The Intelligent Diagnosis and Treatment of Postural Deformities by Analyzing the Given Data from Kinect Camera

SeyedehSara Jalilishani, sarajalili33@gmail.com

ARTICLE INFO

Winner of Gold Medal, ICYS 2018, Belgrade, Serbia
Supervisor: Hossein Azizinaghsh
Accepted in country selection by Ariaian
Young Innovative Minds Institute, AYIMI

http://www.ayimi.org , info@ayimi.org

ABSTRACT

Postural deformities are common abnormalities related to the skeleton form, with growing prevalence among people. In the constructed system we have created a method by which any individual can diagnose and treat their postural deformities intelligently with the least requirement of an orthopedic doctor's supervision. In the implementation of the project we used Kinect camera, a gaming device provided by icrosoft company, because it has functional features with a reasonable price. The Kinect camera is capable of body tracking, joint coordinating and motion capturing.

Key words :*Postural deformities, Kinect, diagnosis, treatment, skeleton*

1 Introduction

In postural deformities, there is an imbalance in the loads imposed on different areas. Where loads exceed normal physiological limits consistently and over prolonged periods of time, structural changes occur in the skeletal bones. These structural changes cause postural deformities, such as: genu valgum, genu verum, asymmetric shoulders, Kyphosus and etc. [1]. These deformities are spreading among people and mostly among students and workforces because of the environment they work in.

1-1 Postural Deformities in Workforces

A research was done in Romania to present the risk factors in hand-arm tasks leading to neck and upper limb mascula skeletal disorders (MSDs) among workforces. In this research the relative occurrence of the type of work-related health problem was calculated and as shown, workforces mainly suffered from disorders related to the skeleton structure (Fig. 1).

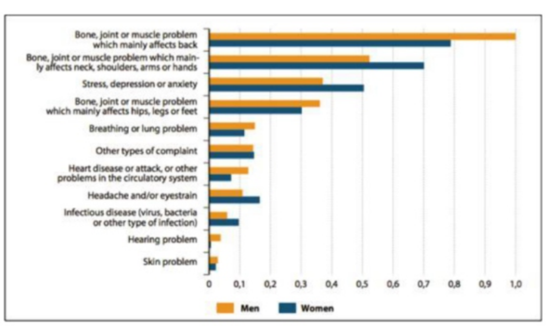

Fig.1: Relative occurrence of the type of work-related health problem[2].

1-2 Postural deformities in students

A research was done to identify the prevalence and the main risk factors of poor posture among school children in Czech Republic. As shown in the table, in average about 40 percent of the students suffered from having a poor posture (Table 1).

Table 1: Trends in the Incidence of Poor Body Posture and Its Component in Relation to Age in Czech School Children [3]

	7 Year-Olds (n = 1097)		11 Year-Olds (n = 1190)		15 Year-Olds (n = 1236)			
Study parameter	Frequency	%	Frequency	%	Frequency	%	p Value	Trend by Age
Poor posture	361	32.91	483	40.59	498	40.29	,0.001*	Increase†
Protruding scapulae	614	55.97	620	52.10	512	41.42	,0.001*	Decrease
Increased lumbar lordosis	352	32.09	393	33.03	365	29.53	0.304	Without trend
Round back	281	25.62	388	32.61	432	34.95	,0.001*	Increase
Scoliosis	17	1.55	59	4.96	129	10.44	,0.001*	Increase

1-3 Kinect Camera

The Kinect sensor for Xbox360 (from now on Kinect 1.0) is an active camera. Unlike other human-based control devices lunched by other firms it allows users to play and completely control the console without having to hold any kind of device, but only by the use of voice and gesture. The Kinect is a low-cost sensor that allows the real-time measurement of depth information (by triangulation) and the acquisition of RGB and IR images at a frame rate up to 30 fps. It is composed of an RGB camera, an IR camera, an IR-based projector, a microphone array, a tilt motor and a 3-axis accelerometer (Fig.2).

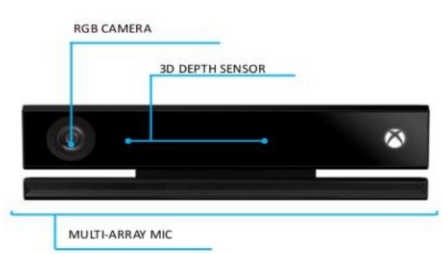

Fig. 2 : Kinect for Xbox one

The implementation of this project requires specific data from the user's body such as the coordination of the joints and their orientation that this camera provides alongside other features like motion capturing and gesture building used for implementing other phases of the projects. Since the project is based on a medical purpose its necessary that it imparts sufficient accuracy. Given that Kinect camera is low-cost, portable and does not require any sensors to be attached to the body, it could provide numerous advantages when compared to established marker- or wearable sensor based system. The Kinect V2 has the potential to be used as a reliable and valid clinical measurement tool [6].

2 Objectives and Importance of the Project

The objectives of this project are:

- Decreasing the costs for diagnosing and treating the deformities by using the proper equipment and methods
- Accelerating the whole amelioration process by gathering the phases in one system
- Reducing the requirement of an orthopedic doctor by increasing the accuracy of the system as far as possible

As mentioned before postural deformities are increasing among people and becoming a serious issue in school children and workforces. Diagnosing and treating these deformities instantaneously not only prevents further damages caused on your health but also saves money and time. Yet many people neglect the importance of diagnosing and treating these deformities for reasons like: the heavy fees for doctor's referral, not being able to spare some time for the amelioration process, living in a disadvantaged area and etc. The designed system can solve these problems by costing less than visiting a doctor, being accessible and having visual attraction that increases the user's interest in doing the amelioration process.

3 Methodology

This research is in the form of a software, created using the Unity game engine which was proper for creating a 3D concept. The environment of this system is designed as a doctor's office to increase the interaction between the user and the program (Fig. 3).

Fig. 3: Experimental environment

Having this system in unity, one of the things we were able to do was creating a hypothetical skeleton of the user's body with 3D objects using the Kinect camera. The main feature of this camera which was the most practical for our purpose was the body tracking feature. When the user stands in a proper distance from the camera, it tracks the body of the user, the tracked body comes with some data that is also received from the user's body such as the coordination and the orientation of the 25 joints .

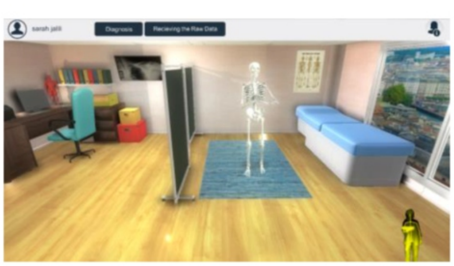

Fig 4: The drawn skeleton

Having the coordination of the joints in three dimension (x, y and z) we were able to draw a skeleton of the user's body in 3D by having a rigged skeleton object and setting its joints' coordination to the coordination that was received from the user's body (Fig. 4).

Having the skeleton in 3D had medical purposes, for instance if the doctor or the user wants to examine the skeleton they can zoom in and examine it closely (Fig. 5).

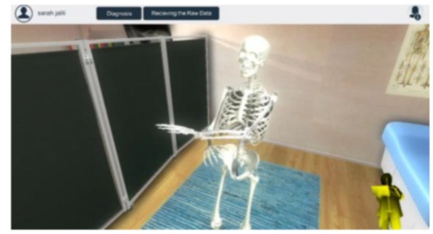

Fig. 5: Zooming in the skeleton

3-1 Creating a Profile for the Patient

Before entering the program users will go through a profiling process in which some personal information will be received from them and will be held in a profile with a profile number that will be also provided for the users. As the profile is created an email will be send to the patient's doctor so that the doctor would have access to this data. The reason for sending this personal info to the doctor which includes the patient's name, height, weight and age, is that in some cases the doctor needs to be able to check if the deformity is caused because the patient is overweight or it's because of the patient's age or etc. After the final diagnosis the intensity of the user's deformity will also be send to the doctor via an email (Figs. 6-8).

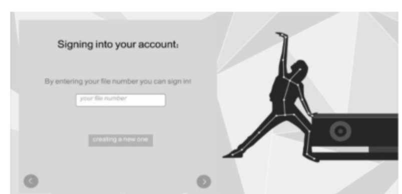

Fig. 6: Entering in the user's account

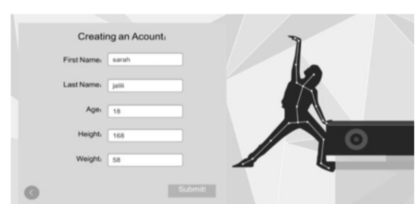

Fig. 7: Receiving the personal info

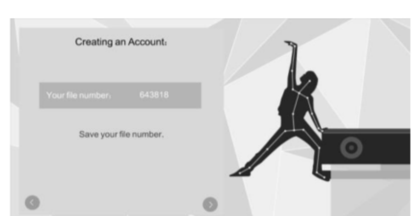

Fig. 8: providing a profile number

The amelioration process is divided into two parts: the diagnosis and the treatment. The diagnosis phase includes the diagnosis of three deformities: wry neck, asymmetric shoulders and genu verum. The diagnosis of these deformities is mostly based on the coordination of the joints received by the Kinect camera. Having the joints' coordination of the user's body we could do the diagnosis by comparing the position of the user's joints with the standard position they must have.

3-2 Diagnosis of the Asymmetric Shoulders

In standard posture the shoulders are supposed to be in the same axis meaning that their variable y must be almost equal, as much as the subtraction of their y variable increases the intensity of the deformity also increases (Fig. 9).

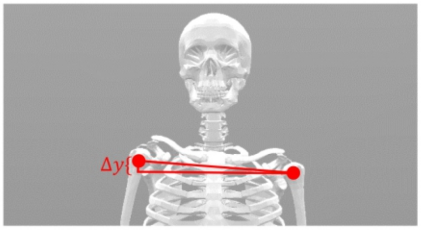

Fig. 9: As shown in the figure Δy is the determinative variable for the intensity of the asymmetric shoulders, as the Δy increasers the shoulders will be more in an asymmetric position

Having Δy we could diagnose the deformity by comparing the given data from user's body and medical references in which the standard of these data is discussed.

3-3 Diagnosis of Wry Neck

In Wry Neck the patient's neck is not in a straight line and the neck is bended toward his/her left or right shoulder. The method for diagnosing this deformity is to compare the x variable of the head and the neck of the user's body (Fig.10).

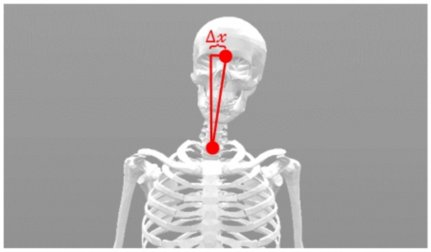

Fig 10: As shown in the figure Δx is the demonstrative variable for the intensity of the wry neck, as Δx increases the neck is more bended towards the right or left shoulders

This deformity is also diagnosed by comparing the Kinect's data and the discussed data in the medical references.

3-4 Diagnosis of Genu Verum

In this deformity when the patient is standing in a standard position (legs closed) the distance between the knees will be calculated using the x variable of left and right knees, based on this distance the deformity will be diagnosed by comparing this distance to standards available references (Fig. 11).

3-5 Drawing the Live Charts

Using the methods declared above we were able to diagnose three deformities. To provide the user with this diagnosis, we showed the diagnosis done on each frame on a live chart. The data of these live charts that includes the intensities of these deformities, will be updated each frame. Each chart has four possible data, zero, one, two or three; and each number states an intensity except for number zero which will be discussed later. When one is shown it means that the deformity is not seen in the person's body, two means the deformity is clearly seen in the user's body, when the data of chart is three the deformity is highly intense in the user's body(Fig. 12).

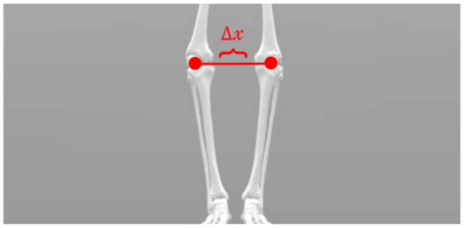

Fig. 11: As shown in the figure Δx is the demonstrative variable for the intensity of the genu verum, as Δx increases the knees are more distanced from each other and the intensity of this deformity also increases.

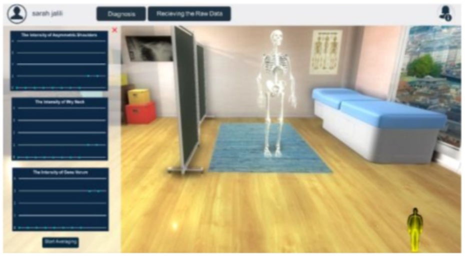

Fig. 12 : The drawn live charts for the intensities of the user's deformities

3-6 The calibration process

Two parameters will affect the results during the diagnosis process: the posture that the user is having and the distance that the user has from the camera. The user must stand in a normal posture in front of the camera, meaning the user's body must be held in an upright position, so if the user stands in a T-pose or has the arms crossed or legs open, we wouldn't be leaded to a valid diagnosis. Another parameter is the distance of the user from the computer, Kinect camera has an exact scope that if the user doesn't stand in it (getting to close to the camera), the skeleton of the body wouldn't be drawn accurately so there will be an error in our diagnosis too (Fig. 13).

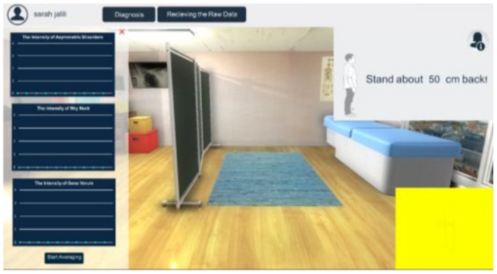

Fig.13: The user is standing in an improper distance from the camera so an alter is shown, the skeleton is disabled and the intensity of the deformities are shown zero.

Therefore, we added the calibration process. In this process when the user enters the diagnosis phase before doing the final diagnosis the posture and the position of the user will be checked to declare whether the user is in the proper distance and having a normal posture or not, if the user is standing too close to the camera or has an invalid posture he/she will get an alter for that and the data of the live charts will change to zero and the skeleton of the user wouldn't be drawn anymore until the user changes his/her posture (Fig. 14).

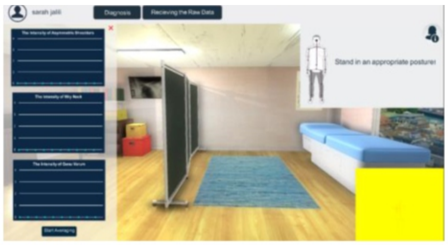

Fig. 14: while the person is standing in an improper posture the same sequence of actions will happen but the distance of the user is prioritized from the posture of the person.

3-7 The Marker-Based Method

Kinect camera's body recognition is a marker-less process which is done using machine learning. Any device using this method can come with inaccuracies. Accuracy of Kinect V2 landmark movements was moderate to excellent and depended on movement dimension, landmark location and performed task. Signal to noise ratio provided information about Kinect V2 landmark stability and indicated larger noise behavior in feet and ankles [7]. These joints don't effect the diagnosis of the deformities except for genu valgum which is diagnosed using ankles' x variable. In this condition for the ankles' joints the suggested method was the marker-based method. In this method specific markers will be attached on the user's ankles and the coordination of these markers will be calculated using an image processing procedure. During the diagnosis of this deformity the coordination of the markers will be used instead of the coordination that are calculated by Kinect camera. As the accuracy of the marker-based method is way more than the marker-less method, this method was discussed for the solution to this problem.

4 Averaging Process

Another method that was used for increasing the accuracy of the system was the averaging method. Kinect camera receives about 30 frames per second depending on different parameters. Doing the final diagnosis based on the data of one frame wouldn't be accurate enough, so to have a valid diagnosis we averaged the data of the user's body (the coordination of the joints) in 90 frames and did the diagnosis based on the averaged data (Figs. 15-17).

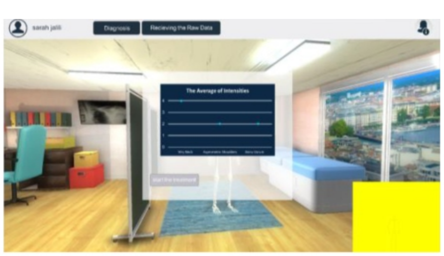

Fig. 15: The final diagnosis that is based on the averaged data

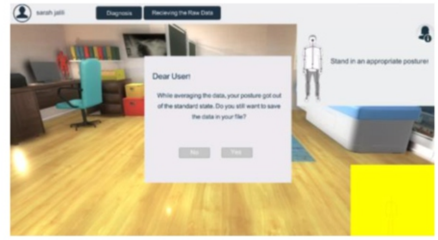

Fig. 16 : If the user's posture gets out of the valid form during the averaging process an alter will pop on to check whether the user wants to save the data of the averaging or wants to do the process all over again

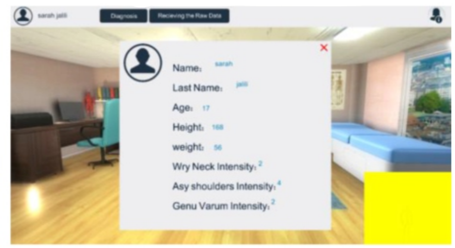

Fig.17: as the final diagnosis finishes the intensities of the patient's deformities will be saved in the user's profile.

5 The Treatment of Deformities

The treatment of these deformities are based on their diagnosis and they are usually in a form of an exercise. The treatment for each deformity is also defined in the medical references, the repetition and the timing of the exercise is based on the intensity of the deformity. The instruction for each exercise is given to the user in the beginning of the treatment phase. The motion capturing capability of Kinect device gave us the ability to control the user's movements and to clarify whether the user is doing the exercises correctly or not. Visual Gesture Builder is a software for defining a gesture or movement for Kinect camera. We used this software to teach Kinect these exercises as the correct movements that must be done by the user (Figs. 18,19).

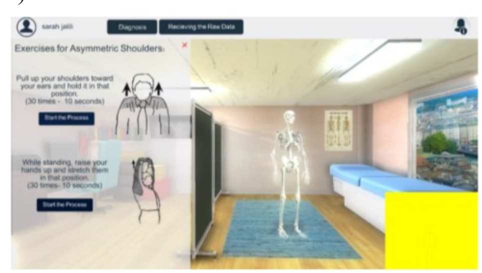

Fig.18: as the user enters the treatment of the asymmetric shoulders an instruction for the exercises will be given to the user

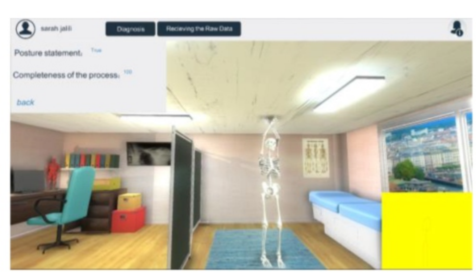

Fig.19: The monitoring section of the treatment phase has two parts, in the first part if the user does the exercise correctly the statement will be true and in the second part the completeness of the exercise that varies between 0 to 100 will be in the range of 80-100

6 The Raw Data Section

This section is created for doctors and medical purposes. In this section the user can have access to the data that the diagnosis of the deformities were done using it; this data consists of the Δx of knees, Δy of shoulders, the angle of knees, the slope of the shoulders, markers' coordination and the Δx of head and neck joints. We provided this data, so that the doctor would be able to see the information of the user's body himself/herself for any medical purposes (Fig.20).

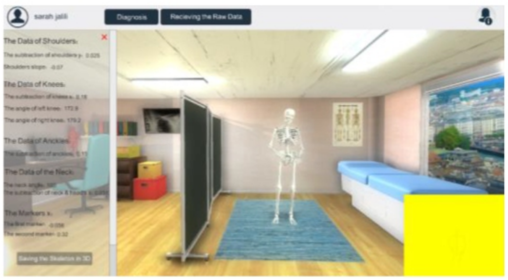

Fig. 20: The raw data panel will be opened as the user clicks on the receiving the raw data and the coordination of the markers are also shown on this panel

7 Results

To measure the accuracy of the system it was examined on 90 adolescence in the age of 16 between 18 (the examination was done on this age range because the deformities are more common in these ages). The results are shown on the chart below (Fig. 21).

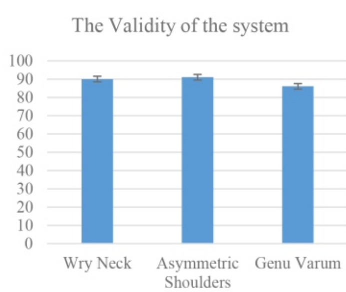

Fig.21: The results are compared in different deformities

The accuracy of wry neck was calculated 90 percent, for the asymmetric shoulders it was calculated 91 percent and the genu varum was about 86 percent; therefore, the validity of the system in average was about 89 percent.

8 Conclusions

Combining Kinect camera's features with the marker-based and averaging method gave us a system with the reliability for a medical diagnosis. This system can be practical in places that the environment often leads to the cause of these deformities such as schools and workplaces, also this system can be used instead of a doctor in places like disadvantaged areas in which there is a lack of medical workforces; it also can be used in any places with large number of users such as clinics, alongside these, any person having access to this system can go through the amelioration process individually. In all of these conditions, this system is going to be used for several years instead of hiring a doctor each time which leads to a reduction in the costs, also this system may absorb the user's interest for doing the amelioration process because of the game-like atmosphere of the system.

Acknowledgment

I would like to express my sincere gratitude to my supervisor, Hossein Azizinaghsh for helping and guiding me through this project. I also want to thank the head of the AYIMI institute for giving me opportunity to have my article in this journal.

References

[1] Solberg G., Postural Disorders & Musculoskeletal Dysfunction diagnosis, prevention, and treatment. Churchill Livingstone.1st ed. Elsevier publisher; 25th October 2007.

[2] Viorica Petreanu, Aurelia-Mihaela Seracin. Risk factors for musculoskeletal disorders development: hand-arm tasks, repetitive work. National Research - Development for Health and Safety; Romania.

[3] Jana Kratenová, Kristyna ZejglicováArticle. Prevalence and Risk Factors of Poor Posture in School Children in the Czech Republic. Journal of School Health. 2007. 77(3):131-7.

[4] Khoshelham, K. Accuracy Analysis of Kinect Depth Data. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 2011; Volume XXXVIII-5/W12. 2011ISPAr3812W.133K:133-138.

[5] Diana Pagliari, Livio Pinto. Calibration of Kinect for Xbox One and Comparison between the Two Generations of Microsoft Sensors. 2015; 15(11): 27569–27589.

[6] Karen Otte, Bastian Kayser, Sebastian Mansow-Model, Julius Verrel, Friedemann Paul, Alexander U. Brandt, and Tanja Schmitz-Hübsch. Accuracy and Reliability of the Kinect Version 2 for Clinical Measurement of Motor Function. November 18, 2016; 11(11):e0166532.