BODY MONITORING SYSTEM OF THE LOWER LIMBS IN THE SEDENTARY POSITION OF A UNIVERSITY STUDENT IN DIFFERENT ACTIVITIES

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***Abstract*— The project shows the creation of a novel system for the corporal monitoring of the student's lower extremities, through the analysis of the movements and calculation of flexion angles of his legs based on free software. This system is based on the use of Microsoft's Kinect sensor to fulfill this purpose of capturing and schematizing the human body in such a way that it is possible to capture the movements and virtualize them, obtaining 4 postures generating a plain text file (.txt) that Contain the record of the previously captured data, and then be processed using statistical analysis software, which will allow the development of estimators to determine which position is most frequently adopted in the various activities.**

Keywords*— *Kinect, Ergonomics, Body Monitoring, sedentary, Lower Extremities

I. INTRODUCTION

The investigation of the different corporal postures that a student adopts at the moment of carrying out an activity can be varied and to the naked eye would not have any relevance, but deepening in the subject will be able to see that it is of greater transcendence, since this can affect in multiple aspects As well as in their health, whether physical, emotional or psychological, as well as in their academic performance or the development of daily activities [1].

El Analysis of sedentary postures and lower limb movements at work stations is a key issue in assessing the potential risks of musculoskeletal disorders [2]. To this end, methods have been developed which are the most applied, the first employs image processing technologies [3] and the second is based on sensors [4]. Image processing technologies such as Kinect allow the evaluator to perform the analysis and monitoring of users without being an invasive method, achieving better captures without interrupting the activity that is performing [5].

Positions that the lower extremities may adopt in a seated position may be classified differently, [5] Indicates that based on the biomechanics of the knee can only take 3 states depending on their angles of flexion according to a frontal plane, on the other hand, [7] establishes 5 postures for the development of the system based on the fact that two limbs may have some combinations, it should be taken into account that each author has proposed a different number of postures that is specifically adapted to his system.

The proper appropriated helps the body posture to its natural state where the positions of the legs do not constantly change and the muscles relax, if it changes to an incorrect position or stays excessively in the same one would cause that the ligaments are tensioned causing pain and discomfort [8].

For the analysis of data of the system it is necessary to use classification algorithms due to the large volume of information obtained from the sensors, for this type of investigation a simple counting method will be used after classifying them by ranges determined by the angles of the lower extremities. To form the angles, we will use the body parts as if they were the sides of a triangle and each joint would be an axis of the same, this must be done in a two-dimensional way so that the data are better treated, since having only one Kinect cannot have our full 3D capture of the body, but only the plane in which the Kinect can observe.

The choice to work in the Open Source environment, specifically Free Ubuntu software is because it is a powerful system, which provides us with broad compatibility with image processing programs as processing and at the same time saving on licensing costs, in addition it should be noted the wealth of open source projects available on the web that allow developers to extend their possibilities of creating new systems by quickly prototyping a test. [9]

The Internet of Things incorporates four pillars to make network connections more important and valuable: people, processes, objects, data. Being the data the fundamental part for the transformation of atoms to bits, since this process is important to convert the physical world to digital to be able to analyze it [10].

The purpose of the proposed system is to determine the different postures that university students adopt when performing different activities, using the Kinect sensor in conjunction with a PC, which record the movements of the person transforming them into digital data by storing them in a file Flat text, to determine the different positions are used cycles of comparison according to ranges established according to the angles of flexion of the legs. To determine the most frequently adopted posture, a counting method will be used that compares the positions of both the left and right legs, determining that if they are within the same range of angles, they belong to the same posture and have been repeated the greater number of times.

II. MATERIALS AND METHODS

The health problems caused by poor posture when performing different activities affect the health of the person, to detect and correct these postures can be implemented easily accessible technologies and the help of Open Source tools [11]. En la presente sección se indican los principales aspectos sobre

el diseño y las variables consideradas para el desarrollo del sistema.

A. Analysis of the lower extremities in the sedentary position

To determine the most common postures, the direct observation technique was used to establish behaviors for a group of people. The analysis was performed with a group of university students, who were monitored during their daily activities as shown in Fig1, a pattern of coincidences was found which allowed to determine three postures, however considering that they are two limbs and these are not always Are in the same range a fourth posture was established.

Fig 1. Analysis of positions in an academic environment

Students in different activities take different postures by sitting for long or short times so that, in Table I, each one is specified and detailed, represented by a number in Fig. Where position one is ergonomics concepts is correct, eliminating extra loads and maintaining the stability of the body while performing an activity [9].

Table 1: ANALYSIS POSITIONS

Posture 1	Posture 2	Posture 3	Posture 4
Straight angle formed between the calf and the thigh, you can observe that a variation is made crossing the legs to the height of the ankles	Straight angle formed between the calf and the thigh, you can observe that a variation is made crossing the legs at the height of the ankles	An obtuse angle formed between the calf and the thigh, it can be observed that a variation is made crossing the legs to the height of the ankles	Posture is considered by default in case the legs do not match within the same range of analysis

The study to determine the data to be learned by the system was performed by a pilot analysis of 10 people (7 men and 3 women), each of which was sensed in 4 positions that the system detected, see Fig2.

Fig 2. Postures

1. Angles between 85 ° and 120 °
2. Angles less than 85 °
3. Angles greater than 120 °
4. Left and right leg at different angles

B. Design

The circuit was designed using the Kinect Sensor connected to the computer via the XBOX-USB adapter, which allows the sensor to be recognized by the computer Fig 3.

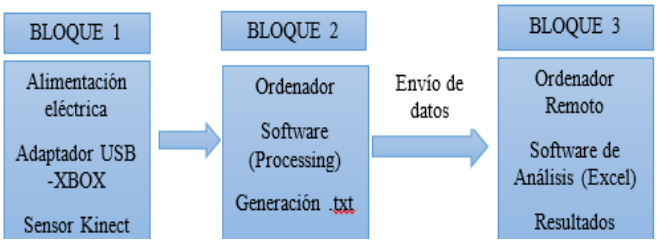

Fig3. Diagram of System

Block1: contains everything related to the monitoring hardware, such as the Kinect Sensor and its way of connecting to the computer, together with your XBOX A USB adapter to be connected to the computer.

Block 2: includes the personal computer with free software Ubuntu, the Software for processing "Processing" which will generate a flat text file with the information collected.

Block3: consists of the Remote Computer in which it received the data previously collected and then processed in the Excel Analysis software and presented in statistical graphs.

The Kinect sensor was placed in front of the user in such a way that it is fully captured, for this it is extremely important that objects such as furniture and technological equipment do not obstruct capture as shown in Fig 4.

Fig 4. located of the Kinect sensor to realize captures

C. Data Capture and Processing

At this stage the user is schematized and the joints are already points of reference to determine the angles that allow us to detect what position the person adopts. The values acquired are not completely accurate since they are subject to a margin of error because they are real-time catches, thus obtaining position estimators. The data that was scanned will be stored in a .txt file and analyzed statistically to determine position estimates.

Once the location reference points extracted from the skeleton plotted by Kinect are found according to Table 2. Next, we calculate the angles between the joints. These are the values that will be stored to form the file that will then be processed to achieve position estimators.

Tabla 2: Application-defined points

Angle	Body Parts
Right knee	Foot, knee, hip (right)
Left knee	Foot, knee, hip (left)
internal Right knee	Right knee, left knee, right foot
internal Left knee	Right knee, left knee, left foot

To do the calculations correctly we will use our body parts as if they were the sides of a triangle and each joint would be an axis of the same, in figure 5 we can appreciate the construction of the triangles and the diagram of angles and outer sides of the knee Which will determine the individual's postures according to their flexion.

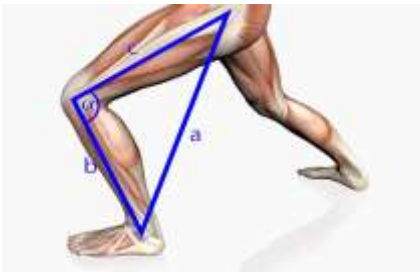

Fig 5. Formation of the triangle for calculating angles

With the use of trigonometry, it is possible to calculate the length of the "bone" between two joints and the angle between two connected bones. To calculate the distance, or rather the length of the bone, we used the formula distance between points.

$$|v| = \sqrt{(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2}$$

Once the magnitudes of each side were calculated, the cosine law was used to determine the angle of the knee.

$$\cos(\alpha) = \frac{b^2 + c^2 - a^2}{2bc}$$

With this process, we can see the result of the calculation of the right and left leg flexion angle as seen in Fig 7.

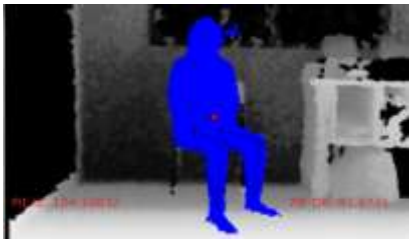

Fig 7: Triangle formation view from the system

Figure 8 shows the calculation of the distances of each of the sides of the triangle and of the flexion angles of each of the legs.

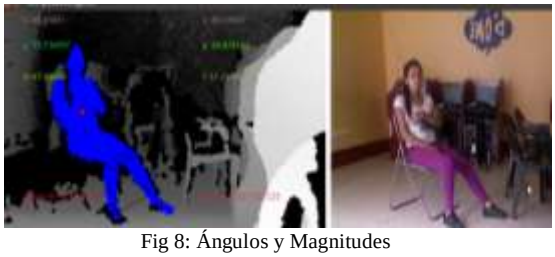

Fig 8: Ángulos y Magnitudes

he development of the program is represented in the flowchart of fig 9.

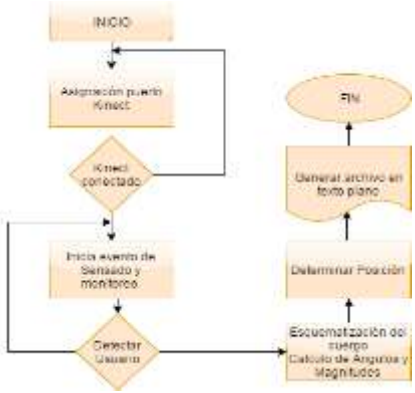

Fig 9: Flujograma

D. Tests

Ten people were followed up for 2 minutes per user, being able to monitor the postures adopted by them in different activities. These tests were performed in an environment controlled with the variables shown in Table 3.

Table 3: Variables the test

Variables	Descripción
Light	Luz estándar ninguna modificación a las condiciones que proporcione el escenario (Aula FICA)
Furniture	Chairs of the Faculty of Engineering in Applied Science, the tables will not be used
Time of the day	Morning hours from 8:00 a.m. to 12:00 p.m.
obstruction	Do not consider the use of objects that interfere with the capture between the user and the Kinect sensor (tables, chairs, reflective objects, etc.) that complicates the data collection

Test 1 - Student Play: Users were given a Tablet (digital tablet) or cell phone in which is installed a game that requires you to have a high degree of concentration since it consists of playing level one and overcoming it within the set time.

Test 2 - Student Read: Users were given a document to read and adopt the position they felt most comfortable with.

Test 3 - Student in the Library: It consists of capturing the postures that each student adopts while they continue doing their normal activities like surfing the internet in which it does not demand a high level of concentration, but neither does it cause boredom, in the You can see how the data was captured within this location, which includes the furniture of the same.

III. RESULTS

Table 4 shows the results of the tests in which the sensor Kinect correctly detected the position and time in which the user remained more frequently, resulting in users who prevail in a position for a longer time regardless of the activity you perform.

Tabla 3:Resultados de las pruebas

STUDENT	TEST 1		TEST 2		TEST 3	
USER 1 H	1	99	3	82	1	49
USER 2 H	1	65	1	59	1	71
USER 3 H	1	52	4	53	1	53
USER 4 H	3	53	3	53	1	100
USER 5 M	2	49	4	41	2	69
USER 6 M	1	43	2	55	2	52
USER 7 H	4	43	3	55	2	52
USER 8 H	1	54	3	58	2	58
USER 9 H	1	57	2	58	1	67
USER 10 M	4	54	1	101	2	43

In users 2, 8, 9 it has been detected that they remain more than half the time of the catch in the same position in all the tests, considered that the total catch is 109s.

A curious fact that could be found is that while users are more aware of their mistakes and trying to correct their postures both back and neck, the legs are points in which they unconsciously used to remain immobile without any variation for long periods of time, actions that could result in discomfort in the joints.

It has been found that users remain in a rigid position for more than half of the test, coinciding with [9] indicating that staying in the same position for long periods of time can cause health problems.

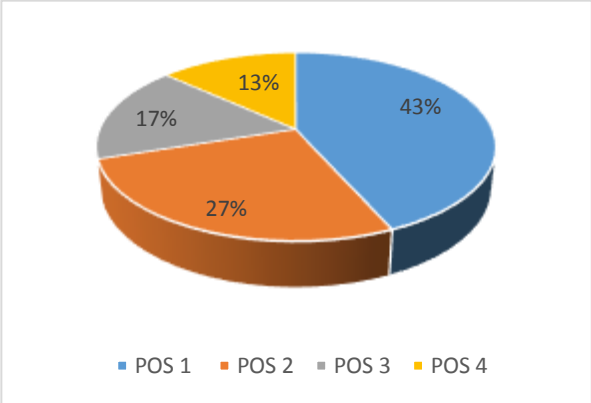

Fig 10: Average of Adoption of Positions According to the tests

As shown in Figure 10, the position that most adopts a student is posture 1 for the various activities, however, this gives no conclusive information on whether the legs reveal a state and concentration of the student in the classroom.

IV. CONCLUSIONS

- An efficient lower body movement monitoring system was developed, achieving 4 delimited positions according to the range of flexion of the legs and formulation of angles.
- After carrying out the various tests, it was possible to determine that the posture that the human being adopts is not always the same and that it changes according to the activity that it performs even though it is a repetitive activity.
- The information obtained in this research has not been conclusive enough to determine a posture that indicates that a person is concentrated, but it has been detected that position 1 is the most used to perform activities that require a high degree of mental activity.
- This study is part of one of the fundamental pillars for the IoT when collaborating with the analysis of objects without having contact with them, in this way it was possible to capture data of a non-digital object such as body movement.
- In a controlled environment, it is possible to reduce the range of errors of the various limitations and objects that can cause interference between the catches of the Kinect sensor, achieving a more accurate data acquisition.
- The use of this system significantly reduces procedural time compared to other methods of body monitoring by monitoring the student while performing

movements and saving them as digital information automatically.

V. RECOMMENDATIONS

- To make a better capture of form it is necessary to isolate all elements that could cause problems such as: the amount of incident light, natural and artificial, furniture, reflective objects and obstacles on the sensor.

- Finding the precise angle and position of the sensor is a key point to obtain correct data avoiding to hide the points or Joints necessary to build the human body, otherwise, we would get completely random and meaningless values as the skeleton of the user It could not be located properly and its representation on screen would be totally chaotic.

- Based on the study carried out in this work, future improvements could be made by implementing a second Kinect, which allows monitoring the human body from two perspectives at the same time, so that the joints obtained will have greater precision.

- Using position recognition by calculating angles between segments of the lower limbs is the most appropriate and accurate way to capture data.

- The use of minicomputers in this type of study is not advisable since to process image, video and large volume of data it is necessary great capacity of characteristic that do not fulfill these equipment's.

- To ensure that the tests are performed objectively, it is advised that the user does not have prior knowledge about the system's functionality, thus achieving better results.

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