Sitting Posture Assessment using Computer Vision

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***Abstract*— Since most people usually sit most of the time nowadays because of the modern lifestyle, proper sitting posture must be exhibited so that postural abnormalities can be avoided. In order to see how proper the posture is, posture assessment is usually done by measuring the sitting parameters defining the sitting position which are the thoracic angle [TA], cervical angle [CA], retraction angle [RA], sitting height [SH], sitting eye height [SEH], sitting shoulder height [SSH], shoulder breadth [SB], hip breadth [HB], buttock-popliteal height [BPH], and the popliteal height [PH]. These sitting parameters can be measured through different methods, namely: the plumbline method, which is usually done by physical therapists; using goniometers; using accelerometers; the radiographic method; and the pressure distribution analysis through pressure sensor on a chair. However, these methods do not able to measure all the sitting parameters mentioned. Thus, there is a need to develop an algorithm that can measure and assess the parameters mentioned, which can serve as assistance for the physical therapist for posture correction. In this paper, the researchers present a method of obtaining sitting posture parameters and assess it through the use of Computer Vision in order to be used as an assistance for physical therapists in their sitting posture assessment and correction. With 42 samples, the proposed algorithm gave an accuracy of 61.9% in assessing sitting posture.**

Index Terms- ***Sitting Posture, Computer Vision, Sitting posture Parameters***

I. INTRODUCTION

Sometimes, sitting for a long period of time causes back pain. The reason behind is that people do not maintain their proper sitting posture for a long period of time. Thus, postural assessment will help in correcting bad sitting posture to prevent posture abnormalities. Inappropriate sitting posture can result to musculoskeletal diseases such as lumbago, forward head posture syndrome and cervical disk. Bad sitting posture is usually accompanied by pains in muscle and connective tissues of tendons, ligaments and joint capsules [1]. For the physical therapists to assess posture, certain parameters are needed to be considered and measured. These sitting parameters are the thoracic angle [TA], cervical angle [CA] , retraction angle [RA],sitting height [SH], sitting eye height [SEH], sitting shoulder height [SSH], shoulder breadth [SB], hip breadth [HB], buttock-popliteal height [BPH], and the popliteal height [PH].

Considerable methods have been available on detecting and correcting the sitting posture. These methods include the use of plumbline [2], the analysis of tilt angles through the use of accelerometer [3][4], postural assessment through radiographic method [5][6], and analysis of pressure distributions obtained from a mat with a pressure sensor on a chair [7]. However, each method does not measure all the sitting parameters presented. Thus, the need to develop an algorithm that can measure all the parameters and assess it is needed for the purpose of assisting physical therapists in their postural analysis.

In this paper, the researchers present a method of obtaining and assessing sitting posture through Computer Vision. The main objective of this study is to develop an algorithm measuring and assessing the sitting parameters in order to be used as an assistance for physical therapists in their sitting posture assessment and correction. To obtain the contours of the person a method of background subtraction has been applied to the images obtained. The contour would be achieved through successively application of the Prewitt edge detection and through Freeman chain coding. With 42 samples, the proposed algorithm gave an accuracy of 61.9% in assessing sitting posture.

II. METHODOLOGY

In this study, the researchers developed a working software that measures and assesses the sitting posture parameters that can assist physical therapists in giving a proper treatment for the patient regarding sitting balance. This section consists of the following: Data Acquisition, Background Subtraction, Freeman Chain Code and Feature Extraction.

A. Data Acquisition

Thirty-three (42) study volunteers were participated in the study. The participants comprise of 24 males and 18 females ranging from 16-24 years old. Eligible study volunteers were healthy male and female subjects. People were excluded if they experienced any musculoskeletal pain/illness or have early stage of osteoporosis and scoliosis. The participants were asked to sit in his/her preferred manner in front of the camera. For all the tests, the cameras (A4Tech PK-635M webcam) used are 360 cm away from the seat.

Written informed consent was obtained from all participating study volunteers and authors declare right to confidentiality of data and to privacy. The information

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questionnaire includes the basic information about the study and the role of the study volunteers. It is accomplished before taking their photograph. Basic information like name, age, gender, occupation and contact details are to be filled up by the study volunteers. While for the body mass index and sitting measurements are acquired by the aid of a length measuring device and a weighing scale. A signature is sealed by the study volunteer to indicate their consent to use their information and photograph in the study.

The study volunteers are using black clothes, headgear, and leggings for fitting which are required for test results. When shooting the subject volunteers, they need to sit erect with flat foot on the ground, legs are apart from each other, hands on the lap and sit comfortably for both front and side view.

The study is conducted at a controlled environment with proper lighting. The gathering of data must be in private and comfortable for the study volunteers. Persons with no written information consent will be restricted before and after the data gathering. Only authorized personnel including the authors and licensed or registered physical therapist may enter to the area of conducting the study.

Two cameras will be involved in the experimental setup. One camera will be allotted for the frontal view of the study volunteer while another camera will be assigned for the sagittal view and a chair adjusting to different heights.

In Figures 1 and 2, it shows the experimental set-up while obtaining the images. The camera is 80 cm above the ground and 360 cm away from seat of study volunteer. There are two camera used in order to obtain the needed parameters. One was placed from the side and one in front, both 360 cm away from the study volunteer.

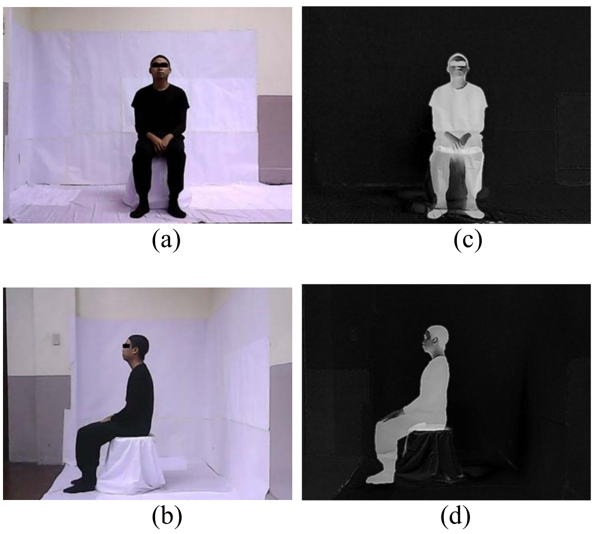

Fig. 1 (a) Front view &(b) Side view of the set-up,(c) Front view and (d) Side View of Foreground Image using Background Subtraction

In the experimental setup figure 1.a and figure 1.b, a controlled environment and surroundings is needed. Based on continuous trial for an effective feature extraction, white surrounding is needed within the area of the study volunteer. Shadows are avoided as it gives off dark color and it shows up after background subtraction. White background and a chair covered by white cloth is used as they are to be subtracted in the background subtraction.

B. Background Subtraction

Background subtraction is a commonly used approach to distinguish objects, especially of moving objects in a video, from a static camera [8]. In the method to be used, after the image acquisition, background subtraction would be done to the image. Image's foreground would be extracted which would be processed and examine to obtain needed parameters.

The background subtraction code is used to detect the silhouette of the study volunteers for pre-processing of image. The image is captured 640 x420 pixels for both front and side view. Another mage is also captured for the background without the study volunteers. Both RGB images are converted into gray images for the process.

In this figure 1.c and figure 1.d, the image (I) is represented as the front or side view image and image (B) is the background view. The background image is then subtracted to the image of the person exhibiting sitting posture. During the image subtraction, the value of the image must be absolute as (J). There must be no negative image subtraction because an error on MATLAB may occur. The global image threshold is used in considering the conversion of the foreground to binary image having values of 0 and 255 per pixel. 2-D adaptive noise and median filter were used to further eliminate the noise. The gaps in the silhouette are filled and Prewitt edge detection is used.

The silhouette of the side view of the subject is extracted, after that Prewitt edge detection is successively applied to locate the silhouettes of human body. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be "fooled" by noise, and more likely to detect true weak edges. The standard of using the edge detection must be a two single pixels with no less than two pixels neighbor around it. Otherwise, the detection of pixel is difficult for the consecutive processing of images. For such a good criterion for Prewitt edge detection are good detection which optimal detector must minimize the probability of false positives as well as the false negatives of the image from the background subtraction of the image previously; and good localization of edges detected must be as close as possible to the true edges. Likewise, the detector must return on point only for each edge point and the quality of the edge detected must be robustness to noise, localization, and the response of the pixel detected.

(a) (b)

Fig. 2 (a) Front view and (b) Side view of Foreground Image using Edge Detection

C. Freeman Chain Code

In Freeman chain coding, the pixel is to be assigned values of 0, 1, 2, 3, 4, 5, 6 and 7 if the next pixel is located to the right, up to the right, due north, up to the left, to the left, down to the left, due south, and down to the right, respectively. For the first pixel, the only allowable values are 0, 7, 6, 2 and 1 in order to introduce a clockwise motion for the pixels. The variable B stores the corresponding Freeman chain codes. XX and YY store the abscissas and ordinates of the pixels of the edge. Once the chain code has been assigned to the pixel, the next value of the abscissa and the ordinate will be the coordinates of the next pixel [9].

Chain code = 0: $dx = +1, dy = 0$ (1)
Chain code = 1: $dx = +1, dy = -1$ (2)
Chain code = 2: $dx = 0, dy = -1$ (3)
Chain code = 3 $dx = -1, dy = -1$ (4)
Chain code = 4: $dx = -1, dy = 0$ (5)
Chain code = 5: $dx = -1, dy = +1$ (6)
Chain code = 6: $dx = 0, dy = +1$ (7)
Chain code = 7: $dx = +1, dy = +1$ (8)

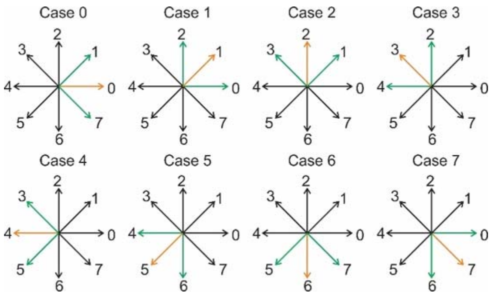

Fig. 3 Chain code with assigned values from 0 to 7

If the previous chain code is equal to zero, then the chain code of the current pixel should not be equal to 4 in order to avoid infinite loops. If the previous chain code is equal to 1, then the chain code of the current pixel should not be equal to 5 in order to avoid infinite loops. If the previous chain code is equal to 2, then the chain code of the current pixel should not be equal to 6 in order to avoid infinite loops. If the previous chain code is equal to 3, then the chain code of the current pixel should not be equal to 7 in order to avoid infinite loops. If the previous chain code is equal to 4, then the chain code of the current pixel should not be equal to 0 in order to avoid infinite loops. If the previous chain code is equal to 5, then the chain code of the current pixel should not be equal to 1 in order to avoid infinite loops. If the previous chain code is equal to 6, then the chain code of the current pixel should not be equal to 2 in order to avoid infinite loops. If the previous chain code is equal to 7, then the chain code of the current pixel should not be equal to 3 in order to avoid infinite loops.

D. Feature Extraction

In extracting the features, an array is formed to apply the chain codes in a single code. The position of the chain code in the image is tracked. The pixels are considered as a feature by satisfying these conditions:

$$d_2 - d_1 = -1 \; and \; d_2 - d_3 = 1 \quad (9)$$
$$d_2 - d_1 = 1 \; and \; d_2 - d_3 = -1 \quad (10)$$
$$d_2 - d_1 = -1 \; and \; d_2 - d_3 = -7 \quad (11)$$
$$d_2 - d_1 = -7 \; and \; d_2 - d_3 = -1 \quad (12)$$
$$d_2 - d_1 = 1 \; and \; d_2 - d_3 = 7 \quad (13)$$
$$d_2 - d_1 = 7 \; and \; d_2 - d_3 = 1 \quad (14)$$
$$|d_2 - d_1| = 2 \quad (15)$$

d_1, d_2, and d_3 are the previous number, present number and future number of array B, in which the reduced Freeman chain code is stored. If any of the conditions mentioned were satisfied, then the starting pixel of d_2 is a feature of the foreground.

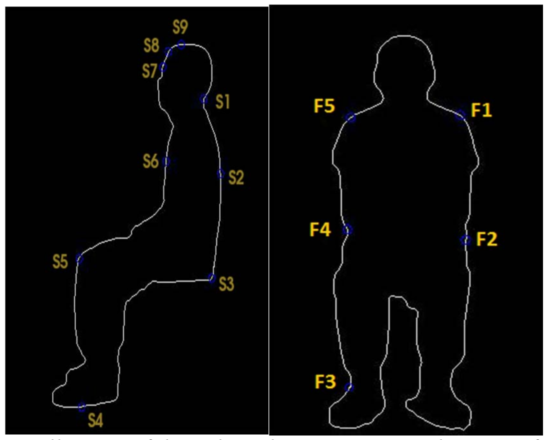

Fig. 4 Silhouette of the Side and Front Image with its significant feature points

Figure 4 shows the silhouettes and the significant feature points from the front and side images obtained. Through this feature points, the sitting posture parameters would be derived. These parameters include:

a) Thoracic Angle – it is the angle between the line of spine and manubrium.

b) Cervical Angle – it is the line of tragus of the ear and the line horizontal to the spine
c) Retraction Angle- the angle between the midpoint of the humerus and spine.
d) Popliteal Height- Euclidian distance from the floor to the underside of the knee (where the tendon of the biceps femoris muscle inserts into the lower leg)
e) Buttock-Popliteal Length- Euclidian distance from the back of the uncompressed buttocks to back of the knee (where the back of the lower legs meet the underside of the thigh)
f) Sitting Height- the Euclidian distance from the vertex of the head to the supporting surface on which a person is sitting erect
g) Sitting Eye Height- Euclidian distance from the sitting surface to the corner of the eye
h) Shoulder Breadth- horizontal breadth across the shoulders
i) Sitting Shoulder Height- Euclidian distance from the seat surface to the acromion (the bony point of the shoulder)
j) Hip Breadth- Euclidian distance across the hips in the sitting position

Through the application of K-fold Cross Validation and Support Vector Machine, the sitting posture assessment was done. The researchers have consulted with Registered Physical Therapists for the assessment of the sitting posture.

III. DATA AND RESULTS

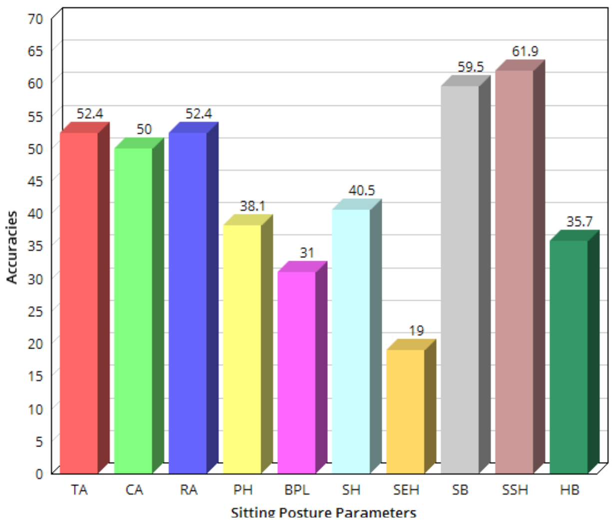

Fig. 5 Sitting Posture Parameters and their Accuracies

Each of the parameters was considered in accordance with how they affect the assessment of sitting posture. Figure 5 shows the accuracies of each sitting posture parameters. It shows that sitting shoulder height, shoulder breadth, thoracic angle and retraction angle give greater accuracies with regard to postural assessment.

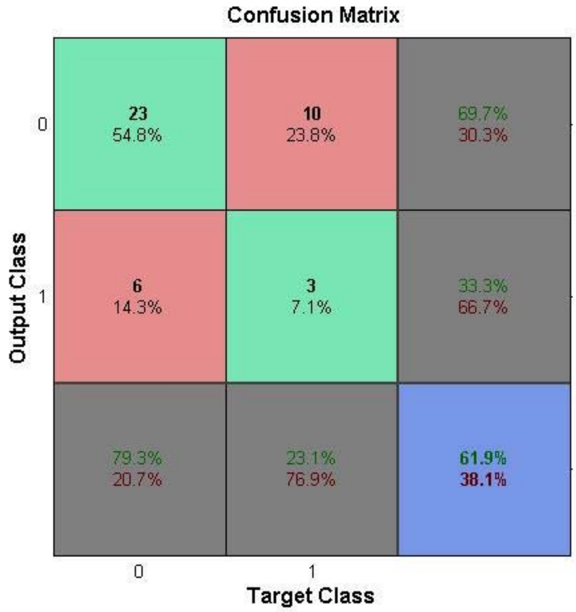

Fig. 6 Confusion Matrix of the Sitting Posture Assessment

After the assessment of the Support Vector Machine, it was then confirmed with the assessment of the physical therapists. The algorithm had an accuracy of 61.9%. The target class which is the assessment of the three physical therapists had 29 bad posture and 13 good posture as shown in the confusion matrix below. While the output class, which is the assessment of the sitting posture of the algorithm had 33 bad posture and 9 good posture. The performance of the algorithm with respect to the assessment also shows that there are 23 true negatives, 10 false negatives, 6 false positives and 3 true positives. The assessment was made considering the parameters that contributes much to the accuracy of the posture.

IV. CONCLUSION

The precision and reliability of the proposed algorithm which assesses sitting posture through Computer Vision was demonstrated and shows an accuracy of 61.9%.The proposed algorithm was able to obtain and measure sitting posture parameters and use it in assessing the sitting posture of a person. This proposed method of assessing sitting posture through Computer Vision offers evaluation considering more parameters compared with sole assessment of traditional methods such as plumbline, accelerometer, radiography, etc. The feature points from the front view are used to determine the sitting shoulder height, shoulder breadth and hip breadth, while those from the side view are used to determine the thoracic angle, cervical angle, retraction angle, sitting eye height, sitting height, popliteal height, and buttock-to-popliteal length. The angles retrieved are dependent to the inclination of the body of the study volunteer. For future study, the set-up can be improved and assessment can be obtained with normal clothing. Also, these parameters can be used to measure anthropometric measurements of a person. It was also suggested by the consultants or physical therapists to include posterior view to assess posture.

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REFERENCES

[1] E. Grandjean and W. Hünting, "Ergonomics of posture—Review of various problems of standing and sitting posture," Appl. Ergonom., vol. 8, no. 3, pp. 135–140, Sep. 1977.

[2] Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis CA. Incidence of common postural abnormalities in the cervical, shoulder, and thoracic regions and their association with pain in two age groups of healthy subjects. Phys Ther. 1992; 72: 425–31. [PubMed]

[3] F. Foerster and J. Fahrenberg, "Motion pattern and posture: Correctly assessed by calibrated accelerometers," Behavior Res. Methods, Instrum., Comput., vol. 32, no. 3, pp. 450–457, Sep. 2000

[4]W.Y. Wong, M.S. Wong, "Detecting Spinal Posture Change in Sitting Position with Tri-Axial Accelerometers ",Gait Posture. 2008 Jan;27(1):168-71. Epub 2007 Apr 6.

[5]Carman DL, Browne RH, Birch JG. Measurement of scoliosis and kyphosis radiographs. Intraobserver and interobserver variation. J Bone Joint Surg Am 1990; 72: 328-333 [PMID: 1'12528]

[6] S. Niekerk , Q.,Louw, C. Vaughan,K.Schreve," Photographic measurement of upper-body sitting posture of high school students: A reliability and validity study", BioMed Central Musculoskeletal Disorders,2008 Aug 20

[7] S. Suzuki, M. Kudo ,A.Nakamura "Sitting Posture diagonis using a pressure sensor" IEEE International Conference on Identity, Security and Behavior Analysis (ISBA) , 2000

[8] M. Piccardi "Background subtraction techniques: a review", 2004 IEEE International Conference on Systems, Man and Cybernetics

[9] L. Jiang, J. Yao, B. Li, F. Fhang, Q. Zhang, M. Heng, "Automatic Body Feature Extraction from Front and Side Images", A Journal of Software Engineering and Applications, 2012, 5, 94-100