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A Computationally Efficient Bad Posture Detection Method to Alert Computer Users in Real Time

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Abstract

These days lot of people spend long hours at a computer, so they face lot of health issues because of wrong sitting postures. Good posture is crucial for human well-being. A vision-based system is proposed to minimize the poor ergonomic practices among computer users. It can be installed in the corresponding user computer, and it runs with low computation burden. The proposed system is based on image comparison with a reference image. The reference image is an image, that the user utilizing their webcam or computer camera to capture themselves in the correct seated posture. Initially it has been a converted into grayscale and applied a Gaussian filter before store in the memory. After making the reference image, the proposed system is stared to capture user's image at a free defined frequency. The captured user's image is filtered and converted to a binary image using a predefined threshold. After that, two parallel processes are applied to same resultant image to identify the moment of left and right side and bending of forward and backward. The decision of both processes has been estimated by comparing the calculated black-to-white pixel ratio with a predefined threshold. The notification has been generated via a pop-up message on corresponding computer screen. To test the effectiveness, the proposed system has been implemented on a laptop computer in a Python environment with the support of OpenCV library. The test has been conducted of four different bad postures such as over leaning to the right angle, left angle, forward and backward postures with 150 attempts. The test results shows that it has high potential to identify the bad postures of computer uses.

Keywords: Poor ergonomic practices; Image comparison; Gaussian filter; Binary image; Black-to-white pixel ratio

Introduction

As technology becomes more common, the screen time in front of computer is increased, often for long stretches. But we often forget to sit properly, which can cause health problems (Occupational Safety and Health Administration, n.d.). Mainly it is required to give attention for, four main bad postures such as over leaning to the right angle, left angle, forward and backward postures throughout this research. There are some tools that can stop the bad posture in real-time, but they can be a hassle, interrupting the work. Hence the identification of the bad posture of the screen user by a simpler tool is more essential. In order to provide a solution, a vision-based bad posture detection mechanism, which can be installed on computer enabling low computational burden

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is proposed. It can identify bad postures and notify to the user to sit better. As a result, the proposed system can mitigate health issues associated with poor posture during computer use, without the need for specialized hardware.

According to the existing systems, a human action recognition approach firstly converts human action videos into a series of 2D image frames and those image frames then prepossessed, and features are extracted from them. The features are then classified using a K-Nearest Neighbour's (KNN) classifier as well as this research uses Kernel Principal Component Analysis (KPCA) to identify image features and combined features (Anitha, 2020). This research compares two algorithms were implemented using Open CV on an embedded platform and evaluated on a dataset of 2850 images. According to the research Histogram of Oriented Gradients algorithm was accurate than Haar-like feature algorithm for detecting human presence in image. (Padmavathi, 2019) Then another system, using the Microsoft Kinect sensor, develop an automatically detect risky postures during human work activities as well as tested the system on a pick and place task, where three people moved cardboard boxes from a bookcase. The system was able to detect risky postures with an accuracy of 93 percentage, after a slight relaxation of the detection criteria (Rocha-Ibarra, 2021). In the aforementioned research, machine learning and human identification were utilized. However, the proposed system utilized a low-complexity approach using image processing, specifically employing binarization techniques. The mechanism captures user images and converts them to binary images before proceeding with processing. Here, we solely rely on OpenCV image processing without employing machine learning, unlike the comparison research. We prioritized real-time responsiveness and low computational demands, ensuring the system remains practical even for users with standard computing resources. This simplified, non-machine learning approach also enhances ease of implementation and maintenance.

The approach presented in this report involves utilizing the computer's camera for identifying ergonomic factors, thereby facilitating the development of a program with simplified resources. The proposal is to construct a system to detect poor posture in computer users and send notifications according to the sitting posture using a user-defined frequency. According to the achievement, the detection of incorrect posture during computer usage is successful. In this scenario, it is assumed that there are no objects in the background and the laptop screen is perpendicular to the tabletop. Under these conditions, alerted the user to correct their posture.

Materials and Methods

The proposed system is a vision-based system that can be installed on the corresponding user computer, and it uses the camera attached to the computer. The notification is displayed on the same computer screen. The block diagram of the proposed system is shown in figure 1. The proposed system is based on image comparison with a reference image. The reference image is an image, that the user utilizing their webcam or computer camera to capture themselves in the correct seated posture with white background as shown in figure 2(a), and the corresponding image is called as "template image" hereafter. Initially, the template image has been a converted into grayscale and applied a Gaussian filter to minimize the noises as shown in the figure 2(b). Then the filtered image is converted into a binary image using a predefined threshold as shown in figure 2(c) before store in the memory.

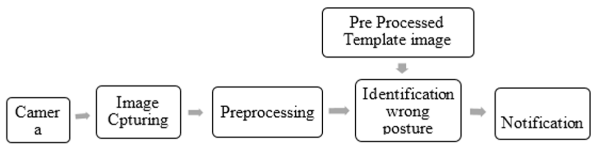

Figure 1. Block diagram of proposed system

After making template image, the proposed system is started to capture user's image at a free defined frequency. These captured images are called as the "target images" hereafter. One of the captured target images is shown in Figure 3(a).

Figure 2. a) Template image, b) Gray scale conversion and Gaussian filter applied, c) binary image

The target image has been converted to grayscale and a Gaussian filter has been applied to minimize the noises in the captured target image. The resultant image is shown in figure 3(b). Then, the filtered image is converted to a binary image using a predefined threshold value, as shown in figure 3(c) to minimize the processing power compared to grayscale pictures and makes.

Figure 3. a) Target image, b) Gray scale conversion and Gaussian filter applied, c) binary image

After applying the pre-processing, the two parallel processes are applied to the resultant image for detecting the poses of the target image. They are, identification of the movement of left and right-sides, and identification of bending forward and backward.

Identification of the Movement of Left and Right-Side

It is targeted to identify the head moment of the user in to left side to right side. In this process, the resultant target image is conditionally subtracted from the pre-processed template image as describe in Equation (1). The resultant image is shown in figure 4.

$$Intermediate\ Difference\ Image\ (x,y) = \{1 \quad |preprocessed\ template\ image\ (x,y) - preprocessed\ target\ image\ (x,y) > 0\ 0 \quad Otherwise \qquad \text{(Eq.01)}$$

Figure 4. a) Pre-processed template image, b) Pre-processed target image, c) Resultant *image*

The estimation of the poses of the target image of the corresponding process is done by comparing with predefined threshold. For the ideal situations, the threshold should be zero, but in the real situations it is greater than zero due to small variation in the background and random errors in the captured image. The threshold is estimated by trial-and-error method.

Identification of Bending Forward and Backward

In this process, both pre-processed template and target images are divided into two sections from the horizontal centreline, as shown in figure 5. Then calculate number of total pixels and the white pixels in the upper half of image sections of both pre-processed temple and target images and calculate the pixel percentage as describe in Eq. 02.

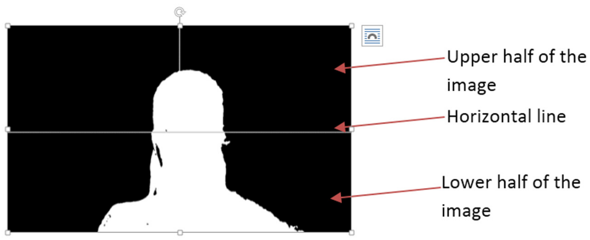

Figure 5. Separated image from the horizontal centreline

$$\text{White pixel percentage in the upper half of the images} = \frac{Total\ Number\ of\ white\ pixel\ in\ upper\ half\ of\ the\ image}{Total\ number\ of\ pixel\ in\ the\ upper\ half\ of\ the\ image} \qquad \text{(Eq.02)}$$

After that, the difference between white pixel percentages of both target and temple images is compared with predefined threshold to estimate the poses of the target image. For the ideal situations, the threshold should be zero, but in the real situations it is greater than zero due to small variation in the background and random errors in the captured image. Therefore, threshold is estimated by trial-and-error method.

Estimate the Poses of the Target Image

To generate poses of the target, the outputs of both identification process are combined and generate the notification either identification process of moment of left and right or identification process of bending of forward or backward. The notification generated the system is shown in figure 6.

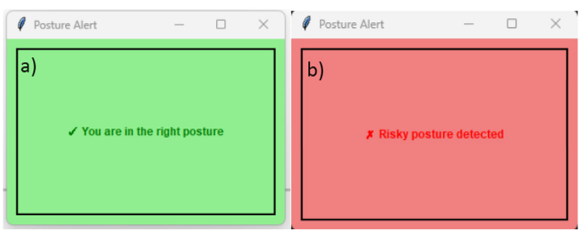

Figure 6. a) Notification from the system indicating correct posture, (b) Notification from the system indicating risky posture.

Results and Discussion

To test the effectiveness of the proposed system, 150 test sample images are used. The selected sample images are shown in figure 7 and the prosed system algorithm was implemented in a Python environment with the support of OpenCV library.

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Figure 7. a) Over leaning to the right angle, b) Over leaning to the left angle, c) Over leaning to forward, d) Over leaning to backward postures

During testing, the test images are converted into binary format using a pre-determined threshold value, typically ranging between 180 to 200, determined through numerous experiments. This "trial-and-error" approach involved repeatedly testing different threshold values to observe which range most effectively. The 150 images converting them to binary images using threshold values between 180 and 200, the success rate was 90.67%. The remaining images had thresholds near 180 but not within this specific range.

Under the identification process of the Movement of Left and Right-Side, the algorithm checks the percentage of white pixels in the result image as shown in Figure 4c. For correct posture, white pixel percentage should be 0-1%. Once this percentage range is not met, a notification is sent. During testing, out of 20 images depicting correct posture, the mechanism correctly identified only 16 as right posture, categorizing the remaining 4 as incorrect posture. However, during testing with 65 images depicting incorrect posture, all of them received correct notifications.

Table 1. Table of results for the Identification process of the Movement of Left and Right-Side

Image Type	Total number of Images tested	Number of images that correctly identified	Percentage
The computer user having correct posture	20	16	80%
The computer user having wrong posture	65	65	100%

Under identification process of Bending Forward and Backward, the calculated the threshold value by experimenting the white pixel variation of template image. The template image threshold value is 0.4. When the experimental time, tested with same 20 template images and 65 target images. The results showed 100% correctness for the template images and 96% correctness for the target images, as shown in Table. 2.

Table 2. Table of results for the identification process of Bending Forward and Backward

Image Type	Total images tested	Number of images that correctly identified	Percentage
The computer user having correct posture	20	20	100%
The computer user having wrong posture	65	63	96.92%

When combining the above two processes, users can receive alerts indicating whether their sitting posture is correct or not. In the experiment, the left and right-angle movement positions were identified, yielding more accurate results compared to the identification process of bending forward and backward. These results are shown in Table 3. When comparing these results, the overall system accuracy is 96%.

Table 3. Table of percentages of result combining two processes

Total images tested	Number of images that correctly identified	Accuracy
150	144	96%

Conclusion

In the modern world, humans frequently adopt bad postures while sitting in front of computers. To address this issue, we have developed an algorithm to effectively detect these bad postures while ensuring a less complex and computationally efficient framework. However, relying on capturing a template image in the correct pose presents practical limitations, particularly in obtaining the target image after the noise filtering process and extracting the contrast of the images. By employing image comparison techniques and real-time feedback mechanisms, the system offers a potential solution to address poor ergonomic practices among computer users. Through testing, the developed vision-based system has shown good results in correctly identifying and addressing bad postures. Based on these results, Future work will focus on improving the system's adaptability to different backgrounds and lighting conditions. Implementing a background removal function allows the system to work with any background, eliminating the need for a white background.

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