Proceedings of the
34th International Conference on Information Technologies (InfoTech-2020)
IEEE Conference, Rec. # 49733, 17-18 September 2020, Bulgaria

REBA WORKPLACE ERGONOMICS USING KINECT

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Abstract: The document presents a development for detecting posture in the workplace and using it to assess the risk associated with tasks. This development was created at the Tecnológico de Monterrey in Mexico so that students can evaluate ergonomic postures. The system consists of a body assessment tool and a Microsoft Kinect V2, as the hardware in charge of collecting the information. Students use the results to identify postures that can cause damage to certain areas of the body and to make changes in the workplace as a measure to reduce risk.
Key words: Posture Detection, Risk, Visual Interface, Workplace, Educational Innovation, Higher Education.

1. INTRODUCTION

Posture plays an important factor in the ergonomics of work-related activities, adopting poor posture can lead into several problems such as muscular and joints injuries, reduced blood flow, fatigue, and low productivity at work. Having a non-invasive visual system as an analysis tool can contribute to reduce the risk involved.

This project includes the development of the software using Kinect sensors and was given the name Ergo Vision. This development was created at the University for the use of students. The aim of this project is for students to carry out ergonomic studies in real time in order to analyze in detail the positions people adopt when carrying out a work activity. It is known that, during a work shift, a person performs various activities, some standing, others with a sitting posture, others with handling loads. There are tasks that require repetitive movements, with extreme postures. This development use the REBA method (Rapid Entire Body Assessment).

According to Pheasant (2006), Ergonomics is the science of work of people doing an activity, with tools and equipment, the workplace and the working situation which takes into consideration the safety and health of the workers [1].

2. BACKGROUND

2.1 REBA Tool

The tool proposed as a way to obtain the risk that the worker can develop is the Rapid Entire Body Assessment or REBA. REBA was designed as a quick visual analysis tool that assigns a score value depending on the worker's movements and postures during the work cycles. The method was developed by Hignett and McAtamney (2000) [2]. This method uses a REBA worksheet format to collect the information to be analyzed.

REBA tool divides the body into two sections, section A for the neck, trunk and legs, while section B refers to the analysis of the arms, lower arm and wrist. REBA defines other factors that it considers decisive for the final assessment of the posture, such as the load or force used, the type of grip or the type of activity. Based on the REBA score, five possible levels of risk are considered and these carry a certain level of action that indicates the need for ergonomic intervention. Depending on the degree of inclination of each part of the body, a score is assigned and recorded to calculate the level of risk. Figure 1 shows the different angles of inclination of the back, and the greater the inclination, the higher the score value. It can be seen in the image that if it is twisting or flexed, one more point is added.

TRUNK

Movement	Score	Change Score
Upright	1	+1 if twisting or side flexed
0°-20° flexion 0°-20° extension	2	
20°-60° flexion >20° extension	3	
>60° flexion	4	

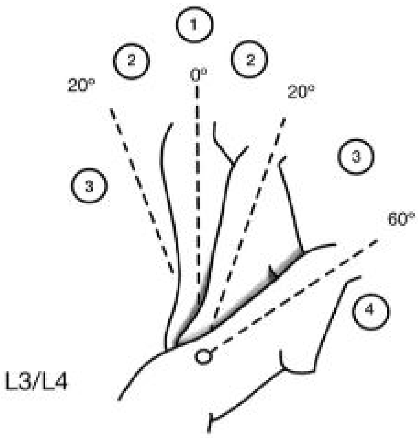

Fig. 1. Trunk tilt angles and score to assign. Source: Hignett and McAtamney (2000)

The angles of inclination are identified and a score is used to which loads, forces and coupling are also added to give the final REBA score as shown in figure 2.

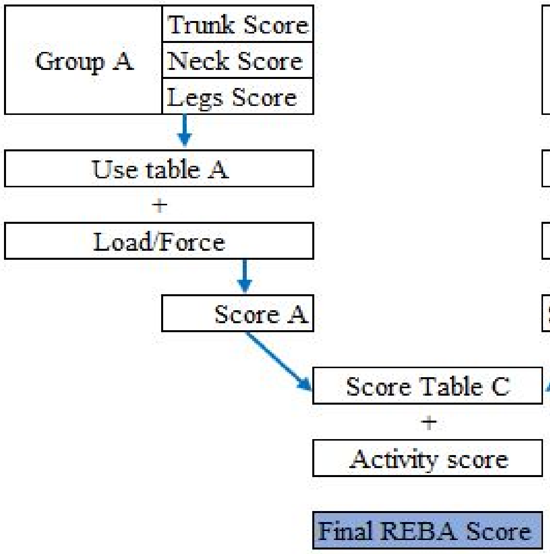

Fig. 2. Reba Final Score. Source: Hignett and McAtamney (2000)

The final REBA Score gives the risk levels and the action to take after obtaining the results. There are 5 levels, the first level that means there is no risk and the last level that means that immediate actions need to be taken. Figure 3 has this levels and descriptions.

REBA final score

1	no risk, no action required
2 - 3	low risk, change may be needed
4 - 7	medium risk, further investigation, change soon
8 - 10	high risk, investigate and implement change
11 - 15	very high risk, implement change

Fig. 3. Reba Actions levels. Source: Hignett and McAtamney (2000)

In contrast to the REBA worksheet, the Ergo Vision system can be placed in the workplace for a continuous identification of the worker's movement during several cycles and periods of time, for an uninterrupted sample acquisition and analysis. The Kinect and Ergo Vision is placed to one side of the workstation as shown in figure 4.

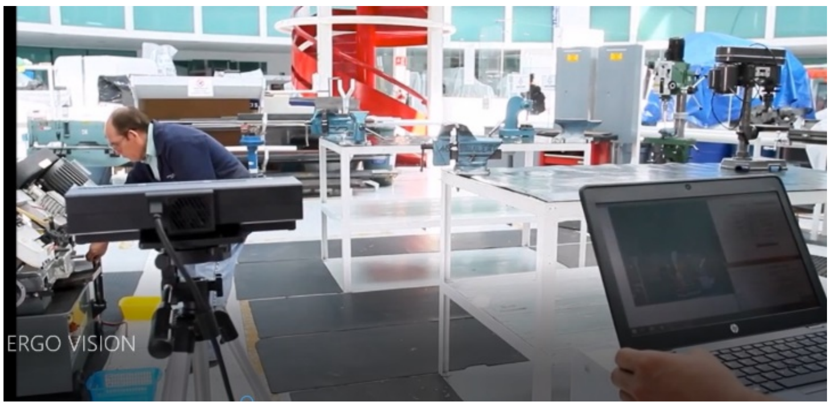

Fig. 4. Placement of the equipment for the continuous study of worker movements

2.2 KINECT and Visual Studio

The hardware responsible for collecting the information is a Kinect V2, as shown in figure 5, and functions by using either the color camera or the IR camera-projector system for a live picture feedback.

Diego-Mas (2014), Modesto Manghisi (2017) and Sek Tee (2017) consider the Kinect sensor a useful tool to conduct ergonomics assessments in a workplace environment [3], [4], [5].

Fig. 5. Kinect V2

The Ergo Vision developed uses the Kinect movement sensor to capture the positions that the human body of the person who is working has and to process this information in a faster and easier way. For this, the Kinect SDK allows us to know the coordinates of each movement represented in a 3D plane, that is (X, Y, Z), as shown in Figure 6.

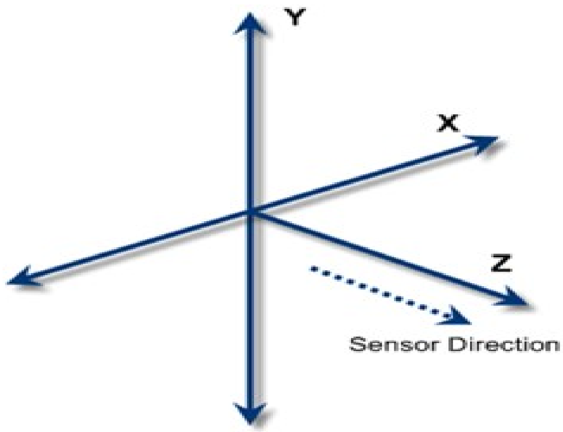

Fig. 6. Coordinate system used by the Kinect sensor

The SDK allows recognizing the elements in the image with characteristics of the human form. Once a person's body parts are recognized, the SDK identifies each point in space in front of the sensor. The SDK allows us to obtain different views from the color camera and infrared sensors, obtaining the information related to the recognition of the skeleton. This skeleton is broken down into points called "Joints" represented by green dots within the structure of the same skeleton in red, as can be seen in Figure 7, which regularly represents the joints of a person. It is interesting to capture the "Joints" because from them we can see the movements made by the person and obtain the angles of each one of them and thus carry out the evaluation.

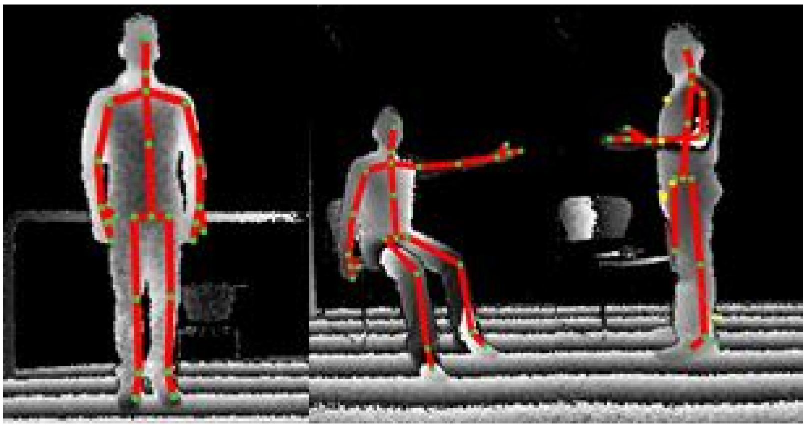

Fig. 7. The Kinect Sensor gives us a representation of the human body in the form of a skeleton and its joints are the points called "Joint" represented in green.

Within the view module are the functions responsible for displaying the information obtained by the sensor visually, that is, by means of an image. Kinect allows us to obtain different views depending on the type of "frame" that interests us:

a. Color images: in this case we make use of the RGB camera that includes the sensor to obtain a color image of what is in front of the sensor.
b. Depth map: makes use of infrared sensors to obtain a three-dimensional map of the environment in front of the sensor, that is, from the different distances of each point emitted by the IR projector it is possible to obtain a depth view.
c. Infrared image: it makes use of infrared sensors to obtain in an image the pattern of points or light beams emitted by the IR projector.
d. Graphic representation of the skeleton: the Kinect SDK allows recognizing 25 points or "Joints" to make a representation of the human skeleton, as shown in figure 8. From each "Joint" it is possible to generate 2D points that allow us to visualize their position in an image.

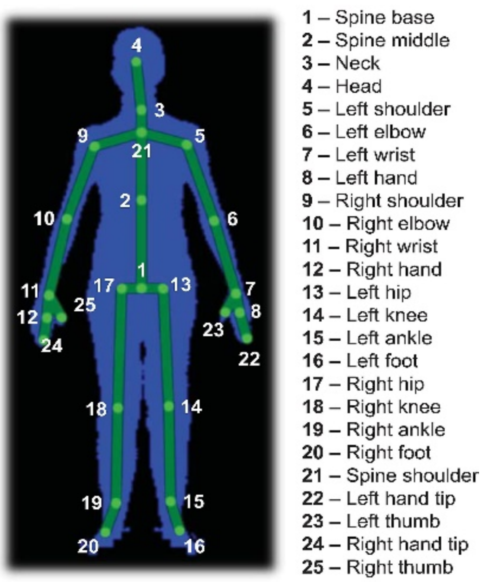

Fig. 8. Joints provided by the Kinect SDK

For the system, as shown in figure 9, a Windows Form Application on Visual Studio was developed to program the basic functions of the REBA tool and the Kinect SDK in order to use the hardware.

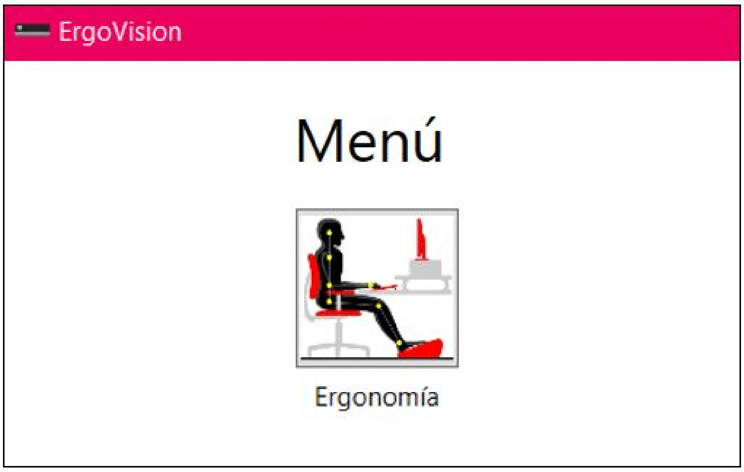

Fig. 9. Windows Form Application developed for the system

The process by which the application gathers the information is the following:

a. Detect the Kinect sensor.
b. Get the color camera frame (width and height), and assign it as the reference frame.
c. Detect the body that is on the frame, and draw the joints over it according to the frame resolution and the coordinates. The joints are described on figure 5, then draw the connection of each the joints. The color frame has a resolution of 1920 x 1080 pixels, while the other frames have a 512 x 424 resolution.

For each section of the body, the angle between joints was obtained by converting their x, y and z coordinates into vectors and then applying cross product.

a. Trunk analysis: The Spine Base and Spine Shoulder vectors were passed.
b. Arm analysis: first the Shoulder and Hand vectors were obtained and the difference between them, then the Spine Shoulder and SpineBase vectors difference were obtained, and the cross product between both of the differences were applied.
c. Leg analysis: similar to the arm analysis, the Knee and Hip vectors were obtained and the difference between them, then the Knee and Ankle vectors difference were obtained, and the cross product between both of the differences were applied.

Each flexion made by the person is captured with two vectors a and b, the angle formed by the two vectors is calculated and the result of each angle is stored in a database for later use. The important thing about using the Kinect sensor is that obtaining angles is performed simultaneously each time the person moves from position and gives a result in real time.

3. ERGONOMICS STUDIES CONDUCTED BY STUDENTS

Ergo Vision, through the Kinect SDK, obtains the coordinates of each point (Joint) through the infrared generated by the sensor. In this way it is possible to construct a graphic representation, through points and lines, of a person's skeleton. The software allows to obtain different views of the environment and to observe how the Kinect sensor interprets the environment in front of it, in addition allows to know its behaviour in industrial environments. In figure 10 is an ergonomic assessment in a workstation, the results obtained in REBA final score was 1, no action required.

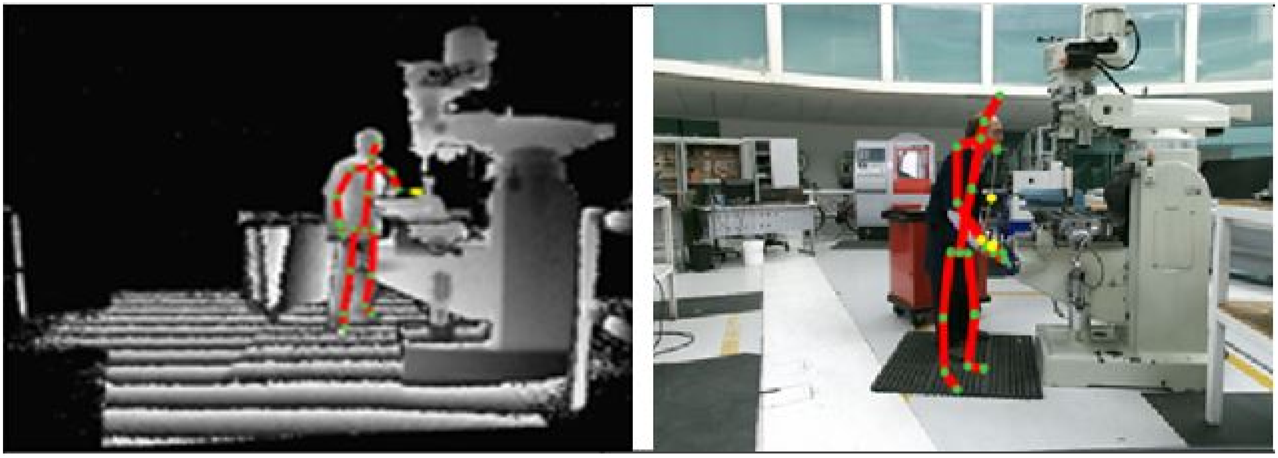

Fig. 10. Representation of the skeleton of the person and view through the color camera. In this workstation with no risk, no action is required.

In another ergonomic study carried out by students it was identified that for some operators their working posture was uncomfortable. According to the REBA method, the level of postural risk in the trunk is increased if the angle of inclination is greater than 20° combined with the repetition of this posture during the working day, and in the neck the postural risk level increases if the degree of neck inclination is greater than 20 ° [6]. The REBA score was 7 that correspond a medium risk and the action suggest a change soon. To evaluate the quality of the proposed software, the study was carried out manually with the REBA sheet and the data coincided with the value obtained.

Fig. 11. A workstation with a medium risk

In this evaluation, the students observed the angles and made a prototype of wood so that the workers could fold the textile garments and thereby improve their work posture. With this improvement, the final REBA score decreased from 7 to 2, which is a low risk. The worker's new posture improves his trunk as shown in figure 12.

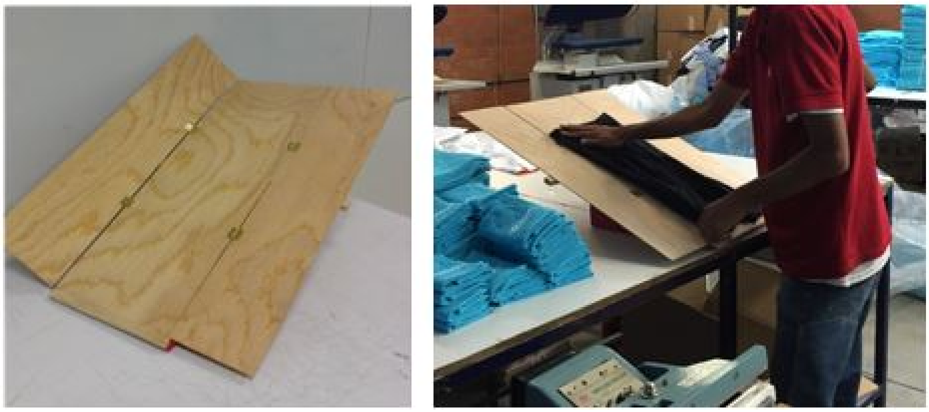

Fig. 12. Prototype made by students at the garment folding workstation

This is one of several studies that students have carried out to evaluate ergonomic postures in the workplace.

4. RESULTS

This development solves the need to perform ergonomic evaluations in real time and with different postures during a working day. The Kinect motion sensor captures the positions that the human body of the person who is working has. The system allows to recognize the elements in the image with characteristics of the human form. Once a person's body parts are recognized, the system identifies each point in space in front of the sensor. For the study carried out by students with Ergo Vision, different postures were evaluated in real time and the most critical posture in which a medium risk was obtained at the workstation was identified. With the manual procedure from one REBA worksheet, only one position is analysed and the risk level is obtained. With Ergo Kinect, you can select and evaluate various moments of the productive activity and, from each one, the level of risk is obtained simply by clicking on the position to be evaluated.

Sek Tee et al. review (2017) offers valuable insights about the approaches and instruments used by the previous works of the researchers in the evaluation of the ergonomics. In this review the features of the ergonomics assessment methods are compared in terms of cost, reliability and accuracy. In table 1, from the review, the comparison in cost and reliability is the same. In accuracy it depends on the performance of the ergonomic assessment [5].

Table 1. Comparison on the features of different ergonomic assessment devices using Kinect

Authors	Cost	Reliability	Accuracy
Dutta	Low	Medium	Medium
Diego et al.	Low	Medium	Low
Haggag et al.	Low	Medium	Medium
Paliyawan et al.	Low	Medium	High
Martin et al.	Low	Medium	Low

Ergo Vision development has low cost, reliability Medium and accuracy Medium due to comparisons made manually with the REBA sheet.

Other existing tool compared with Kinect is the Inertial Measurement Units (IMU), a device which measures static angular displacement in a study. IMU is better in robustness. The cost, reliability and accuracy compared with Kinect is in Medium and High Levels.

For an academic environment, a useful tool is Ergo Vision, which is practical and easy to use for students to evaluate ergonomic workstations.

5. CONCLUSION

Technological projects have been developed in the area of human health with a positive impact. The advantages of using the technology are: a) to reduce the time to obtain results, b) for better quality and c) to carry out non-invasive studies. This Ergo Vision development is a system used in the areas of ergonomics. The system uses the REBA method to evaluate the ergonomic aspects of the workstations in real time. If the dimensions of the place are adequate in relation to the actions of the people, then the worker will do its tasks in the body postures that improve its performance safely. The use of the software, together with the result of the improvement proposals of the students, will allow a better learning.

AKNOWLEDGEMENTS

The authors would like to acknowledge the financial support of Writing Lab, TecLabs, Tecnologico de Monterrey, Mexico, in the production of this work. Additionally, we are grateful to Guillermo Hernández, student who has finished his studies and participated in the Ergo Vision development programming.

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