Research on Energy-Saving Technology Based on Visual Inspection for Classroom-Lighting System

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Received 23 April 2015; Revised 29 May 2015; Accepted 29 September 2015

Abstract. It has great significance to use visual inspection methods to do research on energy-saving system. This paper use visual inspection method to detect classroom seating area, illumination, object, and staff numbers to realize classroom-lighting energy-saving system. First, according to the appearing pixel in the photo of classroom background, this paper makes rough marks on seating area, then using horizontal and vertical projection to make accurate marks in order to divide seating area properly. Second, uses the principle of Gray scale images contain illumination information to detect illumination. Third, uses background subtraction method to achieve the segmentation of foreground from background, and different background model is used in different periods. Then improved erosion and expansion techniques are used for denoising color image. Last, on the basis of classic haar classifier algorithm to mark skin and hair in different colors based on skin model and hair color information. An improved connected labeling algorithm is presented to realize statistics on the number of people. Experiment results demonstrate that the system has greater accuracy, higher practical value.

Keywords: region labeling, object segmentation, human detection, Haar classifier, connected labeling

1 Introduction

The environment agency announced a set of data on February 20th, 2013. The data show that the global number of kerosene which only used for lighting is more than 25 billion tons and the cost up to more than 23 billion dollars per year. For our country, the total amount of electricity used for lighting has reached about 13% [1] and power consumption is increasing every year. For example, colleges and universities need lighting for a long time, and other electricity waste phenomena exist in construction sites. So there is a huge space for energy saving. At present, most colleges and universities are using artificial method to control the lamps and lanterns, but artificial inadequate supervision and the students lack of consciousness of energy conservation, often leads to waste of classroom lighting electricity. If the school only waste 2 hours of electricity a day, according to the rough statistics of the 30,000 lamps with power of 36 W in 9 months of the year, the calculation of electricity time will be wasted nearly 600 thousands degrees a year. With more than 1 million schools and 300 million students in our country, the waste of energy per year must be amazing. Energy retrofitting, energy efficiency and light automatic control not only can achieve the goal of energy conservation and emissions reduction, but also save the money for the school to bring huge economic benefits. In a word, research on the classroom lighting energy saving technology has the great significance and a broad prospect.

In recent years, some scholars have begun to do research on the energy-saving technology for classroom-lighting system. Such as in literature [2], the researchers divided the classroom into four areas and install infrared sensor for each area which was used for human detection. While, because the infrared sensor has a certain range of detection, it needs to measure the best position for installing the infrared sensor. So, the installing process will be very complicated. In literature [3], image processing method was put forward to calculate the average illumin ance of the classroom then according to the illuminance to let the lamps on or off. But this method doesn't take the number of person in the classroom into consideration. So it doesn't have an ideal effect for energy-saving. The method in literature [4], first makes linearization on the classroom image, then makes edge detection, at last detects the person in the classroom by using boundary tracking algorithm. If there is person in the area, the lamps are on; otherwise let the lamps off. The shortness of this method is that the people detection method was studied based on the binary image; it is easy to lead to inaccurate recognition because of the Personnel's occlusion.

In summary, nowadays the research on the energy-saving technology based on visual inspection for classroom-lighting system, mainly performs face recognition [5] and detects the number of people in classroom using computer vision algorithms, so as to control the lamps according to the personnel distribution in the classroom. Different from these systems, when detect the number of person using the system studied in this paper, the background is a relatively fixed classroom background and the person in the picture mostly only show upper part of the body. Therefore the most important key in this paper is to detect the person in the classroom by

using the classroom environment features and the person in the classroom. In this study, considering that the video image of camera in classroom including other non-seat section, not only enlarges the detecting range of human, but also increases the computation, so the detection of seat section is presented in the paper. Set sections firstly are roughly marked based on the histogram of much pixels in classroom image, next, are precisely marked using level projection and vertical projection. The paper mainly uses the principle that gray scale image includes the information of illuminance to measure the illumination. For the objects segmentation, it uses background subtraction method to achieve the segmentation of foreground from background, and different background models are used in different periods. Then improved erosion and expansion techniques are used for denoising colour image, which has preserved colour information. Human detection is the focus of research, so the paper uses the head feature to detect human based on the morphological posture of human in classroom. Based on classic Haar classifier algorithm to detect human, achieved an improved human detection based on connected labeling. Skin and hair are marked in different colours based on skin model and hair colour information firstly in the paper. Then, an improved connected labeling algorithm is presented to count the number of people. At last, according to the number of people in the classroom, the lamps are controlled to save the energy.

2 Detection Algorithm for Classroom Seating

ROI (Regions of Interest) [6] in the field of computer vision refers that people chose their most concerned area of an image. In reality, images are used to transfer some important information for us to handle, and sometimes we are just interested in some certain regions of the image. With the increasing amount of image data, it is no doubt that using the manual inspection to detect the region of interest is difficult. So the computer processing of ROI automatic detection technology emerges as the times require. ROI extraction algorithm is the preparation of many image processing techniques such as image segmentation, image recognition technology. So in this paper we use ROI algorithm before detecting classroom seating. Using ROI can not only reduce the calculation amount of image data and improve the computation rate but also exclude the interference of some objects to make personnel detection more accurate and simple.

In this paper, considering that the video image of camera in classroom including other non-seat section, not only enlarged the detecting range of human, but also increased the computation, so the detection of seat section is presented in the paper. Set sections firstly are roughly marked based on the histogram of much pixels in classroom image, next are precisely marked using level projection and vertical projection.

2.1 Roughly Mark Seating Area

Usually, in the picture of the empty classroom we can see that tables and chairs cover the majority of area of the whole image. In the classroom background image tables and chairs have many color gamuts than other things. So we use this feature to mark the classroom seating area. First, we count the more appearing color pixel in the picture of the classroom background and use histogram to represent them. Second, marking these seating areas' pixels in the same color and those pixels which are not of the seating area will be marked by another color. But if there are some small parts of another color pixel in the seating area, it may result the seating area was not completely marked. It may also result mark the other area as seating area if other area have the same color pixel with the seating area. In order to avoid the above two kinds of circumstances and mark seating area more accurately, we uses projection method to solve this problem.

2.2 Accurately Mark Seating Area

The projection method is divided into two parts: horizontal projection and vertical projection. The horizontal projection is a method that projects the image which will be processed to the direction of y axis by column. The vertical projection is a method that projects the image which will be processed to the direction of x axis by row. After roughly labeled, the image will be made horizontal projection and vertical projection. According to the coordinate values which the binary image of the labeled seating area project to the x axis and y axis in the projection effective picture, we can make the length width coordinates range of the seating area and obtain the seat area accurately. When calculating the length and the width of the seating area range we should exclude the pixels project to the coordinate axis which same to the seating area pixels.

3 Illumination Detection

Illumination refers to the visible light energy which is received by unit area of an object. It is a kind of physical terms and an abbreviation of lighting intensity. In popular and easy-to-understand language, illumination refers to the illuminated degree of places or objects in places [7]. In our daily life, illumination can be divided into natural illumination and artificial illumination. Excessive or insufficient illumination would do harm on people's eyes. When there have moderate illumination in the environment, it can not only increase work efficiency, but also good for people's eyes. Thus, it is essential to make illumination detection for each region of the classroom when doing research on energy-saving for classroom-lighting technology. So in this paper, we make detection on classroom illumination. And the illumination is measured mainly using the principle of gray scale image including the information of luminance.

The image's gray scale is an important data of the image which can react to the illumination information of the image. So only using image gray scale, we can describe an image. We make g(x, y) as the representation of image gray scale brightness function. According to the knowledge of physics and mathematics, the function g(x, y) should have the following properties:

1) As the luminosity function, g(x, y) should be non negative and bounded which satisfies the equation:

$$0 \le g(x,y) \le M, \text{ (M is a finite value)} \quad . \tag{1}$$

2) Considering that the image is formed by the light which hits an object and be reflected back. That is to say, the image can be measured by both illumination and reflection of the scene, as shown in the formula (2).

$$g(x, y)=\alpha \cdot i(x, y) \cdot r(x, y) \quad . \tag{2}$$

α is constant in the formula (2). And i(x, y) is illumination function which is determined by the light source, and has non-negative and bounded value. Because the illumination of the adjacent place which in the same environment has tiny difference. So i(x, y) also changes slowly with the change of position. r(x, y) presents the reflection of the scenery. Because each object has its own reflection, so the value of r(x, y) depends on the nature of the object. In practice, the object whose surface is rough and in dark color has little reflection but those whose surface is smooth and in light color has much reflection. In theory, dark object can absorb light completely and its reflection is zero. On the contrary, white object's reflection is one. So we can conclude that r(x, y)'s value is between zero and one.

Gray image usually shows white (the most bright) and black (the most dark) and other different gray 256 colors which are between white and black, so that the brightness function g(x, y) which represents gray degree, its range is [0, 255]. Then from the view of theory, we can use the image gray to calculate a scene illumination.

The Research of energy -saving technology based on visual inspection for classroom-lighting system in this paper makes illumination detection in the situation of writing on the blackboard model and studying model during the day. Due to the seat which next to window in the classroom, there will be more light, while the other position in the classroom may be relatively dark, this leads to the illumination in the classroom which is not uniform and can not make determinations on the classroom's brightness through calculating the average illumination of the classroom. So we use papermaking average illumination measurement in different regional to achieve better results.

In the above, dividing classroom into four regions and counting average gray value of the seating area in the classroom. After analyzing the different brightness of the classroom picture, we can conclude that: when the average gray value greater is than 180, the illumination will be sufficient, when it is far less than 180, the illumination will be insufficient.

4 Target Personal Segmentation Method

Target segmentation method can segment interested target from background through processing a single image or image sequence [8]. There are three common methods of moving target detection in the video image processing at present. Frame difference method, Background difference method, Optical flow method.Frame difference method can not detect correctly. Optical flow method needs a large amount of calculation and can't apply to process complex background. Because of its detection rate is so slower, it is very difficult to be used in real time detection of video surveillance. Background difference method is commonly used to extract moving object from static background [9]. Its fast calculation speed and good real-time performance are more suitable for classroom personnel detecting. So in this paper use real-time background updating background difference method for classroom personnel detection is the most appropriate.

In this paper, to realize the target personal segmentation, three steps, including background difference, background modeling, and the improved corrosion expansion algorithm were studied in this paper.

4.1 Background Difference Method

Heikkila and Silven give a simple mathematical expression for background difference method:

$$| \boldsymbol{I}_t(x, y)-\boldsymbol{B}_t(x, y)| > \tau \quad . \tag{3}$$

In the above mathematical formula: t is the moment t; It(x, y) is the moment t's image; Bt (x, y) is the background image; τ is the setting threshold. The target image is composed of the pixel whose background different values are greater than threshold. Background model updating usually use (4).

$$\mathbf{B}_{t+1} = \mathbf{B}_t + (\alpha_1(1-\mathbf{M}_t) + \alpha_2\mathbf{M}_t)\mathbf{D}_t \quad . \tag{4}$$

In the above mathematical formula: **B**t is the current gray value of the background; α_1 and α_2 is the changing background factors; $\mathbf{M_t}$ is the binary value of current moving target; $\mathbf{D_t}$ is the disparity value of the current frame and background's gray value.

It is the most appropriate to use background difference method for the lighting energy saving system in this paper. As for the background difference method, real-time updating background is a very important link which can prevent the background image to be suffered from the influence caused by light changing. So it is Necessary to establish an estimation model to update the background. Most of the background difference method is carried out in RGB color space. While RGB image's three components represent a same color, they will contact mutually and restrict each other. In addition,when the light changing happened in the same scene, the R, G, B value of the image will change too. Doing background differential calculation under this situation will produce unnecessary noise. Comparing with the RGB color space, HSV color space is not only in-depend on processing equipment but also more consistent with human perception of color. So in this paper we use background difference method which based on HSV color space to determine the foreground pixels and background pixels in the image of the classroom, which is to determine personnel region and background region.

Using F(x, y)={R,G,B}={H,S,V} to represent the each component value of the pixel (x, y) in the current frame image, B(x, y)={Rt,Gt,Bt}={Ht,St,Vt} to represent the each component value of the background pixel in the same position and D(x, y)={ΔR,ΔG,ΔB)to represent the background subtraction values of the position pixel. Judging background and foreground according to the relationship between the H and S component and the threshold. If it is the background pixel then assigning the value of the color white to the differential pixel otherwise assigning the differential pixel value as current frame pixel value. R, G, and B component values are utilized directly when assigning a value in order to reduce the amount of calculation and to display easily. The calculation formula is as follows:

The difference value of H component:

$$dH(x, y)=| H- H_t| \quad . \tag{5}$$

The difference value of S component:

$$dS(x, y)=| S-S_t| \quad . \tag{6}$$

The difference value of V component:

$$dV(x, y)=|V-V_t| \quad . \tag{7}$$

$$D(x, y) = \{\Delta R, \Delta G, \Delta B\} = \begin{cases} \{255,255,255\} & dH(x, y) < \tau_1 \text{ and } dS(x, y) < \tau_2 \\ \{R, G, B\} & \text{others} \end{cases} \quad . \tag{8}$$

In this paper, using HSV color space background difference algorithm to determine the foreground pixels and background pixels of the image, that is, to determine the classroom and classroom background region. At first, photos without people in the classroom were taken and used as the initial background images. Second, photos with people on the seats in the classroom were taken. By making subtraction on this image, the contour area of the target person can be obtained on the initial background images.

4.2 Background Modeling

Make background subtraction before does an image model of background estimation. At present, there are generally three types of background modeling method: Average background mode [10], Gauss background model [11], Code Book background mode [12] and so on. The average background mode is more applicable to the scene changes little. But it can not make very good estimations on the sudden changing illumination scene. The mixed gauss background modeling is a method which has a good processed affection, but is very sensitive to

the changes of light. Because it is very complexity, which leads to a large number of calculation and its processing speed is relatively slow. Codebook algorithm can deal with the scene which has moving object background or the illumination in it is changing. When the foreground color is very close to the background color, Codebook method is more sensitive than Gauss background modeling method.

After making an estimation on the background of the classroom environment which be studied in this paper, we can conclude that the classroom lighting will change slowly during the daytime while in the night the image of the classroom will be effected mostly by the lighting in the classroom because in the night the number of the people in the classroom, it controls the lights on or off. In this paper we use different segment methods during different periods based on this characteristic. Using Average background model in the daytime and Code Book background model in the nighttime.

4.3 Improve Corrosion and Expansion

The above processing will usually produce some isolated point and some unconnected or intermittent areas which are not in the target person area. These will cause a certain interference on the image which be processed. In the image processing field, there are some mathematical morphology operations, which can resolve the above problem. Such as Corrosion, it can eliminate some irrelevant details in the image and Expansion can make the discontinuity crack in the image getting together. Corrosion and Expansion are very simple and effective but the image which is processed by them will become binary image. This paper needs color image of target person instead of the binary image. So we improve a method which can denoise color image according to the erosion and expansion techniques. This improved method when processing the background difference image not only removing the unnecessary parts in the image but also making the target person area be segmented more connectivity and retain the original image color information.

Expansion method which be improved for color all-around in this paper was based on the corrosion expansion algorithm. In this paper, the background of the target person image which is segmented is set as white. That is R=255, G=255, B=255. Making the target person area in the image is colorful. That is R≠255 & G≠255& B≠255.

The color expansion method is: first, making S shift to someplace in the colorful image x, if the corresponding position of all elements of the S within the X is not white. Recording the position where the origin of S in X and assigning it (i, j). This position may have white pixels (they are the yellow points which we want to deal with). Second, finding the summation average of the pixels' RGB value which are the corresponding position in x of the elements in the S (this paper have five elements). Assigning the summation average of the RGB value to the position (i, j) in the target image Y. At last, assigning the pixels which meet the above situation to Y, and those pixels which do not meet the situation will be assigned by white. Through the above three steps can obtain color image which was processed by color all-round expansion method.

The color erosion method is: first, shifting S someplace in the color image X, if the corresponding positions of all elements of the S within the X are not white, recording the position where the origin of S in X and assigning it (i, j). Second, we assign the RGB value of this position in the original image X to the corresponding position in the target image Y. Last, assigning the pixels which meet the above situation to Y, and those pixels which do not meet the situation will be assigned by white. Through the above three steps, we can obtain color image which was processed by color all-round corrosion method.

5 Detection Technology of Classroom Personnel

After above pre-processing in this paper, we can not only segment target personnel in the classroom image but also retain the appearance of the personnel in the original and real-time image. In this paper, using the personnel head color information (hair and skin's color) in the colorful image and an improved connected labeling algorithm are presented to detect the target personnel in the classroom.

There are mainly two methods in making person-face-skin model [13]. One method is based on statistics and another is based on physics. While skin color model based on statistics which can be divided into two kinds. One kind is based on static and another is based on dynamic [14]. The several types of commonly used static skin color model are: Determining the color threshold method, the single Gauss model, Gauss mixture model and ellipse model [15]. And dynamic skin model has two kinds of methods. One is used for sequences image which can make image adapt to the change of time. The other one kind can adjust the parameter of skin color model in order to make it compatible with a static image [16]. Chai and other researchers [17] find the skin color range in the YCbCr color space through experiments. The skin color range was shown in the formula (9). In HSV and TSL color space: there are also some researchers who have found the skin color range. They were shown in the formula (10) and formula (11):

$$85 < Cb < 135, 135 < Cr < 180, Y > 80 \ . \quad (9)$$

$$0 < \mathrm{H} < 50,\ 0.23 < \mathrm{S} < 0.68,\ \mathrm{H} = [0,360],\ \mathrm{S} = [0,1] \quad (10)$$

.

$$0.4 < T < 0.6,\ 0.038 < S < 0.25,\ L > 80 \ . \quad (11)$$

YCBCr color space has a good performance in skin color detection comparing with the above several spatial modeling methods. First, the calculation of YCbCr is relatively simple. Second, skin color has better clustering in YCbCr space. So this paper selects the YCbCr color space's elliptical model to make detection on skin.

For hair modeling, this paper takes lots of face images, extracts the YCbCr values of the hair region. Through analyzing the experimental results, we can conclude that the verdict scope of the person hair area in YCbCr color space:

$$Cr \in [124,140], Cb \in [123,139], Y < 40 \ . \quad (12)$$

After making model we need to make marks on hair and skin. Anil K Jain and another researcher choose 853571 skin color pixels from the HHI image database and drew in the YCbCr color space. Then they found that the skin color clustering is similar to the spindle shape and along the Y axis different Y values have different cluster range and show two pointed state. So we must consider Y axial direction, making nonlinear segment color transformation on color space. After transformation we found that skin color was clustering in YCbCr space. Then projecting it onto Cb'-Cr', we got a skin color region which similar to the elliptical shape and can be shown in the formula as below:

$$\frac{(x-ecx)^2}{a^2} + \frac{(y-ecy)^2}{b^2} = 1 \ \text{Among them} \begin{bmatrix} \mathrm{x} \\ \mathrm{y} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\ \theta & \cos\theta \end{bmatrix} \begin{bmatrix} C_{\mathrm{b}}^{'} - \mathrm{cx} \\ C_{\mathrm{r}}^{'} - \mathrm{cy} \end{bmatrix} \quad . \quad (13)$$

In the above formula: The long axis value of the elliptical was be assigned by a and the short axis value of the elliptical was be assigned by b(if a>b); x, y are respective coordinate values of the pixel. The Constant values are as below:

$$cx = 109.38, cy = 152.02, \theta = 2.53, ecx = 1.60,\ ecy = 2.41, a = 25.39, b = 14.03 \ . \quad (14)$$

The policy decision of the face skin color is: if the coordinate values (Cr, Cb) of the pixel are in the elliptic inner, then making the decision that the pixels are the skin's pixels. Otherwise the pixels are not the skin's pixels. We Mark skin and hair according to the skin color model and the threshold range of the hair area. We Mark the skin in red, the hair in blue and the background in whiter.

We make an improvement on the traditional binary image after acquiring the red -blue-white "three values" image. Different from the traditional marking method, the improved marking method in this paper must include not only the connectivity area values which it belong to but also contain the pixels value which belongs to the hair area or the skin area. So the marking value is composed of two parts, one part is the marking values of the connectivity area and another part marking values represent the pixels, which is marked red or blue. By scanning the image, we can acquire the index value of the pixel (1 represents red and 2 represents blue). And the two parts which are marked can be determined by the index value of the pixel. The first part of the improved marketing method makes an improvement on the traditional marking method. This improved marking method scans the image in right-to-left, top to bottom order. If the pixel which be scanned is white then assigning he connected marking value to be 0. Then we scan the next pixel. If the pixel is blue (possibly hair pixels), discussing respectively into the following situations:

①Making judges on the left and top pixels in the image, if both the pixel and connects marking values are the same, then assigning the pixel as the same mark.

②If the left and top pixels are all blue and connected marking values are not the same, then we assign the pixel as same as one of the mark and making a mark that represent the pixel and the making are equal.

③If the left and top pixels are all white, assigning new connected marking value to be the pixel.

④If the pixel's top pixel is red; no matter what color the left pixel has the pixel is endowed with new connected marking value.

⑤If the pixel's left pixel is red and top pixel is blue. If they have the same connected marking then endowing this pixel the same connected marking. If they do not have the same connected marking then endowing this pixel the same connected marking with the blue pixel.

If the pixel is red pixel, we also discuss in several cases. The ①②③ cases are similar to the case ④:

①Making judgment on the left and top pixel, if they are all red and have the same connected marking value then assign the the same mark to the pixel.

②If the left pixel and top pixel are all in red and do not have the same connected marking value then assigning the pixel as same as one of the mark and making a mark that represent the pixel and the making are equal.

③If the left pixel and top pixel are all in white then assigning new connected marking value to the pixel.

④If the top and left pixel are all blue and have the same mark, assigning this pixel the same mark. If the top and left pixel are all blue but don't have the same mark assigning this pixel the top pixel's connected marking value.

⑤If the left pixel is blue and the top pixel is red then assigning the red pixel's connected marking value to the pixel.

After the first scanning, we can classify the same marking into the equivalence group and make different marks on each equivalence group. Then making the second scanning, using the marks which belongs to the equivalence group to replace the mark in the first scanning image. Which be judged as the head should meet: The same connected area, the red area and blue area in this connected area must meet certain scope and proportion. Usually we consider the proportion of personnel look-down and look-up two kinds of situation. Then we can acquire the determinant formula:

$$\frac{1}{4} \le \frac{\mathrm{S(hair)}}{S(skin)} \le 4 \text{ , and } \mathrm{S(hair)} \ge \alpha, \mathrm{S(kin)} \ge \beta \ . \quad (15)$$

In the formula (15), $\mathrm{S}(hair)$ represents the blue area in the same connected region, $\mathrm{S}(skin)$ represents the red area in the same connected. α and β are Constants.

At last, the statistics of the number of connected region which meets the above formula is the number of person detected in the classroom image.

6 Experiment Results

As shown in Fig. 1, it is an image of empty classrooms; Fig. 2 shows the histogram of many pixels in classroom image and based on this picture to roughly mark the seat sections then showing the marking result in Fig. 3. After making the rough mark, we use projection method to make precise mark. The level projection and vertical projection were shown in Fig. 4 and Fig. 5. Through the precise mark we can acquire the precise delineation of seat sections in the Fig. 6. When there are some people studying in the classroom as shown in Fig. 7, the system which be studied in this paper will make a distinction between people and the background by using Background subtraction in HSV space. Fig. 8 shows the result which be made Background subtraction in HSV space. In Fig. 8 there are some noises in the picture. Then improved erosion and expansion techniques are used for denoising color image, which has preserved color information. The result was shown in Fig. 9. At last marking skin and hair, the marking result was shown in Fig. 10. Taking the situation that black clothes may be seen as hair pixels and will be marked in the same connected labeling with its front and behind people face into consideration. This people improves connected labeling algorithm to realize statistics on the number of people. The experiment results in Fig. 11 show that the improved connected labeling algorithm of human detection in the paper has a higher detection rate.

Fig. 1. The image of empty classroom

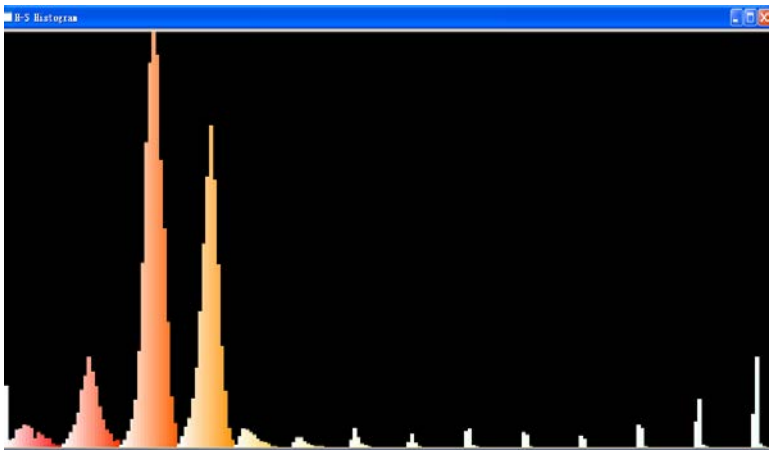

Fig. 2. Histogram of many pixels classroom image

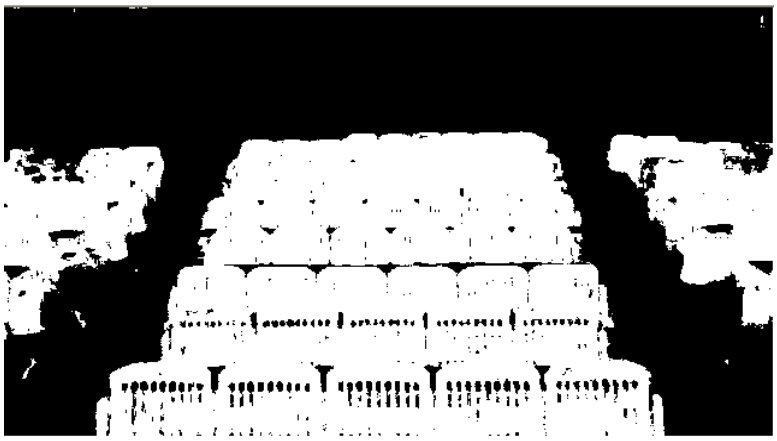

Fig. 3. Seat sections roughly marked

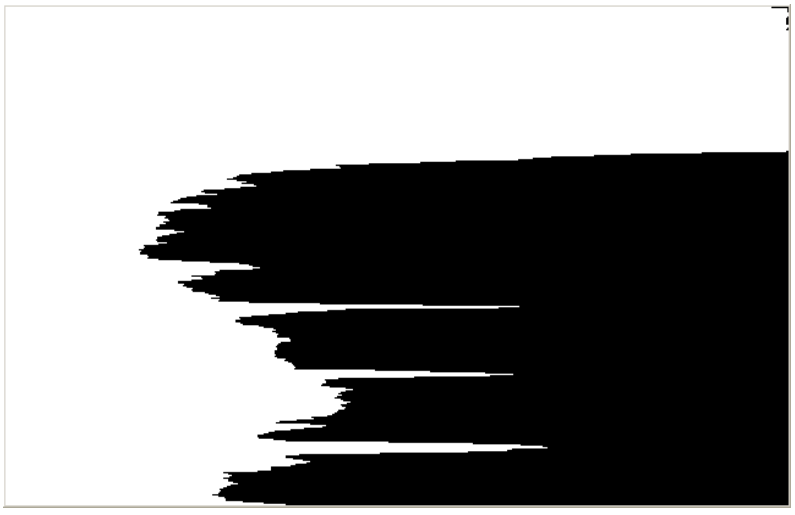

Fig. 4. Level projection of marked image

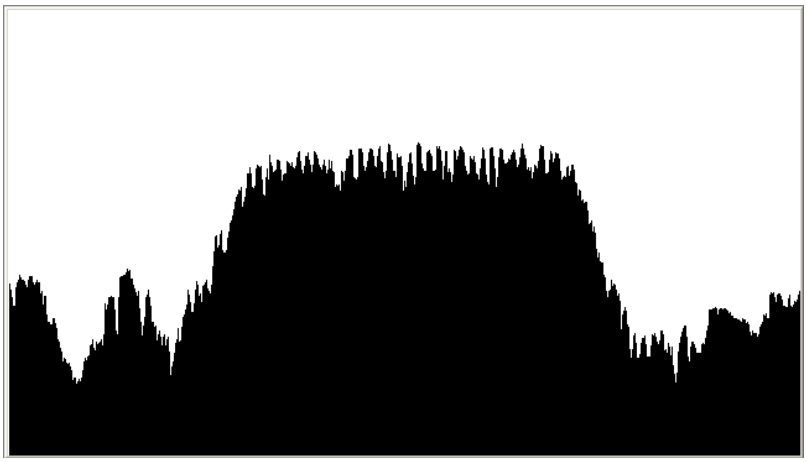

Fig. 5. Vertical projection of marked image

Fig. 6. Precise delineation of seat sections

Fig. 7. Real time image

Fig. 8. Background subtraction in HSV space

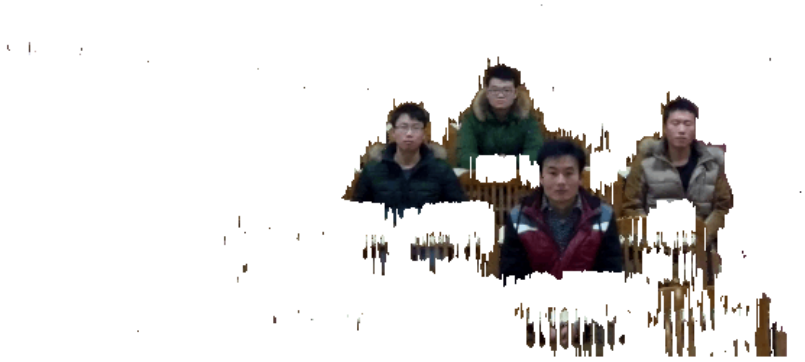

Fig. 9. Erosion and Dilation of global color image

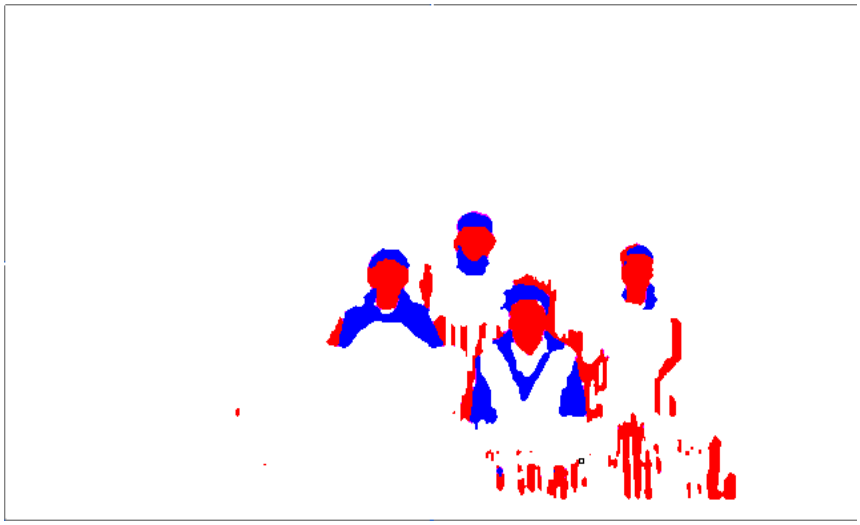

Fig. 10. Marked skin and hair

Fig. 11. Human Detection and people counting

From Fig. 11, the data in Table 1 can be obtained. From the result we can conclude that the system studied in this paper have a higher detection correct rate.

Table 1. Detection results

The actual number of person in image	The number of person which be detected	The number of person which be mis-detected	The number of person which not be detected	The correct detection rate (%)
four	four	zero	zero	one- hundred

In order to further illustrate that the system which studied in this paper has better applicability and accuracy than the traditional face detection system, we have made some contrast experiments. We collect classroom image samples with different number of people in order to make detecting experiment. We use the Harr classifier and the method which be studied in this paper to make detection respectively. After comparing the different detecting result we can acquire the data in Table 2 and Table 3.

Table 2. Detection results of face image using Haar classifier

The actual number of person in image	The number of person which be detected	The number of person which be mis-detected	The number of person which not be detected	The correct detection rate (%)
four	four	zero	zero	one- hundred
ten	nine	zero	two	ninety
twenty-two	twenty	one	three	eighty-six
forty-three	forty	two	five	seventy-nine

Table 3. Detection results of face image using the method in this paper

The actual number of person in image	The number of person which be detected	The number of person which be mis-detected	The number of person which not be detected	The correct detection rate (%)
four	four	zero	zero	one- hundred
ten	nine	zero	two	one- hundred
twenty-two	twenty-two	one	one	ninety-five
forty-three	forty-two	two	three	ninety-three

The experiments prove that the Haar classifier and the classifier method which be studied in this paper both have better effect of front face detection. But for some special face posture in the image, such as bow face or the face been partially occluded, the method studied in this paper will defect more directly than Haar. The contrast data between using Haar and the classifier method which be studied in this paper to detect of human with special face posture were shown in Table 4.

Table 4. Contrast data between using Haar and the classifier method which be studied in this paper to detect of human under special position

Detection method	The actual number of person with special face posture	The number of person which be detected
Haar classifier method	eleven	five
Classifier method which be studied in this paper	eleven	ten

From Table 4, we can know that Haar classifier method has precise result in detecting the front face but has bad performance in other special face posture. And in order to ensure the detection result, the Haar classifier method needs to collect many positive and negative samples, It will takes a lot of time to train samples. While the method which be studied in this paper has more accurate result when detecting the special face posture than Harrier. So it is more suitable to detect people and count the number of the people in the classroom.

7 Conclusion

In this paper first, we analyze the significance of realizing the classroom-lighting energy-saving system based on visual inspection according to the domestic and foreign present research situation of classroom -lighting energy-saving. Then making deep research on the visual detection method which be used in classroom lighting energy saving based on the theories of computer vision, pattern recognition and digital image processing. At last, realizing the visual detection methods which be used in the classroom- lighting energy-saving system in VC++6.0 platform and acquiring the result image. Through experiments, we can conclude that the energy saving system which was researched in this paper can be used for classroom lighting energy saving.

The system based on visual inspection for classroom energy-saving which is studied in this paper has a strong practical value. At present, the vast most colleges and universities are also used the artificial classroom lighting control. Because of the not enough artificial custody and students' less awareness of energy conservation, there is always classroom lighting electricity waste. According to rough statistics, if a school only wastes 2 hours of electricity per day during the nine months per year of electricity using time and there are 30,000 lights, each with a power of 36 W, then nearly 60 million Kilowatt-hours electricity will be wasted one year. If the system studied in this paper can be used to major colleges and universities, it may transform the schools' energy settings, improve the utilization rate of energy, achieve the purpose of energy saving and emission reduction, save money for the school and bring great economic benefits.

Although in this paper we make some achievements on the classroom lighting energy saving based on visual detection method, there are still some deficiencies which can be improved in the future. Such as:

(1) The system studied in this paper is in need of image processing on the classroom monitoring image. Considering that there is a relationship between the distance from staff to the camera and the size of person, when detect person, we can use this relationship to estimate personnel area. In the future, we can acquire more accurate person detection method based on this system.

(2) When using connected area marking algorithm for person detection in which the person is kept out before and after, it can not detect accurately. So in the future we should do further research on this problem.

Acknowledgment

We would like to express our gratitude thanks to the Shenyang Ligong University for their invaluable suggestions to improve this paper.

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