DEVELOPMENT OF A SYSTEM FOR ASSESSING THE POSTURE OF THE HUMAN BODY

MIERLITĂ Iulia-Sorina[1], BĂCIOIU Mihaela-Roxana[1], CIOCOIU Daniela-Adriana[1], UȚICĂ Nicoleta-Georgiana[1], VOINEA Costin-Bogdan[1], ZAHARIA Ștefania[1], DIJMĂRESCU Manuela-Roxana[2], ABAZA Bogdan Felician[2], SPIROIU Marius Adrian[3]
[1]Faculty: Industrial Engineering and Robotics, Study program: Engineering and Management of Complex Projects, Year of study: 2, e-mail: sorina.iulia98@yahoo.com
[2]Faculty of Industrial Engineering and Robotics, Manufacturing Engineering Department
[3]Faculty of Transports, Railway Vehicles Department, University POLITEHNICA of Bucharest

ABSTRACT: The present study is based on the analysis of the proposed need for follow-up and focuses on the development of a technical solution, as well the performing of tests to build a prototype. It addresses the issue of the link between user awareness of the problem and action to address it. Thus, by applying the sensors in key positions, it is desired to develop a device with which the user is alerted and can correct the position of the back. Performing the experimental tests there are determined the key positions that will lead to the realization of the prototype.

KEY WORDS: human body posture, device, sensor, tests, measurements.

1. Introduction

The need that led to the development of this paper is the incorrect position of the back.

The device for warning of the incorrect posture of the back has the role of helping us to have a correct posture of the body, especially during the state on the chair.

The general objective of this work is to develop an innovative product that will alert the user to every incorrect position of the back. All data collected by the sensors will lead to the transposition of the information received by the sensors into graphs and diagrams to inform the user interactively about the position approached during the use of the device.

2. Need analysis

One of the fundamental steps in the development and prototyping of a device is the identification, understanding and characterization of the need. So, we compiled a list of the experienced need that we parameterized and capitalized on.

A characterization of the expressed needs / requirements is presented in Table 2.1.

Table 2.1. Expressed need

Need expressed	Parameter	Value
I want it to be quickly adjusted	Time	3-4 sec
I want it to be easy to adjust	Force	Some N
I want it to be resilient	Supported weight	Max. 130 kg
I want it to be easy	Weight/ Material	Max. 800 g
I want it to be easy to store	Volum	Max. 100 x 60 x 20 mm^3
I want it to be stable	Stable center of gravity	Depending on body position
I want to be warned about the correctness of the posture	Vibration / sound	Hz/ dB

Need expressed	Parameter	Value
I want to have access to the data collected on my phone	Dedicated device application	Bluetooth connection
I want it to have an attractive design	-	Varied design, wide range of colors

2.1. Functional need analysis

Environmental elements and the interfaces of these elements with the device for keeping the back straight, are shown in Fig. 2.1.

When defining the functions of the system, the relations of the system with the environmental elements are followed [1].

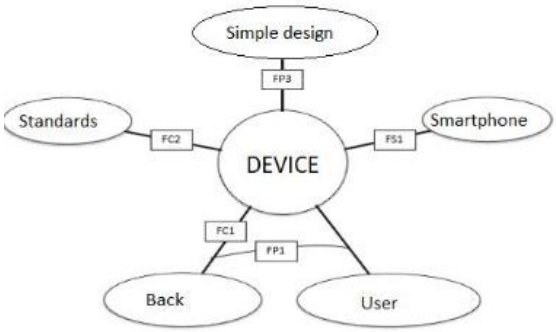


Fig.2.1. Relationships of the system environmental elements

The functions of the product are defined as:

FP1 – the device warns of the incorrect position of the user's back;
FC1 – the device adapts to the shape of the user's back;
FC2 – the device complies with the rules and regulations;
FC3 – the device must be easy to use;
FS1 – the smartphone provides data about the user's position;

The analysis shows that the first function is the most important. In order to achieve the concepts related to this project, this function was respected as a priority.

2.2. Research and evaluation of the posture of the human body

Posture is defined as the attitude assumed by the body either with support during muscle activity or as a result of coordinated action by a group of muscles working to maintain stability [5].

There are two types of posture: dynamic posture and static posture.

The spine has three natural curves at the level - cervical, thoracic and lumbar. The correct posture should keep these curves in a neutral position, without increasing or decreasing the angles.

In order to define the user's positions while using the developed product, an analysis of the anatomically and / or medically described posture types was required. The most common types of posture are shown in Fig. 2.2.

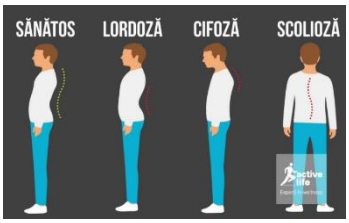


Fig. 2.2. Posture types

Were analyzed articles that debate the idea of the posture of the human body, with the aim of centralizing and creating a system for assessing posture.

3. Concurrent concepts

3.1. Existing products that meet the need

Following a rigorous documentation, two competing products were selected, as shown in Fig.3.1, 3.2:

Corset for correction and straightening column and shoulders with smart sensor

Fig. 3.1 [2]

Trainer posture Upright

Fig. 3.2 [3]

3.2. The competition's analysis

A comparative analysis between competing products and the product proposed for development is presented in Table 3.1.

Table 3.1. Compare specifications

Specifications				
Nr. crt	Product	Warning device of the incorrect posture of the user's back	Corset for correction and straightening column and shoulders with smart sensor	Trainer posture Upright
1	Adjustment time	***3 – 4 sec***	-	-
2	Type of grip	***Velcro closure***	-	-
3	Supported Weight / Size	***Max. 130 kg***	Universal	-
4	Weight / Material	***Max. 800 g***	Textil, antialergenic, nylon-elastic	-
5	Volum	***Max. 100 x 60 x 20 mm^3***	-	48mm^3
6	Stable center of gravity	***Depending on body position***	-	-
7	Warning type	***Vibration***	-	Vibration
8	Data accessibility	***Bluetooth connection - phone application***	-	-
9	Colour	***Wide range***	White or black	-
10	Charging time	***Aprox. 1,3 h***	Aprox. 1,5h	30 h
11	Charger	***USB C***	Universal with included micro USB	-
12	Charging voltage	-	DC5V	-
13	Charging current	***1200mA***	500mA	-
14	Battery specifications	***3,7 V/ 1000mAh***	400mA/ 3,7V	-
15	Upload interface	***USB C***	Mini-USB	-

As can be seen (Table 3.1), the product proposed for development has several characteristics that could place it in an important place in the market. The wide range of colors, the type of charger, the battery with its specifications, etc., are some of these advantages that it could have compared to other competing products [2, 3].

4. Business strategy

4.1. Possible market segments and their evaluation

For market segmentation, an analysis was performed for the product developed from a geographical, demographic and economic-social point of view.

The criteria on the basis of which the market is segmented are the following: age, occupation, gender, type of customer, etc.

From a geographical point of view, the product can be distributed both nationally and internationally, and the areas where, initially, the market of the product takes place are the counties of Ilfov, Prahova, Argeș and Neamț. This is due to the fact that they are the countries of origin of the team members, and this would influence when the product will be launched, put to use.

Demographically, according to a global study [4] on the incidence of back pain, it was found that 88% of people in the countries participating in the study suffer from this problem. People between the ages of 35 and 65 are among those most at risk. The activity carried out by the people on whom the study was carried out is mainly office work, with a minimum of 8 hours / day. The device is intended for both males and females, and can be adjusted according to the height of the user. The type of customer who would purchase such a device can be: individual, medical office or a recovery center.

From an economic and social point of view, the income that a user must have differs depending on various factors, among which: the country of origin, the place where he carries out his activity, the salary package, etc.

4.2. Choice of target segment

The development of the device will take into account the segmentation from the demographic point of view, and the criteria on which this segmentation is based are age, gender, respectively occupation.

Table 4.1. Choice of target segment

Age	Gender	Ocupație	Ability to straighten the spine	Client category
< 18 years	- feminin - masculin	-pupil	high	- individual - medical office - recovery center
18- 30 years		- student - office work - field work - mixt work	high	
> 30 years		- office work - field work - mixt work	medium	

4.3. Target customer profile

Following the above analysis, the profile of the target customer can be outlined, namely: in particular, people aged 18-30 years, regardless of gender and geographical position, who spend a lot of time sitting on seat.

5. Development of technical and prototyping solution

5.1. Conceptual variants

The idea that was chosen for development led to the generation of five conceptual variants, as shown in Fig. 5.1 - 5.5, with different types of drives: mechanical; mechanical-electronic; made up of different types of components and materials.

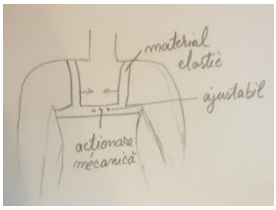


Fig. 5.1

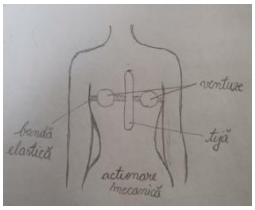


Fig. 5.2

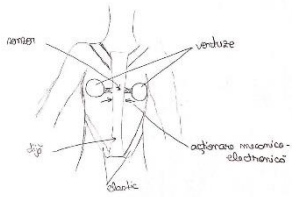


Fig.5.3

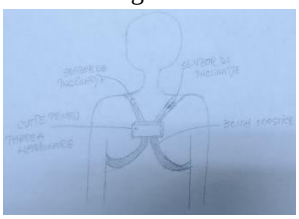


Fig. 5.4

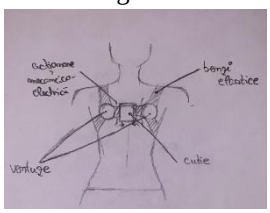


Fig. 5.5

5.2. Analysis and choice of two concepts

For the choice of two concepts, which will be further developed, an analysis was performed based on the following criteria:Sistem de prindere ușor de utilizat;

1. -Presence of sensors for immediate detection of incorrect position;
2. -Mechanical-electronic drive;
3. -Simple design.

It is found that there are two concepts that are closest to meeting the need. The most important and defining point in choosing the two concepts was how to measure and detect the incorrect position. This involves measuring angles and, when the reference points exceed the preset range, a vibration will be triggered [6].

5.3. Development of the proposed concept for prototyping

The present concept was chosen following an analysis, based on certain criteria, from a list of concepts, it having the highest score. Therefore, the high score he obtained leads to the idea that it will satisfy to high standards the need that we set out to satisfy.

The mode of operation of this concept is as follows: the user "dresses" the device as if he were wearing an item of clothing. When the user's position exceeds the preset angle when setting the device, it starts to vibrate until the user corrects its position so that it is within the preset angle range. One of the three sensors will be placed in the housing of the device for recording the coordinates of the chosen point as the main reference. The other two sensors will be placed on the deltoid muscles, which will also record the coordinates of the points. When the angle between the sensor in the housing and the other sensors exceeds the set tolerance range, the device will start vibrating [7]. All data collected by the sensors will be recorded and processed to provide the user with graphs and charts to illustrate the progress they are making using this device. The 3D realization of the future prototype in a 3D design software marks the evolution of the project and outlines the prototype we want to obtain. From the point of view of the demands that may arise on the device, there are no elements that

interfere with its smooth operation. The total mass of the product is in the order of hundreds of grams, so the user will not be adversely affected.

The accepted technical solution involved a simulation of the angle of inclination and the allocation of an orthogonal system of axes. Thus, all this approach led to the establishment of points on the user's back where the sensors can be placed.

The 3D model of the concept is shown in Fig. 5.6 - 5.11.

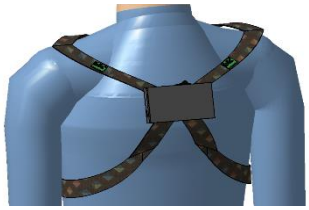


Fig. 5.6. Isometric view 1

Fig. 5.7. Isometric view 2

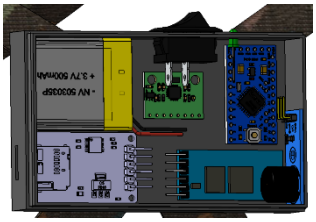


Fig. 5.8. Detail 1

Fig. 5.9. Detail 2

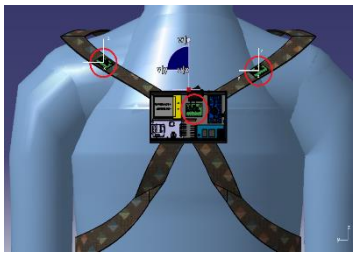


Fig. 5.10. Measure points

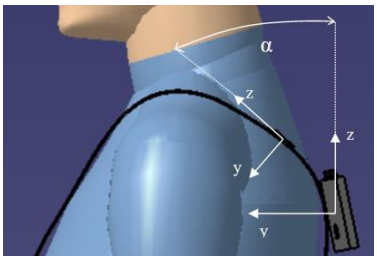
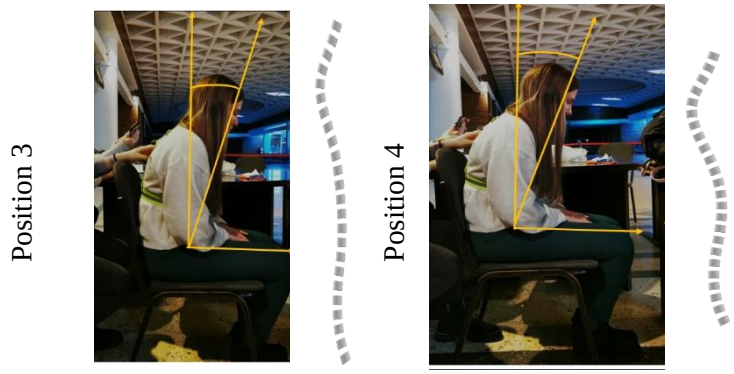


Fig. 5.11. Measurement principle

Experimentally, connections were made between the Arduino Pro Mini board and the MPU6050 sensor, and the case and cover were 3D printed in the faculty lab [8].

The usage scenario marks the route of the steps the device will go through during use. Closely related to this, the product life cycle also appears.

After assembling the components, it was possible to read the data recorded by the sensor. Thus, five body positions were determined. The first position was recorded as the reference position (the correct one), and the next four positions represent incorrect body positions. The data recorded by the sensor was collected for their interpretation.



5.4. Data measurement, monitoring, transmission and analysis subsystem

Experimentally, for measurement, connections were made between the ESP8266 NodeMCU board and the MPU6050 sensor.

The MPU-6050 module consists of a digital motion that performs all complex processing, calculations and provides sensor data to other MCUs via I2C communication. It communicates with other microcontrollers and sensors via I2C communication. The architecture of the ESP8266 NodeMCU measuring subsystem with MPU-6050 is shown in Fig.5.12.

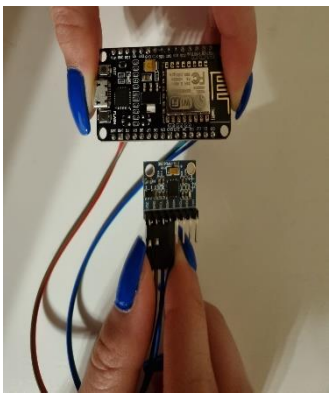


Fig.5.12. Measurement subsystem architecture

The data is transmitted via WiFi, through protocols to be tested (I2C) and tested.

6. Economic analysis

Following the calculations performed, it was established that, at an annual quantity of 5000 pieces sold, with a selling price of 670 lei, the break-even point will be reached at the beginning of September. This is justified by the fact that in the first year the investment is the largest, being necessary the acquisition of both the raw material, the production system and the place where the activity will take place. Starting in the second year, the recovery of losses will begin.

7. Conclusions

The idea for this paper was obtained after a brainstorming session. The realization of the project consisted in using the numerous methods of analysis to outline the profile of the target customer, to know the competition, but also to identify the risks that may arise. The functional analysis, followed by the elaboration and development of several concepts outlined the technical solution with which we continued the study to try to obtain a prototype. Economic analyzes were also performed to ensure that the project is reliable and to ensure a fair cost for both the developer and the end customer.

Analyzing the objectives that were proposed in the introduction of the paper, they differ from the results obtained. Thus, the current stage of the project is an intermediate one. The main components have been assembled. Several experimental measurements were performed, which led us to five positions, including the reference position (the one considered correct). By collecting all the data from the sensor, but also the photography of the stations, we obtained the necessary parameters to perform an analysis, which will be the basis of the programming code of the device. In the following educational cycles, this study can be completed and a fully functional prototype obtained.

8. References

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Acknowledgement

The authors would like to thank to Prof. Marian GHEORGHE from Manufacturing Engineering Department, Faculty of Industrial Engineering and Robotics and to Associate prof. Camelia STANCIU from Thermotechnics, Thermal engines, Energy and Refrigeration Equipment Department, Faculty of Mechanical Engineering and Mechatronics, for their support and guidance in completing this research.