A System for Real Time Monitoring of Users' Postural Attitudes

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Abstract— **This paper presents a system for real time monitoring of users' postural attitudes with particular focus on children. Maintaining for too long a wrong posture could cause serious problems to children and, in worst cases, they could receive permanent spinal deviations. The system is composed of two different elements: 1) a device equipped with inertial sensors (accelerometer, magnetometer and gyroscope), which are applied to the patient's spine and are able to measure his spinal curvature; 2) a mobile application for smartphone that provides a graphical user interface. Considering the age of the target of this project, we have decided to make use of the system similar to a game, giving the user a score based on his posture and creating a ranking. Our system can also give an alarm when the patient is maintaining a bad posture in order to educate him.**

Keywords- Posture; Inertial Measurement Unit; Serious Game for Health.

I. INTRODUCTION

Bad posture attitude is one of the main causes of backache and it can easily degenerate into real pathologies, especially when the patient is in his childhood and his growth is not concluded yet [1]. Thanks to some studies [1], we know that postural interventions, such as reminders about the good posture during a school lesson, significantly reduce the level of pain reported by children at the end of the class.

We also know that users are more willing to use whatever kind of product (in our case a medical device), also improving its effectiveness at maximum, if it is presented in form of a game, especially if it is aimed at children [2]. So that, this system would fall under the category of serious games and, in particular, games for health (games that are designed for a primary purpose other than pure entertainment) which are becoming largely adopted in various health problems for improving the people wellness [3].

The remainder of this paper is organized as follows: in Section 2 we briefly present a study on the state of the art related to posture problems, talking about what is needed to put our project into practice and considering some of the systems already existing focused on the same problem. In Section 3 we present the project itself, analyzing the very elements of which the system is composed and the algorithms we have developed. In Section 4 we examine the benefits deriving from the inclusion in our project of some typical aspects of gamification and we explain the idea we are developing. We conclude our paper in Section 5 by analyzing the results obtained with tests and proposing further experiments in order to verify the real impact of our device.

II. STATE OF THE ART

What is needed to put into practice our project is a system able to monitor postural attitudes suitable for an environment different from a laboratory (e.g., it could be used in a classroom); this should be non-invasive, and finally it should not either restrict or alter in any way user's motion. Nowadays, many systems have already been proposed but without achieving all our three goals at the same time. The main analysis methods of movement are based on videos and optoelectronics; they offer a good precision but they cannot be employed outside of an environment specifically studied for them [5]. Other interesting techniques perform the analysis by means of electromagnetic tracking systems and potentiometric goniometers, but the first one can be affected by the presence of metallic objects in the work environment and the second one restricts the patient's movements.

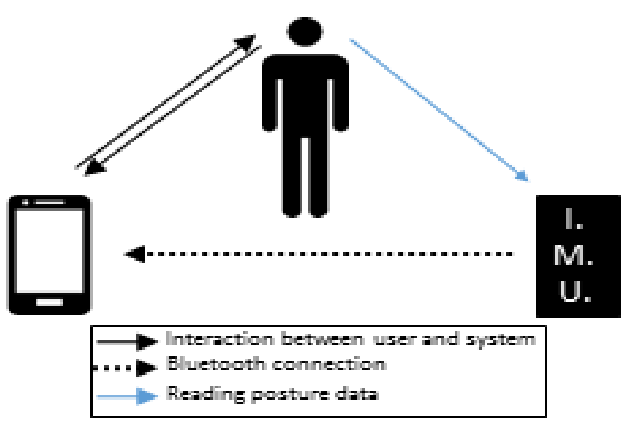

Figure 1. System components relation

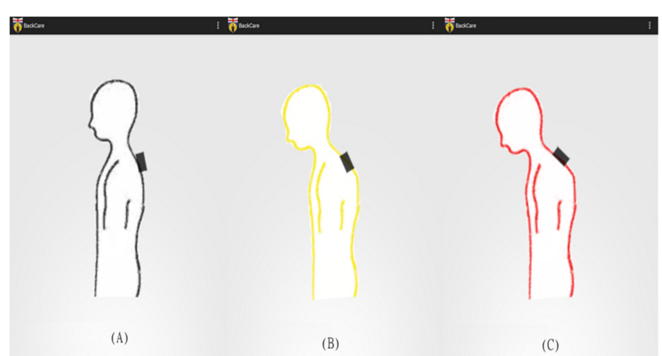

Figure 2. Graphic User Interface: a) Correct curve; b) Medium curve; c) Wrong curve

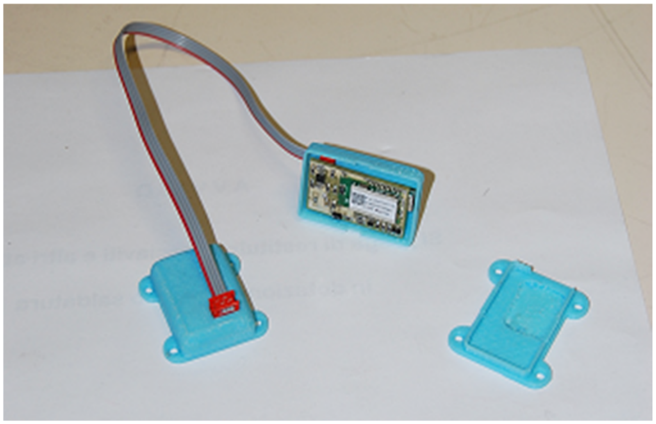

Figure 3. The system hardware prototype

III. THE PROJECT

Once we evaluated the above considerations, we decided to implement a system based on inertial sensors and in particular a three-axis gyroscope, a three-axis magnetometer and a three-axis accelerometer. These sensors are used to obtain the Eulero angles, three data that describe the orientation of a rigid body in the space. The use of accelerometers and gyroscopes to analyze the spine position of a human being has already been studied [4]-[7], but we have introduced in our system a magnetometer in order to avoid a typical problem of gyroscopes, called drift.

Our system is basically composed of two components: the first one is dedicated to the measuring of the patient posture, and the second one analyses the data and allows the user to interact with the system through a graphic interface. The two elements can communicate each other via Bluetooth connection (Figure 1).

We have designed and developed a device (Figure 2) equipped with an ST iNemo module [8]. With this module it is possible to receive data from a three-axis accelerometer, a three-axis gyroscope and a three-axis magnetometer, and filter them to compute Euler angles.

The measurement of the posture kept by the user occurs by placing one or more devices on different spots of his back in order to monitor the main curves of the spinal column. In particular, our sensors are used to measure back curves of the patient on the sagittal plane (to monitor kyphosis and lordosis) but they can also be used to monitor angles on the coronal plane (to monitor scoliosis).

The device we have developed is composed of two Inertial Measurement Units (IMUs): the first one, called master has to handle the data transmission to the Android application via Bluetooth, in addition to measurement task using the sensors; the second IMU, called slave, is only able to measure and elaborate data, working as master satellite. This structure allows us to perform simultaneously measurement in different areas of patient's back, giving a more accurate set of data.

The graphic user interface is implemented to be executed on a mobile device (smartphone or tablet) equipped with an Android operative system; in turn, the device is connected with the sensor component using a Bluetooth connection. When it receives data from the sensors, it gives back to the user a real time view of his position, emitting three different kinds of warning in case of a prolonged bad posture: a graphic one (Figure 3), an acoustic one, and a vibrating one. In order to avoid excessive noise from our system, we have set the alarm so that it will sound only after a certain span of time during which the patient is maintaining a wrong position; in this way the system will not measure patient's temporary movements/changes of position.

Another function performed by our app is the possibility to save various information concerning monitoring shifts within a database so that the user can examine them later.

Finally, the software has been designed to be used by more than one user on the same device; when the system is launched, a user authentication is required so each patient can access their own personal data and profile.

IV. POSTURE MONITORING AS A SOCIAL GAME

An important aspect we have considered in developing our system is the great success that social games have been recently achieved. Several studies show that the fact of sharing the results obtained between user and the possibility for them to leave a usually positive feedback, make the system more attractive. This is a feature common to every kind of activities, be they virtual or real, experienced by the user who is nowadays used to share many aspects of his life through social networks.

For all these reasons, while developing our system, we have thought about giving a score to the user based on the time he spends in maintaining the correct position. This score is then inserted within a rank to create a certain sense of competition among users/players and, most importantly, to push them to maintain the correct position. This idea would be of particular effectiveness in case of children or teenagers belonging to the same class.

The score is given accordingly to the framework shown below:

- +1 point every minute spent in the correct position;
- 0 points every minute spent in a position partially incorrect;
- -1 point every minute spent in the wrong position.

The system updates the results of all participants every thirty minutes to highlight children who have kept the position particularly wrong. Besides, we have thought of the possibility to form teams to increase interaction among children. Finally, as mentioned before, users' scores can be shared on social networks and inserted within a global rank to develop a challenge.

V. CONCLUSIONS

In order to evaluate our system, we have carried out experiments in lab. They showed the validity of the approach both for the precision in measuring the posture and for the feedback given to the user.

The experiments conducted so far left us quite optimistic about the results our system could give but, the real impact of social games have not been completely verified.

In order to verify the real impact of the device we have developed, shaping it as a social game, we suggest working in partnership with a school. In this way, we could test the system on a significant number of subjects. The general idea we propose is to split up the students in two group called *Group A* and *Group B*. The first group should use our system in "social game modality"; in the meanwhile Group B should be using the system only with "real time feedback modality". During the experiment we expect the members of Group A to maintain a correct position for a longer period of time than the one kept by members of Group B.

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