can vary, depending on the surrounding illumination, and the type of the receiver device. Fig. 4 shows the structure of the designed decoding algorithm.

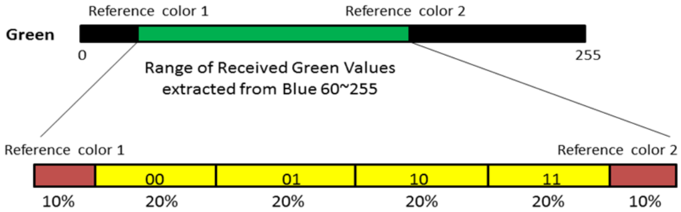

Fig.4. The color code decoding algorithm

The structure of the decoding algorithm is similar to that of the encoding algorithm, but there is a small difference, in that the range of the detectable color value is not fixed. The receiver device has to set the range of valid green values, by using the received reference colors in every frame. The upper bar in Fig. 4 indicates the range of green values, and the bright part indicates the range of valid green values set by the two reference colors. The bright part is expanded in the lower bar. The red-colored parts indicate the sections of reference colors, and the remaining 80% of the area is divided into four smaller sections of 20% area, which have bit values assigned.

3 Experiments and Result

To measure the data transfer accuracy, we divided the screen of the mobile device into 10 rectangular areas as a 2 × 5 window, and displayed two reference colors at the bottom row of the window. We extracted color values from the center of each divided area. The distance between the sender device and the receiver device was about 20 cm.

In the experiment, we converted four alphabetical characters to ASCII codes, and made each rectangular area display two bits in one frame. Excepting reference colors, there were a total of eight rectangular areas, so we could send two alphabetical characters (16 bits) per frame. The speed of changing colors was set to 5 times per second, so 80 bits could be sent per second.

Table 1. Data transfer accuracy of the color communication system

	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	Average
Letter	99.2%	94.9%	99.7%	99.4%	99.2%	98.4%
Word	98.9%	87.5%	98.9%	97.9%	97.9%	96.2%
Bit	99.4%	97.5%	99.9%	99.7%	99.6%	99.2%

We transferred data for 1 minute in every experiment, and performed five experiments that measured the average transfer accuracy at the word, letter, and bit levels. The average data transfer accuracy at the bit level was about 99.2%, and Table 1 shows the results of the experiment.

4 Conclusion

We propose a user authentication system that uses RGB color code display on a subdivided mobile device screen area. We also proposed an encoding algorithm and a decoding algorithm that can be used in our system, and estimated the data transfer accuracy at bit, letter, and word levels by experiments. Our approach can compensate the defects of existing security systems. It is more secure, because the password that is encrypted by a specialized algorithm passes through a mobile device, and is transferred by a visible light communication method. For future work, we plan to increase data transfer accuracy and transfer speed, so that it can be used in real environments.

Acknowledgments. This 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(2014023704) and This research was supported by Basic Science Research Program through NRF of Korea, funded by MOE(NRF-2010-0020210)

References

1. Catalin, L., Vasile-Gheorghita, G., Valeriu, L.: Security enhancement of internet banking applications by using multimodal biometrics. 2015 IEEE 13th International Symposium on, 47—52 (2015)
2. Hung-I, H., Junghsi, L.: Fingerprint image cryptography based on multiple chaotic systems. Signal Processing, 169—181 (2015)
3. Endo, H.: TWO-DIMENSIONAL CODE, TWO-DIMENSIONAL CODE READER, AND PROGRAM, KR Patent. No. 1020127008099 (2012)
4. Kim, K., Kim, J.: Image Recognition Code for Approaching Contents, and Method and Apparatus for Approaching Contents by Image Recognition Code in Broadband convergence Network. KR Patent, No. 1020080008674 (2008)
5. Bradski, G.: Computer vision face tracking for use in a perceptual user interface. Intel Technology Journal (1998)
6. Comaniciu, D., Ramesh, V.: Mean shift and optimal prediction for efficient object tracking. IEEE int. Conf. Image Processing, Canada, 70--73 (2000)

