ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2011. No. 9(115)
ELEKTRONIKA IR ELEKTROTECHNIKA

SYSTEM ENGINEERING, COMPUTER TECHNOLOGY
T 120
SISTEMŲ INŽINERIJA, KOMPIUTERINĖS TECHNOLOGIJOS

Design and Implementation of a Personal Computer Authorization System using Color Detection

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crossref http://dx.doi.org/10.5755/j01.eee.115.9.758

Introduction

Today, the computer authorization and to access information is very important problem for schools, institutions, companies and organizations. The central objective of any security system is the ability to prevent undesired access, while still allowing authorized access to information. As computer usage expands into more areas and the number and variety of users increase, we expect to see an increased demand for more complex security provisions [1].

There are different types of user authentication to make personal computers (PCs) secure. Traditionally, verified users have gained the access via passwords, Personal Identification Numbers (PINs), or smart cards [2]. Recently, biometrics has been received considerable attentions, which refers the personal biological or behavioral characteristics used for verification or identification. Biometric systems make use of fingerprints, hand geometry, iris, retina, face, hand vein, facial thermograms, signature or voiceprint to verify a person's identity [3]. But, these systems cannot provide a practical and cost-effective solution for PCs which have more than the number of users and which users' change frequently. For example, an easily-updatable security system can be created to use each of PCs by different students in information technologies (IT) classrooms.

Color sensing has a variety of applications including detection of environmental, biological, and chemical parameters [4]. In this study, to ensure the authorization of computer usage, a color recognition system has been developed by applying a color sensor (TCS230). For this purpose, color coded cards are prepared and defined for each computer. A color code is printed by using one or more color tone on the card. The color codes on the card detected by a color sensor. The color sensor generates the output signal in square waveform which frequency varied directly with the hue of color in RGB (red, green, blue) color system [5, 6]. The decoders which recognize the signal frequencies obtained from the sensor are located inside of the computer cases. Each decoder can recognize different color coded cards. If computer user puts the color coded card into the color decoder correctly, the decoder allows switch on the power supply of computer. Otherwise, the decoder does not allow to work of computer and it warns the user by providing both voice and visual message. This study shows that it can also be used color recognition for authorization problems as different from other usage fields of it. Proposed method can also be used cost-efficiently and to be preferable for PCs which users are often changed.

Color theory

There are many standard color systems used nowadays in various applications, but most standards generally hold some common idea, that is, the color representation in 3-dimension space. For instance, in RGB color system; there are three color axes for Red, Green, and Blue. RGB HSV (Hue Saturation Value) is a popular color system [6].

Also other recent studies have established that there are three different types of cones in the human retina and their spectral responses can be represented as $S_1(\lambda)$, $S_2(\lambda)$ and $S_3(\lambda)$ where, λ_{min} = 380 nm and λ_{max} = 780 nm. Light is a type of energy, which makes up a small portion of the electromagnetic spectrum. Visible light could be expressed as a frequency, but the magnitude is so large people generally express the wavelength of light in units of nanometers to describe light.

Color measurement

Color measurement has been classified and specified in several ways [7–9]. Two of the most widely used systems for describing color are the Munsell System and the International Commission on Illumination (CIE) color/order system. The Munsell System compares the perceived color of an object with a standardized and orderly arrangement of colored chips [8]. It describes colors in a 3-dimensional coordinate system of hue, value, and chroma. In this system, hue is represented by 10 different colors. Each color is arranged around the circular horizontal plane of the coordinate axis. Chroma is the strength (or intensity) of the color and is represented by the spokes of a wheel, with the purest color at the periphery. Value refers to the lightness or darkness of a color. The 10 value levels are represented by 9 wheels on the vertical axis [9].

The CIE system is the international standard for color measurements. It incorporates a standard observer and light source. In the CIE concept, all colors can be matched by mixing relative amounts of the 3 primary colors: red (*X*), green (*Y*), and blue (*Z*) [8]. CIE color matching functions x(λ), y(λ), and z(λ) represent the amounts of R, G, and B needed to match a constant amount of power per small constant-width wavelength interval (λ) throughout the spectrum. The CIE X, Y, and Z tristimulus values quantify the perceived color of a reflected surface. These are calculated directly from the three properties required to specify the color of an object and can be determined in four steps (The *w*'s refer to optical wavelengths) [9]:

- ***Step 1:*** Determine the surface reflectance values: $r(w_1)$, $r(w_2),\ldots,r(w_5),\ldots r(w_n)$. These values of reflectance are provided by system hardware.
- ***Step 2:*** Multiply the reflectance values of *Step 1* with the spectral power distribution of the illuminant thus

$$r(w_1)P(w_1), r(w_2)P(w_2), \ldots, r(w_n)P(w_n). \tag{1}$$

- ***Step 3:*** Multiply the products of Step 2 by the color matching values given:

$$\begin{cases} r(w_1)P(w_1)x(w_1), \ldots, r(w_n)P(w_n)x(w_n), \\ r(w_1)P(w_1)y(w_1), \ldots, r(w_n)P(w_n)y(w_n), \\ r(w_1)P(w_1)z(w_1), \ldots, r(w_n)P(w_n)z(w_n). \end{cases} \tag{2}$$

- ***Step 4:*** Sum the products of Step 3 to obtain CIE Tristimulus Values ***X, Y, Z:***

$$\begin{cases} r(w_1)P(w_1)x(w_1) + \cdots + r(w_n)P(w_n)x(w_n) = \boldsymbol{X}, \\ r(w_1)P(w_1)y(w_1) + \cdots + r(w_n)P(w_n)y(w_n) = \boldsymbol{Y}, \\ r(w_1)P(w_1)z(w_1) + \cdots, +r(w_n)P(w_n)z(w_n) = \boldsymbol{Z}, \end{cases} \tag{3}$$

thus ***X, Y,*** and ***Z*** are the quantitative measures of the response of the three cone types in the eye of the standard observer to the color of an object [9].

Scaling the white point to give unit luminance results in the three tristimulus values of 0.9807, 1.0000, 1.1818. The above analysis will give the relationship between *R, G, B,* and known values ***X, Y,*** and ***Z*** as shown in (1) [9]

$$\begin{bmatrix} 1.9098 & -0.5324 & -0.2882 \\ -0.9846 & 1.9991 & -0.0283 \\ 0.0583 & -0.1184 & 0.8980 \end{bmatrix} \begin{bmatrix} \boldsymbol{X} \\ \boldsymbol{Y} \\ \boldsymbol{Z} \end{bmatrix} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}. \tag{4}$$

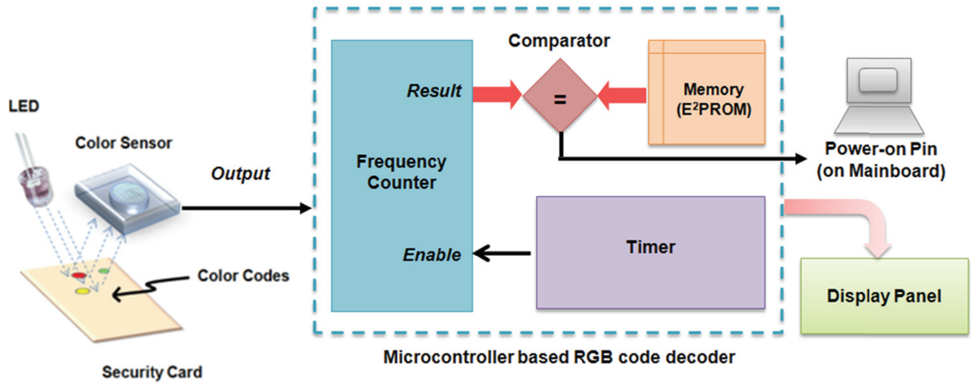

Fig. 1. System block diagram

Hardware-based PC authorization system by color detection method

Designed system is composed of a color sensor with high resolution, a microcontroller based RGB code decoder and a LCD panel to display messages to user (Fig. 1). Previously, to be given to each PC user, printed security cards with color codes are prepared. Then, the color code on these cards is introduced as RGB codes into the color code database of this system. The color in which specific coordinate on a security card is detected by a color sensor (TCS230) converted to RGB code. Sensor output signal is sent to RGB code decoder unit. Then, the codes obtained from the sensor output signal, RGB codes, are compared by the RGB codes on a color code database to check of matches for authority. The color code database is located at E2PROM of microcontroller. RGB code decoder is implemented by using a PIC16F877 microcontroller. For checking of matches' process, embedded software is developed inside of the microcontroller. If the comparison is successful, a control signal is sent to PC's power control pin on mainboard from microcontroller to power-on the PC.

In RGB code decoder unit, a microcontroller (PIC16F877) is used for controlling the security system. PIC16F877 is a microcontroller with 40 pins and property of 8-bit CMOS Flash. Also it has a timer/counter module for measuring the frequency of sensor output signal [10].

The reasons for choosing this microcontroller are its popularity, being low cost and having within the required modules.

Used color sensor in this study, TCS230, programmable color light-to-frequency converter combines configurable silicon photodiodes and a current-to-frequency converter on single monolithic CMOS integrated circuit [6]. This device can detect 256 hue values for each of red, green and blue and totally 16.777.216 hues.

Color detection unit

The TCS230 color sensor has an array of photo detectors, each with either a red, green, or blue filter, or no filter (clear). The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity. To obtain red, green and blue values from output of the sensor, the selection pins (S0, S1, S2 and S3) are used. As shown in Fig. 2, when the light reflected from the color code of an authority card onto photodiode array which could be selected the color filter by signal S3 and S2, the current would be generated by photodiode and send to light-to-frequency converter which could be selected the range of output frequency by signal S1 and S0. Output enable ($\overline{OE}$) places the output in the high-impedance state for multiple-unit sharing of a microcontroller input line [6]. Table 1 describes the selectable options of the color sensor. L and H respectively describe low and high values of the signal, as logic "0" and logic "1" situations.

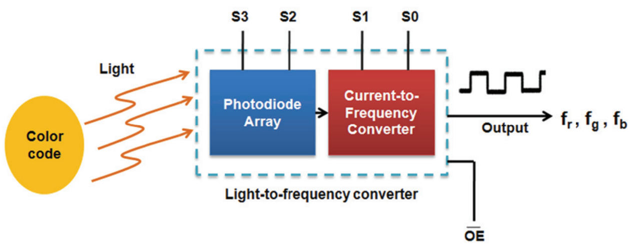

Fig. 2. Sensor processing diagram

Table 1. Selectable options for the color sensor

S0	S1	Output Frequency Scaling (f_o)	S2	S3	Photodiode Type
L	L	Power down	L	L	Red
L	H	2%	L	H	Blue
H	L	20%	H	L	Clear (No filter)
H	H	100%	H	H	Green

The color codes are located on a security card made from polyvinyl chloride (PVC). The coordinates of the color fields can be determined to be different for each of card reader devices.

Firmware implementation

To perform decoding of the color sensor output frequency, a firmware is implemented. Initially the frequency of the color sensor is read by a firmware-based frequency meter.

In Fig. 3, a flow chart of firmware main program is shown. To obtain the value of the frequency, low-to-high transitions (rising edges) of the square wave that sent from sensor is counted for 1 second by microcontroller. The time of 1 second is kept by the timer module in microcontroller. The counting process is implemented by the counter module in microcontroller. First, the counter and timer are configured and enabled. At this state, the program enters an infinitive loop to wait a timer interrupt.

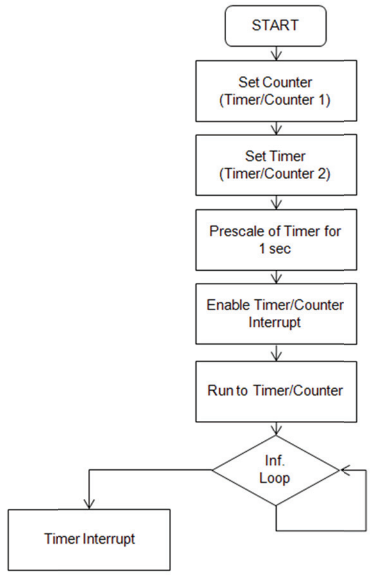

Fig. 3. Main program flow chart

In Fig. 4 is shown a flow chart of timer/counter interrupt subprogram. When the period of 1 sec. is filled, the frequency value obtained from RGB code decoder is compared by the RGB values on a color code database to check of matches. In the beginning, the output state of the power-on control bit is initially reset to logic "0". When these values match, the output bit is set as logic "1". At the same time, the result of comparison is displayed on LCD panel.

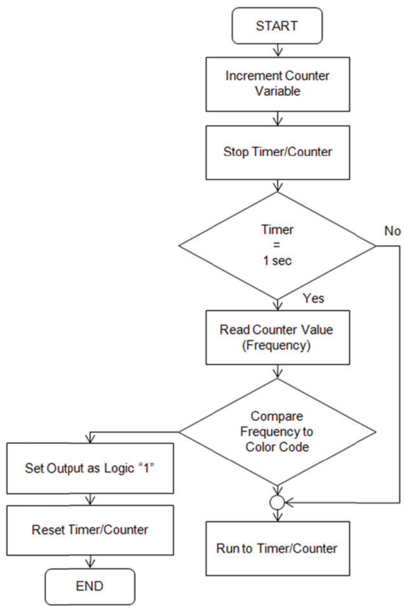

Fig. 4. Timer interrupt subprogram flow chart

At prepared test circuit, the microcontroller has an oscillator frequency of 4 MHz.

In color detection experiments, it has been observed that precision of the color measurements obtained from the sensor varied according to white LED's luminance. Therefore, the sensor circuit is placed in a dark box. A picture of designed device is shown in Fig. 5.

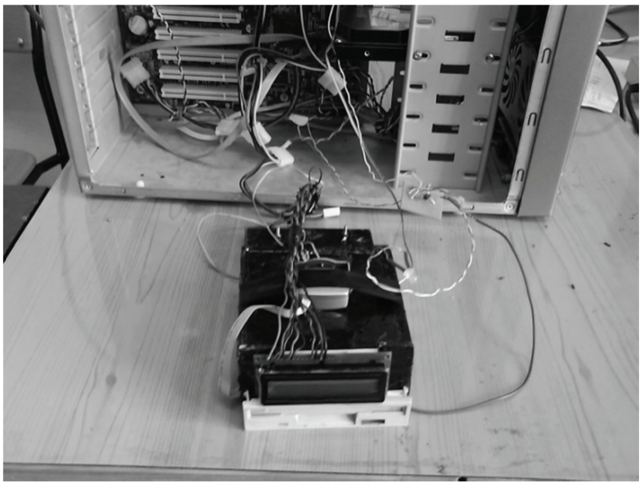

Fig. 5. Designed device

Conclusions

In this study, to ensure the authorization of computer usage, a color recognition system has been developed by applying a color sensor. For this purpose, color coded cards are prepared and defined for each computer. A color code is printed by using one or more color tone on the card. The color codes on the card detected by a color sensor. The decoders which recognize the signal frequencies obtained from the sensor are located inside of the computer cases. When a correct color coded card is put into the color decoder, the decoder allows switch on the power supply of computer. Otherwise, the decoder does not allow to work of computer and it warns the user by providing both voice and visual message. This study shows that it can also be used color recognition for authorization problems as different from other usage fields of it. Proposed method can also be used cost-efficiently and to be preferable for PCs as in computer laboratories which users are often changed, as PCs in computer laboratories or offices. It also can be adapted to other security systems and it is a cost effective method for authorization.

Acknowledgements

Authors thank Antalya Serik Teknik ve Endustri Meslek Lisesi Mudurlugu for their contribution to the realization of this study.

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Received 2010 12 22
Accepted after revision 2011 02 07

F. Yucel, O. Oral , N. Caglayan, M. Tecimen, S. Kocak, E. Yuce. Design and Implementation of a Personal Computer Authorization System using Color Detection // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 9(115). – P. 97–100.

For using of personal computers (PCs) only by authorized persons, there are several methods such as fingerprint or face recognition at logon. In this study, an authorization method based on color detection and coding is designed and implemented. The color on specific coordinate of a color coded card is detected by color sensor with high resolution and converted to RGB code. Then, this code is compared by the RGB codes on a color code database to check the matches. Designed system can also be used cost-efficiently and to be preferable for PCs as in computer laboratories which users are often changed, as PCs in computer laboratories or offices. It also can be adapted to other security systems, and it is low cost. Ill. 5, bibl. 10, tabl. 1 (in English; abstracts in English and Lithuanian).

F. Yucel, O. Oral, N. Caglayan, M. Tecimen, S. Kocak, E. Yuce. Spalvų detekcijos pritaikymas projektuojant ir įdiegiant asmeninio kompiuterio vartotojo autorizacijos sistemą //Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 9(115). – P. 97–100.

Asmeninių kompiuterių vartotojų autorizacijai galima taikyti keletą metodų, tarp jų ir pirštų atspaudų ar veido atpažinimo būdus. Pasiūlytas vartotojų autorizacijos metodas, paremtas spalvų detekcija. Spalva detektuojama naudojant didelės skiriamosios gebos kameras. Detektavus spalvą fiksuojama jos koordinatė, atliekamas vertimas į RGB spalvų paletę, palyginami gauti rezultatai. Tokia sistema gali būti naudojama laboratorijų kompiuteriuose esant dideliam vartotojų skaičiui arba integruota į apsaugos sistemas. Il. 5, bibl. 10, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).