Bad Sitting Posture Detection and Alerting System using EMG Sensors and Machine Learning

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***Abstract*—Poor sitting posture can lead to a variety of serious diseases raging from spinal disorders to psychological stress. This paper aims to design a sitting posture monitoring system that detects improper postures and notifies the user in real time through a mobile application. The system leverages the use of low-cost EMG sensors, and relies on energy-efficient communication via Bluetooth Low energy (BLE). To ensure bad posture detection, different machine learning algorithms are tested and compared, namely support vector machine (SVM), K-nearest neighbours (KNN), decision tree (DT), random forest (RF), and multi-layer perception (MLP) . We formulated the problem as a binary classification (good vs. bad posture) and multi-class classification (good, tilted to the front, right and left). The results of the training performed on a real dataset showed that KNN have the best accuracy (91% accuracy) and execution time (0.0066 ms).**

***Index Terms*—Posture monitoring, smart health, machine learning, Internet of Things**

I. Introduction

Office workers spend long hours sitting in front of computers, which inevitably leads to poor posture. Sustained poor spinal posture is associated with developing and worsening musculoskeletal disorders, leading to neck and back pain, radiculopathy, and sensorimotor deficit symptoms. In severe symptomatic cases, surgical intervention becomes a necessity. Ultimately, poor posture can lead to a significant economic burden through increased healthcare costs and lost productivity within the workforce. While it is difficult to estimate the total cost of poor posture alone, the predicted burden of back pain in the United States alone is an annual net cost of 60 billions of US dollars [1]. Therefore, there is a need for real-time postural monitoring and correction.

Posture monitoring can prevent the aforementioned consequences using real-time feedback, encouraging the correction of sustained poor posture and decreasing total time in poor postural states. It is hypothesized that these systems may instill correct postural habits and yield a decrease in the incidence of posture-related musculoskeletal disorders with long-term use. Besides workplace occupational health and safety, other clinical applications for postural monitoring include post-operative rehabilitation, detecting falls within the home, preventing falls through improved postural control, and assessing Parkinson's Disease severity [2].

Conventionally, spinal posture is assessed in a clinical setting during routine patient examinations, physiotherapy sessions, or formalized laboratory-based evaluation. Such traditional methods have been criticized as costly and impractical, with a critical inability to measure day-to-day posture and provide timely feedback. ICT based solutions (such as sensors) can assess such problems by providing a cheap and practical alternative.

Many posture monitoring systems in the literature are based on cameras and image processing, compromising personal privacy. Recently, sensing technologies have known evolution and spread in different fields, especially in medical and healthcare systems. The sensors are characterized by portability, low cost, ease of use, tiny size, and less privacy-threatening. In this work, we are particularly interested in electromyography (EMG) sensors [3].

The proposed system is composed of three main modules. The first module is composed of sensors that collect data on the body posture. The second one analyzes the sensed data (through a machine learning algorithm) and decides about the posture nature or type. The third module implements a feedback system (mobile application) to alert the user in case of bad posture.

Our contributions can be summarized in the following points:

- The design of a low-cost EMG sensor, Bluetooth Low energy (BLE), and machine learning architecture to detect and alert the user when he is in a prolonged bad sitting posture.
- Collection and annotation of a dataset of EMG trapezius muscle signals on 22 participants from different ages and gender.
- A method to pre-process the collected data and to extract the most significant features.
- The test and comparison of five machine learning algorithms and selected the best in terms of accuracy and execution time.
- The developement of a smartphone application that receives the alert via BLE from the microcontroller and notifies the user.

The remainder of this paper is organized as follows. First, Sec.II presents the related work. Sec.III provides an overview on the solution, while Sec.IV details the dataset construction approach. Sec.V presents the training, results and comparison of machine learning algorithms used for posture monitoring.